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ESMT INNOVATION INDEX 2010 – ELECTRICITY SUPPLY INDUSTRY

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Contents

Executive summary

The most widely used indicator to measure the degree of innovation of an industry is each individual company's actual expenses on research and development (R&D), aggregated across the whole industrial sector. With the *ESMT Innovation Index 2010 – Electricity Supply Industry*, we suggest expanding the notion of innovation beyond R&D indicators to achievements in productivity and sustainability. We test the methodology of the innovation index with a set of 15 large European electricity utilities and find that innovation activities have substantially increased over the last four years. A German and a French utility, RWE and EDF, lead the ranking within our sample.

After years of declining research and development expenditures, European energy utilities seem to have shifted their focus to innovation as a competitive advantage. Between 2007 and 2010, the combined R&D budget of 15 major European energy suppliers increased by 40 percent to more than €1.5 billion. Meanwhile, "new" renewable energy generation, mainly based on wind and solar power, more than doubled, and productivity in terms of EBITDA per employee rose over the same time span by 20 percent. It has now reached €139 per employee – despite the harsh market environment. However, the number of new patents dropped significantly, and aggregate CO_2 emissions increased by 10 percent.

Which European energy utilities take the leading role in innovation? Which companies successfully defend and expand their market position by gains in productivity instead of – or complementary to – focusing on research? Which ones lead the drive to an emission-free generation portfolio?

We consider all these aspects to be elements of an innovation process within the energy supply industry, and see them as part of a fundamental transformation that started with European liberalization and the Internal Energy Market. In our view, a mere focus on R&D expenditures falls short of capturing the full innovation dynamics of the electricity supply industry. Out of this reasoning we developed a tool that encompasses the above-mentioned dimensions: the *ESMT Innovation Index,* an index that measures the transformation speed and transformation results of electricity utility incumbents and thus indicates their ambitions and successes in shaping new energy markets.

The index was developed as a result of consultations and qualitative interviews with industry representatives and specialists at consulting practices. It methodologically complements analyses like the "EU Industrial R&D Investment Scoreboard" and the OECD STAN/ANBERD database of industrial R&D by adding a number of relevant industry-specific variables. It consists of three subindices:

- The **Research Subindex** combines the criteria relative to and of absolute R&D importance as well as a measure for research diversity and number of patents. It accounts for 50 percent of the overall index.
- The **Productivity Subindex** depicts the earnings per electricity output as well as per employee and is given 25 percent weight in the overall index.
- The **Sustainability Subindex** contains the absolute share of new renewables (solar, wind, biomass, etc., but excluding large hydropower) and the specific electricity output per ton of carbon dioxide emissions, with a 25 percent weight in the index.

With the chosen weights, we suggest a more ample interpretation of innovation for the energy supply industry: Although the classical criteria of a firm's innovative strategy and capabilities – captured in the Research Subindex – are still emphasized, efforts to economically and environmentally optimize processes within the firm obtain an equal weight via the Productivity and Sustainability Subindices.

To account for the dynamics of the transformation, each criterion is measured based on the current status in the year 2010 with a weight of 75 percent as well as the annual changes from the first year of the computation (2007) onwards, with a weight of 25 percent. In the computation, the more recent annual changes are given a greater weight than the more distant ones. We varied the weightages allocated to the three subindices (50%, 25%, 25%) and to the timing of the data (75% for the most recent and 25% for changes over the preceding years) and found our results to be consistent and robust. Appendix 2 shows the details of the sensitivity analyses.

The *ESMT Innovation Index* is based on secondary data research for the years 2007 to 2010 (annual reports as well as sustainability reports). It covers in total 15 companies, all considered incumbents in their respective country contexts:

- *Central Europe*: Verbund and CEZ
- *France and Belgium*: Electricité de France (EDF) and GDF-Suez
- *Germany*: E.ON and RWE
- *Italy*: Enel
- *Scandinavia*: Dong, Fortum, Statkraft and Vattenfall
- *Iberian Peninsula*: Iberdrola and Energias de Portugal (EDP)
- *Switzerland*: Axpo
- *United Kingdom*: Scottish and Southern Energy (SSE)

The top two companies of the *ESMT Innovation Index* 2010 are RWE and EDF.

With a score of 70.6 out of 100, RWE achieves the highest score of the *ESMT Innovation Index*, mainly because of its leading position in the Research Subindex. With a coverage of 14 out of 15 relevant energy research fields, an increase of the research budget by €38 million to €149 million from 2009 to 2010, a relative R&D importance of 1.5 percent of EBITDA and 32 patents issued RWE outperforms its competitors. Though its sustainability and productivity scores lag behind its strong research performance, RWE was able to improve its sustainability score by 23.6 percent, triggered by improvements in climate performance and generation from new renewables.

EDF comes second in the index with a score of 57.7. The company's high score in the Research Subindex (38.4) Subindex triggers this position. In 2010, EDF raised its R&D budget from €438 million to €486 million. With more than 2,000 researchers supported by an R&D Advisory Board, EDF covers – as RWE – 14 out of 15 research fields. However, the utility's excellent score is slightly dampened by its poor record in the Productivity Subindex.

A group of three further companies achieve scores above 50: Iberdrola, GDF-Suez and EDP, outperforming most of their peers in the Research or Sustainability Subindices. Six companies exhibit moderate innovation activity with scores between 50 and 25, including Dong, Statkraft, Enel, E.ON, Vattenfall, and CEZ. The last cluster of companies, with scores below 25, does not excel according to our innovation criteria. It contains the utilities Verbund, Axpo and Fortum. An exception within this cluster is SSE with a comparatively high score in the Research Subindex.

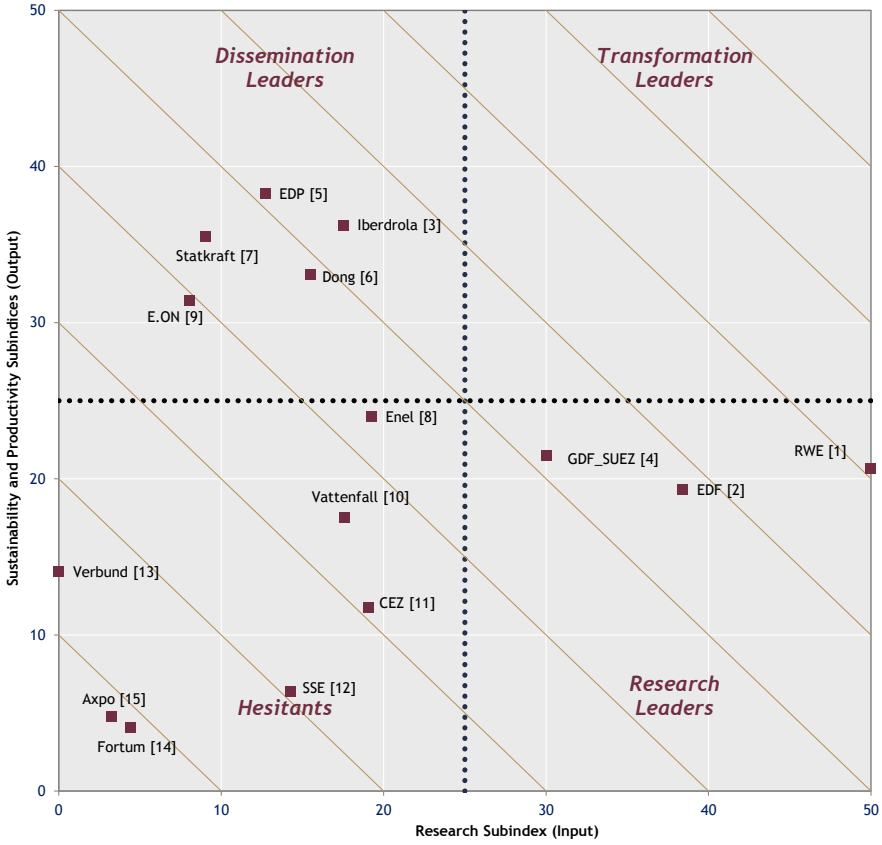
The analysis of the changes in the index shows that 10 of the 15 companies achieved improvements in all subindices – indicating the efforts the companies are undertaking to prepare themselves for future challenges.

The *ESMT Innovation Index* can be used to identify diverging transformation strategies within the European energy industry: When utilities – in their core function as service providers and infrastructure managers – score high in the Productivity and Sustainability Subindices, they exploit innovative processes and technologies developed by component suppliers that focus on machinery, electronics and information technology, and efficiently use and implement their innovations in the energy value chain, without dedicating too many in-house resources to proper research. By contrast, if companies yield high values in the Research Subindex, they pursue a strategy that aims to achieve future competitiveness by strengthening leading-edge know-how within their organization.

The following figure sketches these diverging strategies by plotting the individual company scores of the Research Subindex on the horizontal axis and the sum of the

Productivity and Sustainability Subindices on the vertical axis. The diagonal lines indicate the relative position of each company on the path from "Hesitants" in the bottom left corner to "Transformation Leaders" in the top right corner.

Figure 1: Company clusters based on the scores of the *ESMT Innovation Index* – relative positioning in innovation and transformation



Source: ESMT analysis (2011).

According to the scatter plot, we can distinguish four transformation clusters:

Transformation leaders (high scores in research and high scores in productivity and sustainability): These companies lead the energy transformation not only via improvements in efficiency and climate performance but also based on R&D investments. Unfortunately, in the 2010 index no company is positioned in this group.

Research leaders (high scores in research and low scores in productivity and sustainability): These companies do not score high on sustainability and

productivity – partially due to their generation mix, or caused by recent acquisitions. However, they aim to shape the energy transformation, which is reflected in the high score in the Research Subindex. In 2010, RWE, EDF and GDF-Suez constitute this group.

Dissemination leaders (low scores in research and high scores in productivity and sustainability): These companies focus on the dissemination of product and process innovations, thus achieving high scores in productivity and sustainability. The leaders in this group are EDP and Iberdrola, followed by Statkraft, Dong and E.ON.

Hesitants (low scores in research and low scores in productivity and sustainability): The companies in this quadrant show low scores in research as well as productivity and sustainability.

In all cases, it should be noted that the *ESMT Innovation Index* does not only measure organic efforts. It also reflects the option to improve the company position via mergers & acquisitions and integrates any result of M&A activities into its overall innovation performance.

The results of the index reveal that the European energy industry is preparing itself for the challenges ahead: the overall trend is positive – incumbents have realized that if they do not invest in future product and process innovations, new entrants may take their place, or they may be the next ones to be integrated into a larger company.

The *ESMT Innovation Index* is intended to serve as a measurement tool to assess the transformation speed of energy incumbents. The index facilitates and complements the public discourse regarding the role of energy incumbents within the energy transformation. It allows energy incumbents to compare their efforts among their peer group. Investors and financial consultants may use it to evaluate investment opportunities and risks. In addition, policy-makers, government and business organizations may integrate the findings in their policy formulation or other innovation-related actions.

As an indicator for the role of utility incumbents within the energy transformation, the index shall be updated on an annual basis.

Motivation

Are the big European power companies ready for a fundamental transformation? Are they prepared to undergo a phase of organizational learning, confronted by new regulation and driven by technological change? After years of declining R&D budgets, almost all European energy utilities in our sample have increased their investments in innovation since 2007. But how can innovation be adequately measured in an industry that is primarily focused on providing energy services? We contend that an exclusive focus on R&D expenses provides too narrow a perspective on how fit European electricity incumbents are to tackle future challenges. We suggest a broader measurement of innovation, the *ESMT Innovation Index 2010 – Electricity Supply Industry*. It is composed of generic and industry-specific R&D indicators, and complemented by key company figures on productivity and sustainability.

The liberalization of the energy supply industry has been singled out as the most important factor that induced utilities' spending on research and development to drop drastically since the beginning of the 1990s.[1] Departing from a relatively comfortable position of secured returns, natural monopolies and regulated pricing schemes, the industry was – like many other infrastructure services – confronted with a sudden and largely unexpected shift in the prevailing paradigm. Facing stiff competition for industrial consumers and the emergence of specialized niche entrants in the retail market, deregulation led to urgent and radical restructuring of the utilities' traditional business model. Well-endowed firms adapted to the new situation by seizing opportunities, especially in Latin America and later in Eastern Europe and Central Asia, of acquisitions in the large-scale privatization schemes, and by mergers within adjacent service areas and countries. Research and development, or more generally innovation, drifted – somewhat understandably – out of the focus of managerial foresight during the first frenzy of liberalization.

Figure 2 below shows the drastic decline of aggregate industrial spending on research and development in electricity, gas and water supply for a number of European countries and the USA toward the end of the last century, coinciding with the ratification and implementation of the European Commission's Energy Directives on the Internal Market and Federal Energy Regulatory Commission's

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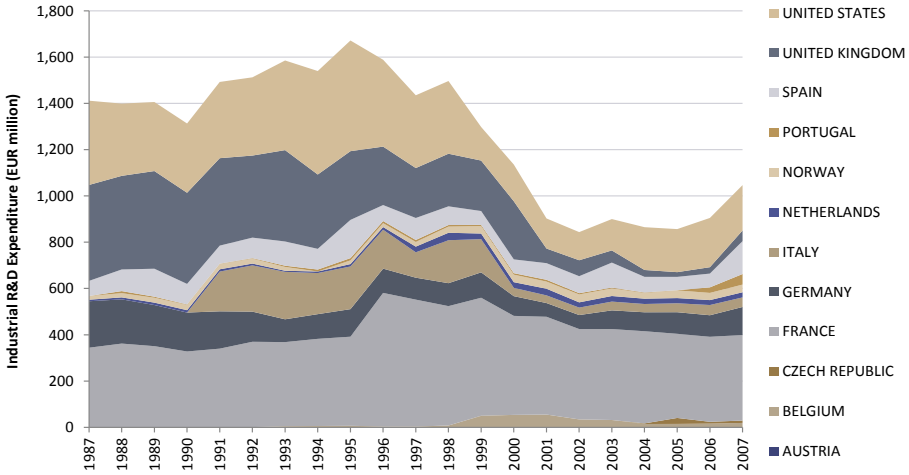
[1] For a more extensive discussion on the topic, see Jamasb, T., and M. G. Pollitt (2008). Liberalisation and R&D in network industries: The case of the electricity industry. *Research Policy* 37(6-7); Margolis, R., and D. M. Kammen (1999). Evidence of under-investment in energy R&D in the United States and the impact of federal policy. *Energy Policy* 27.

Orders 888 and 889 in the USA. As the figure indicates, aggregate, industrial R&D spending started to rise again in 2006.

Figure 2: Industrial R&D expenditures in electricity, gas and water supply

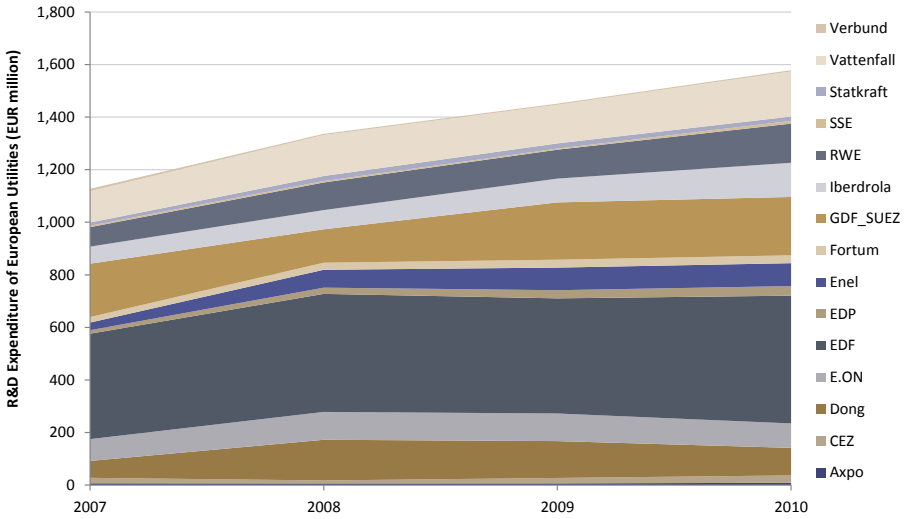


Source: OECD STAN Database (2011), ISIC Rev. 3.

Our analysis shows that for the most recent four years, innovation efforts of almost all utilities in our sample have been constantly expanded – despite the on-going process of consolidation, increasing competition, and the harsher business environment in the aftermath of the financial crisis.[2] For the 15 major European energy utilities in our sample dataset, combined R&D expenses increased from €1,127 million in 2007 to €1,579 million in 2010 – a rise of more than 40 percent.

[2] See appendix 4, figure 15 for an overview of R&D spending within our sample.

Figure 3: Combined R&D expenditures of 15 major European electricity utilities from 2007 to 2011



Source: ESMT analysis (2011).

In the post-deregulation revival of innovation efforts, which R&D strategies do European utilities pursue? Are they directed towards a few promising future technologies, like carbon sequestration or renewable energies from unconventional sources, or do the utilities follow a portfolio approach in their R&D projects?

Only concentrating on industrial R&D expenses does not yield satisfying answers to these questions. We suggest a broader view on innovation efforts. Apart from the companies' in-house research efforts, utilities as service providers and infrastructure managers exploit innovative processes and technologies developed by firms that focus on highly specialized machinery and electronics. An electricity utility's role in the process of innovation then typically consists of advancing, combining, implementing, and maintaining these technologies at the scale of commercial electricity supply.

In addition, many innovations of utilities occur at the organizational and managerial levels. The transition to a framework of competitive wholesale and retail markets induces major adaptation and innovation efforts, including an optimization of the supply and sales strategy with new opportunities arising from the expansion of electricity exchanges, sophisticated trading platforms and a bunch of exotic and conventional hedging tools. Following accounting conventions, these organizational changes are most often not part of the officially denoted R&D budget. They may be reflected in alternative indicators, though, that serve as proxies for efforts to raise productivity and competitiveness.

While both the "research exploiter" role as well as the organizational learning process are apparent in other sectors, especially in telecommunications, the electricity supply industry faces a particular challenge with respect to internalizing environmental damages. According to the current state of knowledge, the most important externality of human civilizations appears to be climate change and the rise in Earth's average temperature due to greenhouse gas emissions.[3] Since electricity generation accounts for approximately a quarter of global greenhouse gas emissions,[4] utilities have an important role to play in curbing the anthropogenic impact on the climate. The importance of clean technologies in mitigating efforts has increasingly been driven into public – and hence political – awareness and subsequent regulatory decision-making, reflected for example in the German feed-in tariffs or the EU's emission trading scheme (ETS). Hence, industrial innovation is also present in actual emission reductions and, more generally, in the notion of intergenerational responsibility and sustainable development.

Based on qualitative interviews with industry representatives and specialists at international consulting practices, we developed and operationalized a set of indicators that take these elements of innovation into account when measuring the innovation and implementation capabilities of electricity companies. The result of the consultation process is the *ESMT Innovation Index 2010 – Electricity Supply Industry*. It allows for comparing innovative processes and the potential for large-scale organizational, technological, and strategic transformations. It thereby complements the single-dimensional approach of cross-industry comparisons like the OECD's STAN/ANBERD database or the EU's Industrial R&D Investment Scoreboard by a set of indicators that monitor complementary dimensions of innovation in the electricity sector.

By focusing on European energy incumbents, we limit our sample to the world's region that claims to be at the forefront of innovation, environmental protection, and the creation of competitive energy markets. Although its components are constructed from company-specific data sources, the cross section of utilities in the sample can provide a perspective on the dynamics of the overall industry sector.

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[3] IPCC (2007), *Climate change 2007, the IPCC Fourth Assessment Report*, see http://www.ipcc.ch/publications_and_data/publications_and_data.htm, (accessed September 29, 2011).

[4] Stern (2007). *The economics of climate change*. UK Office of Climate Change.

The *ESMT Innovation Index* is intended to primarily serve four audiences:

- The general public interested in the role of electricity supply industry within the energy transformation;
- Energy incumbents, to benchmark their innovation efforts and results as additional information for evaluating their business or R&D strategy;
- Investors and financial analysts, to assess investment opportunities and risks; and
- Policy-makers, government and business organizations, to evaluate policy-formulation, regulatory intervention or innovation-related action.

How we measure innovation

The *ESMT Innovation Index* integrates both past developments as well as investments into future technologies and R&D. It is composed of three distinct subindices that operationalize and measure a company's performance with regard to research, sustainability, and productivity.

Innovation is at the heart of an evolving economy. Joseph Schumpeter, the visionary Austrian economist, distinguished between different types of innovation: the introduction of a new product or a qualitative change in an existing product, process innovation new to an industry, the opening of a new market, development of new sources of supply for raw materials or other inputs, and changes in industrial organization.[5] In the liberalized electricity supply industry, each of these components of innovation is present: Utilities implement changes in their existing generation portfolios and develop new products for wholesale and retail markets; they introduce new processes and increase the efficiency of their plants and workforce; they explore opportunities to generate power from renewable and non-conventional energy sources; ultimately, they adapt to and seek to exploit a new industry structure characterized by competition, unbundling, market coupling, and the convergence with internet and communications technology.

How can innovation be measured? Appendix 3 provides an overview of existing innovation indices on different levels of disaggregation. To specifically operationalize and adapt Schumpeter's categories of innovation to the electricity supply industry, we used valuable inputs from industry, academia, and consulting to identify three distinct attributes of innovation activities within an organization: The Research Subindex monitors the importance, efforts and diversity of R&D undertaken by electricity utilities, the Sustainability Subindex evaluates efforts to integrate new and environmentally sound sources of energy and to minimize CO_2 emissions[6], while the Productivity Subindex measures the operative and sales performance of the companies.

Among those three categories, 50 percent of the weight is given to the Research Subindex, thereby valuing efforts to improve the innovation position of a company

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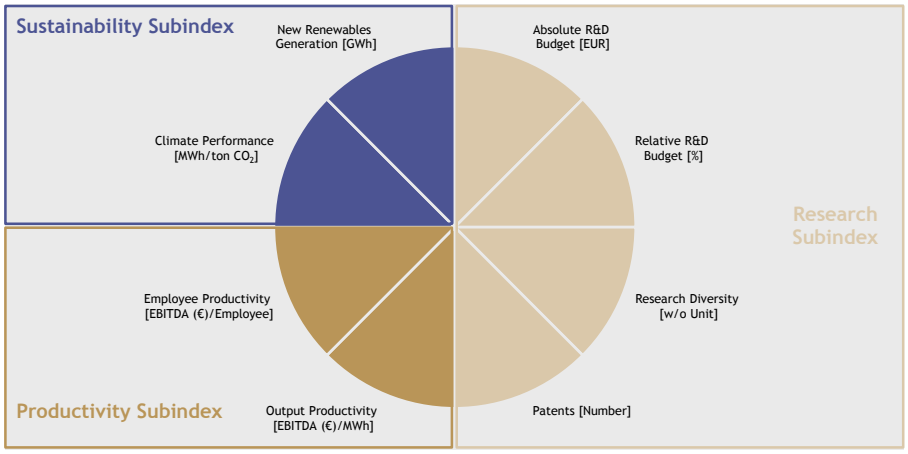
[5] Schumpeter, J. (1934). *The theory of economic development*. Cambridge, Massachusetts: Harvard University Press.

[6] In its terminology, the Sustainability Subindex seems to entail a normative notion. We believe, however, that the policy objective of substantially curbing greenhouse gas emissions in Europe will place those utilities over the medium term into economically disadvantageous positions that will not direct considerable resources into strategies to tackle their emission balances.

and enhancing its long-term prospects as a market leader. The remaining 50 percent are allocated in equal terms to the Sustainability and Productivity Subindices, which represent efforts to environmentally and economically optimize processes within the firm. Figure 4 shows the relative contribution of each of the factors to the overall score of the index.

Figure 4: Composition of the *ESMT Innovation Index – Electricity Supply Industry*



For the composition of the overall index, the individual indicators are normalized. To account for the dynamics of the transformation, each criterion is measured based on the current status (stock) and the changes that occurred during the sample period (flows). More recent changes have a greater weight than past efforts. Appendix 1 provides the methodology for the computation in detail.

The following overview describes all indicators used in the index.

Research Subindex

The Research Subindex reflects the close relation between innovation and company-specific research activities. It consists of four indicators:

- **Relative R&D importance**: A company's overall research budget crucially hinges on the company's actual size. Given the size diversity among European electricity companies, ranging from smaller players in fragmented, highly competitive markets like the United Kingdom to state-owned utilities with a dominant position in their home country like in France, this indicator monitors the proportional budget allocation of annual earnings to R&D projects. It is calculated as the ratio of the overall R&D budget to EBITDA.

- **Absolute R&D budget**: In-depth research can only occur when funds are increased beyond minimum thresholds, in particular given the capital intensity and high-tech orientation of the electricity industry. This indicator complements the first one by taking the overall R&D budget in absolute terms into account. It is measured in million Euro.
- **Patents**: Patents are essential for protecting intellectual property. The number of patents gives an indication of the company's efforts to drive innovation[7]. It is measured by the annual number of new patents registered at the European Patents Office (EPO).
- **Research diversity**: This indicator uses a composite proxy to reveal the variety of research fields a company is (substantially) involved in. For this purpose, a categorization of representative research fields in the electricity industry is established, of which some fields may have two or more subcategories. The categorization serves as the basis for a sector-specific measure of research diversity. This index consists of two factors:
  - First, "Research Coverage" measures the number of sub-fields in which a company undertakes R&D efforts. It is divided by the total available number of sub-fields (currently max. 15).
  - Second, "Research Depth" represents the ratio of a company's number of activities in sub-fields over the number of main research fields (currently max. 8).
  - In a final step, "Research Coverage" and "Research Depth" are multiplied to yield the final score of Research Diversity.

The table in figure 5 provides an overview of the classification.

[7] For a discussion on the role of patents in innovation of the electricity supply industry, see e.g., Jamasb, T., and M. G. Pollitt (2011). Electricity sector liberalization and innovation: An analysis of the UK's patenting activities. *Research Policy* 40(2).

Figure 5: Research areas covered in the Research Diversity indicator

	Research field		Research subfield
1	Thermal efficiency	1	Thermal process optimization
		2	Energy efficiency
2	Renewable energies	3	General renewable energies
		4	Wind power
		5	Ocean power
		6	Solar power
		7	Biofuel
3	Nuclear	8	Nuclear
4	Decentralized generation	9	Decentralized generation
5	Transmission and distribution	10	Smart grid
6	Mobility	11	E-Mobility
7	Energy Storage	12	Energy storage
8	Climate change and environment	13	Carbon sequestration/CCS
		14	Clean coal/IGCC
		15	Biodiversity, reduction of nuisances, etc.

Sustainability Subindex

The Sustainability Subindex accounts for 25 percent of the index. It measures a company's efforts with regard to curbing carbon dioxide emissions and ensuring long-term resource adequacy[8]. It consists of two indicators:

- **Climate performance** is represented by the company's specific carbon dioxide emissions, as reported within the entire sample's annual reports or sustainability reports. Its unit is electricity output in MWh per ton of CO_2.
- **"New" renewable energies**: The second component of the Sustainability Subindex is the total amount of renewable energy produced by each company's power plants in GWh, acknowledging a company's effort to foster the transition to climate-neutral and waste-free generation technologies. It includes all "new" renewable sources like wind, solar,

[8] For a discussion on measuring progress in sustainability, see e.g. European Environment Agency (2006). *Eco-innovation indicators*. Report by the EEA, Copenhagen.

biomass, and geothermal energy, but excludes large-scale hydropower production.

Each element of the subindex is given equal weight in the score.

Productivity Subindex

The Productivity Subindex reflects the efficiency in managerial organization and institutional performance a company is able to achieve as well as any productivity increases due to process efficiency[9]. Productivity not only raises a utility's financial indicators and increases profits, but contributes to its overall competitiveness vis-à-vis other European players and, ultimately, leads to affordable prices for final customers. It is measured by the key drivers of productivity in the electricity industry, namely:

- **Output productivity** (EBITDA/MWh), and
- **Employee productivity** (EBITDA/employee).

Both elements of the subindex have equal weights in the score.

Dynamics and aggregation

Each criterion is measured based on the current status in the year 2010; the state variables ("stocks") are granted an overall contribution to the index of 75 percent. To integrate past improvements in the overall index ("flows"), 25 percent are assigned to the annual changes from the first year of the computation (2007). More recent changes are given a greater weight than the more distant ones. Thus, within the 25 percent that accounts for the "flows" the latest change from 2009 to 2010 has a weight of 1/2, whereas the changes from 2008 to 2009 and 2007 to 2008 have weights of 1/3 and 1/6, respectively.

The indicators of each subindex are individually standardized in order to ensure comparability and remove the units. They are then aggregated to form a joint subindex. The highest-ranking company is assigned the maximum score of each subindex, i.e., 50 for the Research Subindex and 25 for each of the other two subindices, and the lowest-ranking company the score 0, while the relative values

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[9] On the discussion of process innovation, see e.g., European Commission/Eurostat (1992). *The measurement of scientific and technological activities - Oslo Manual*, Paris: OECD, 16; Lugones, G. (2009). *Training module for the recollection and analysis of innovation indicators, Working Paper 8,* Washington DC: Inter-American Development Bank, 23-25.

of the companies between the minimum and the maximum of the sample are allocated according to the absolute level with respect to the total distance between minimum and maximum. This approach is methodologically inspired by the benchmarking exercises in utilities regulation, where several company-specific indicators are assembled to statistically identify the utility with the best performance within the sample and locate each of the other utilities' relative position in relation to the leading firm.

In a final step, the three subindices are weighted according to the 50-25-25 rule, and added up to yield the final score of the company. If a company scored highest in all three categories, it would achieve an *ESMT Innovation Index* score of 100. Similarly, if a company performed worst in all three subindices, it would obtain a score of 0.

How European energy utilities innovate

In our sample, we have concentrated on 15 major European electricity incumbents. This section presents the companies, their respective positions in the three subindices, and the performance changes from 2009 to 2010.

The major European electricity utilities

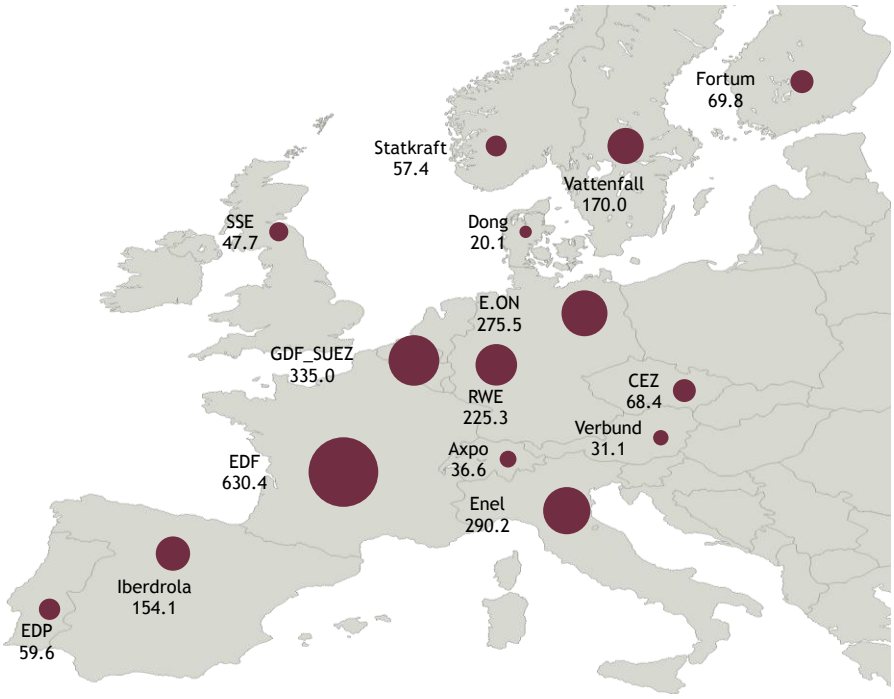
We applied the *ESMT Innovation Index* to European electricity incumbents, in total 15 companies from the following countries and/or regions:

- *Central Europe*: Verbund and CEZ
- *France and Belgium*: Electricité de France (EDF) and GDF-Suez
- *Germany*: E.ON and RWE
- *Italy*: Enel
- *Scandinavia*: Dong, Fortum, Statkraft and Vattenfall
- *Iberian Peninsula*: Iberdrola and Energias de Portugal (EDP)
- *Switzerland*: Axpo
- *United Kingdom*: Scottish and Southern Energy (SSE)

The selection of companies is motivated by the fact that they occupy an incumbent position in their domestic electricity market. Niche players are excluded. One major additional condition to enter the sample is that they are not mere subsidiaries of (another) multinational company, but have their own research and development strategy. As a matter of fact, most of the companies in the sample have become multinational players over the last 15 years by expanding abroad and integrating smaller rivals in neighboring countries, transition countries, or in the developing world.

The power generation portfolio of the sample's electricity companies consists of a widely varying mixture of technologies, with some companies almost exclusively relying on one primary energy source, especially hydropower and nuclear, while others markedly strive for a balanced and diverse set of different resources.

Figure 6: Companies covered in the *ESMT Innovation Index* and their respective annual electricity generation (in TWh)



Source: ESMT analysis (2011).

Note: Bubble size proportional to total annual power generation (TWh) which is shown below the company name. Location of companies is only meant to be indicative of the country they are headquartered in.

To provide full transparency and facilitate direct comparisons, figure 15 in appendix 4 shows the split of the total energy production between thermal, nuclear, and renewable as well as all other data used for the calculation of the index (CO_2 emissions, EBITDA, employees, R&D budget, number of patents, etc.).

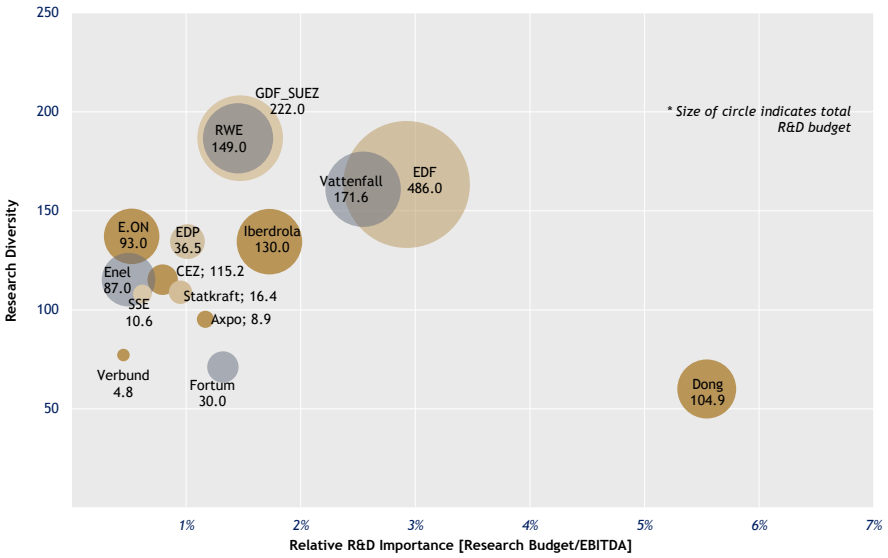
The *ESMT Innovation Index* is based on annual reports as well as sustainability reports of the 15 companies for the years 2007, 2008, 2009, and 2010.[10]

[10] Of the 15 companies, Axpo and SSE do not have a January to December reporting financial period. For example, the financial period of SSE ends on March 31. We have recorded the entries of its latest, i.e., 2010/11 annual report under 2010, since nine out of the 12 months are in 2010. Please see appendix 5 for further details.

Research Subindex

Between 2007 and 2010, the combined R&D budget of 15 major European energy suppliers increased by 40 percent to more than €1.5 billion; from 2009 to 2010 the utilities in the sample raised their aggregate spending on R&D by almost €130 million. However, the 15 companies analyzed in the *ESMT Innovation Index* show largely varying performances in the Research Subindex. The following figure depicts relative R&D importance on the horizontal axis, research diversity on the vertical axis, whereas the size of each observation's circle indicates the absolute R&D importance, that is, the total R&D budget.

Figure 7: Research diversity vs. relative R&D importance (2010)



Source: ESMT analysis (2011).

While the Danish company Dong clearly leads the criterion R&D importance with a R&D budget of 5.5 percent of EBITDA, EDF (€486 million), GDF-Suez (€222 million), Vattenfall (€172 million) and RWE (€149 million) lead by absolute R&D importance. Additionally, these latter companies show a broad research diversity, being active in nearly all research fields besides one or two, whereas Dong focuses on six of the 15 research fields, namely thermal process optimization, energy efficiency, wind power, biofuel, e-mobility and carbon sequestration already since 2007. A detailed analysis of the research activities of each utility is provided in appendix 4, figure 16.

In the ranking of the number of patents issued in 2010 (not represented in the figure), RWE clearly outperforms its competitors by 32 new registrations, while the

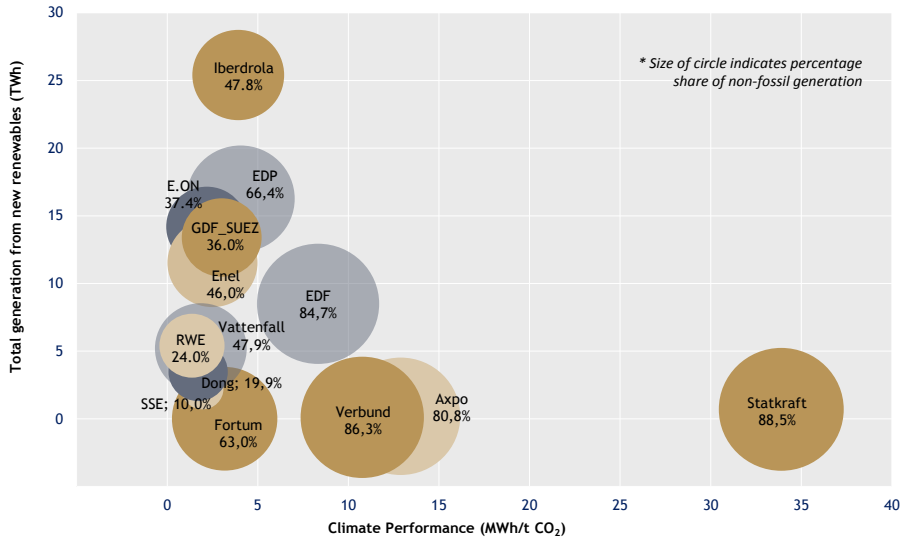
next best utility, GDF-Suez, only had six patents, and seven out of 15 companies did not register any patent at all in this year. Compared to the previous years, a sharp decline in new patent registrations can be observed: While in 2007 a total of 125 new patents were issued and numbers even rose until 2009, in 2010 only 54 patents could be counted. Observations in the following years may shed light on whether 2010 was just an outlier, whether it represents a trend among energy suppliers to outsource, or whether it is induced by a long-term strategy to hide ideas and intellectual property from competitors.

Sustainability Subindex

Strong path-dependence characterizes each individual company's performance with respect to the Sustainability Subindex.

In figure 8, climate performance (i.e., energy produced per ton of carbon dioxide) is depicted on the horizontal axis, while the total electricity generation from "new" renewable energy sources is shown on the vertical axis. As a benchmark (but not explicitly integrated in the subindex), the share of non-fossil generation is indicated by the size of the circles.

Figure 8: Climate performance vs. "new" renewable generation (2010)



Source: ESMT analysis (2011).

Due to its heavy reliance on hydropower, the highest electricity output per ton of CO_2 is achieved by Statkraft with 33.9 MWh/t CO_2. Axpo, due to nuclear power (12.9), Verbund because of hydropower (10.8) and EDF due to nuclear power (8.3)

follow Statkraft and are positioned around the benchmark of 10 MWh/t CO_2, which is not met by the other companies.

The lowest electricity output per ton CO_2 is with companies still relying on thermal power production: RWE (1.4), Dong (1.7), CEZ (1.8) and Vattenfall (1.9).

While many of the first impulses to build plants supplied by "new" renewable resources came from niche players, over the last four years the big European utilities took the lead and more than doubled their intake from new renewables generation, reaching an unprecedented 107 TWh in 2010. The largest input was achieved by Iberdrola (25 GWh), then – with considerable distance – EDP (16), E.ON (14), GDF-Suez (13) and Enel (12). The top rank of two smaller players of the sample indicates that size matters, but it is not an absolute prerequisite for the implementation of an environmentally beneficial generation portfolio.

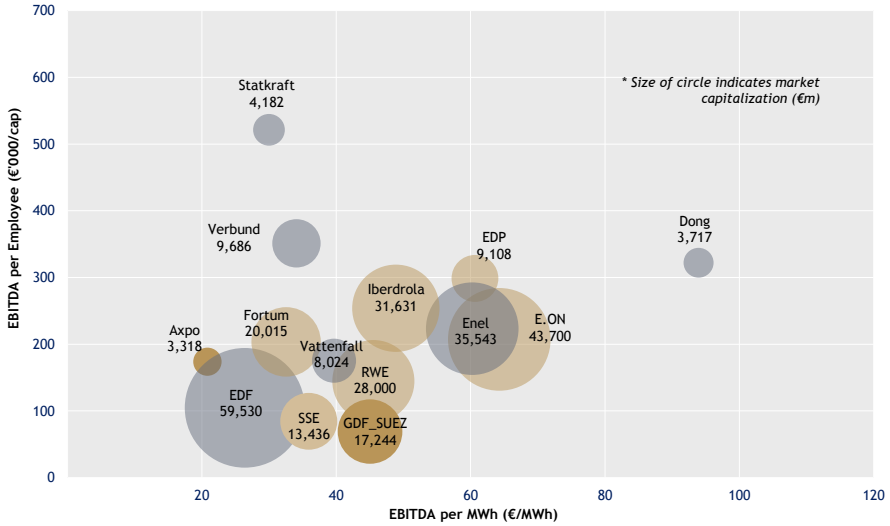
Productivity Subindex

The Productivity Subindex reflects the efficiency in managerial organization and institutional performance a company is able to achieve, as well as any productivity increases due to process efficiency and sound financial management. Productivity not only raises a utility's economic indicators and increases profits, but contributes to its overall competitiveness vis-à-vis other European players and, ultimately, leads to affordable prices for final customers.

Figure 9 below shows the individual company's performances in the Productivity Subindex. Output productivity, that is, earnings per generated electricity, is shown on the horizontal axis, and employee productivity, with earnings per employee as its proxy, is shown on the vertical axis. For easier comparison, the size of the circles depicts the total market capitalization of a company as of the end of 2010.[11]

[11] In the case of companies that are not publicly listed, market capitalization has been estimated based on book values of equity and price to book value ratios (Market Cap = BV of Equity x PBV); PBV ratios have been taken from Aswath Damodaran's EuroCompFirm database (www.damodaran.com).

Figure 9: Employee productivity vs. output productivity (2010)



Source: ESMT analysis (2011).

The company leading output productivity is Dong (94 EUR/MWh). E.ON (64), EDP and Enel (both 60) follow, while other companies stay below the €60/MWh benchmark.

With regard to employee productivity, only Statkraft beats the €400/employee benchmark (521).

Over the observed time span and across all companies in the sample, the utilities were able to increase both employee productivity and output productivity despite the financial turmoil and an increasing degree of competition in the European wholesale markets. In particular, the weighted average of the EBITDA per employee rose by 20 percent between 2007 and 2010, and has now reached €139 per employee.

Performance changes 2007–2010

Annual performance changes over the period 2007–2010 are given a weight of 25 percent for all criteria besides research diversity. The following figure 10 depicts the changes achieved by the companies under consideration.

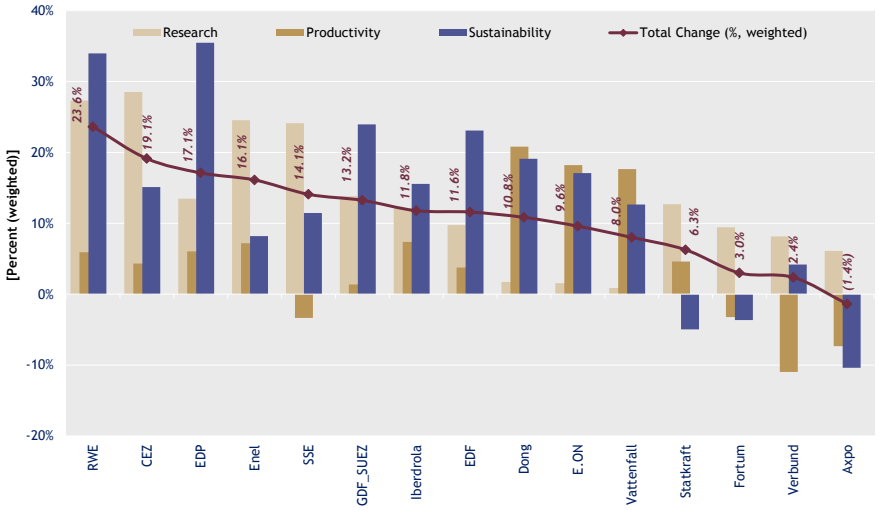
RWE (23.6%), CEZ (19.1%), EDP (17.1%) and Enel (16.1%) showed the most striking improvements by 15 percent or more, compared to 2009. Also, 10 of the 15 companies increased their performance in all subindices, indicating the tremendous

efforts for change the companies are undertaking. SSE, Statkraft, Fortum, Verbund and Axpo, however, showed drawbacks in at least one subindex.

The highest improvements in the Research Subindex are achieved by CEZ (28.5%), RWE (27.3%) and Enel (24.5%). In productivity, Dong (20.8%), E.ON (18.2%) and Vattenfall (17.6%) were able to record the highest changes. In sustainability, EDP (35.5%) and RWE (34.0%) improved most substantially.

Overall, the biggest change can be notified in the Sustainability Subindex with an average increase of 13.4 percent, followed by the Research Subindex with 12.9 percent and the Productivity Subindex with 4.8 percent. The strong performance in the Sustainability Subindex not only indicates the speed with which the transformation of the energy markets toward an environmentally sound system is proceeding, but suggests that regulatory instruments to foster the deployment of new renewable energies, as they are implemented in most EU member states, provide clear investment incentives also for bigger players on the market.

Figure 10: Performance changes (% over previous year – 2010/2009)



Source: ESMT analysis (2011).

The *ESMT Innovation Index* ranking 2010

For the interpretation of the results of the *ESMT Innovation Index*, we first comment on the individual companies' position in the overall ranking. Second, we explore how investment and the index are interrelated. Third, we introduce a matrix to cluster the role of energy incumbents in four categories: transformation leaders, research leaders, dissemination leaders, and hesitants.

Overall *ESMT Innovation Index* ranking

The top two companies of the *ESMT Innovation Index* in 2010 are RWE and EDF.

With a score of 70.6, RWE achieves the highest score of the index – mainly because of its leading position in the Research Subindex. With 14 out of 15 research fields covered, an increase of the research budget by €39 million to €149 million in 2010, a relative R&D importance of 1.5 percent of EBITDA and 32 patents issued, RWE outperforms its competitors. With the acquisition of Essent, RWE can count on 360 R&D employees. While the 32 patents also include regional or country-level rights for one invention, none of the other utilities seem to be as active in securing innovation efforts for the future. The companies following RWE with regard to patents in 2010 are Iberdrola (6), EDF (5) and E.ON (4). Though its sustainability and productivity scores lag behind its strong research performance, RWE was able to improve its sustainability score by 34 percent, triggered by improvements in both climate performance (1.26 to 1.37 MWh/t CO_2) and generation from new renewables (3.1 to 5.4 GWh). RWE's lowest performance was in the Productivity Subindex where an increase of EBITDA/employee (€130 to €145) was outweighed by a decrease of EBITDA/MWH (€49 to €46), thus only leading to an overall productivity improvement of 5.9 percent.

EDF comes second in the *ESMT Innovation Index* with a score of 57.7. High scores in the Research (38.4) and the Sustainability (17.4) Subindex trigger this position. In 2010, EDF raised its R&D budget from €438 million to €486 million, significantly more than its follower GDF-Suez (R&D budget €222 million after a €4 million increase). With more than 2,000 researchers supported by an R&D Advisory Board, EDF covers – as does RWE – 14 out of 15 research fields. The R&D budget is dedicated to environmental protection (20%) such as energy efficiency and renewable energies, local impacts of climate change or projects instigated by the operational divisions and Group subsidiaries (70%) and to medium- and long-term actions for the future (10%). EDF's R&D strategy promotes three priorities:

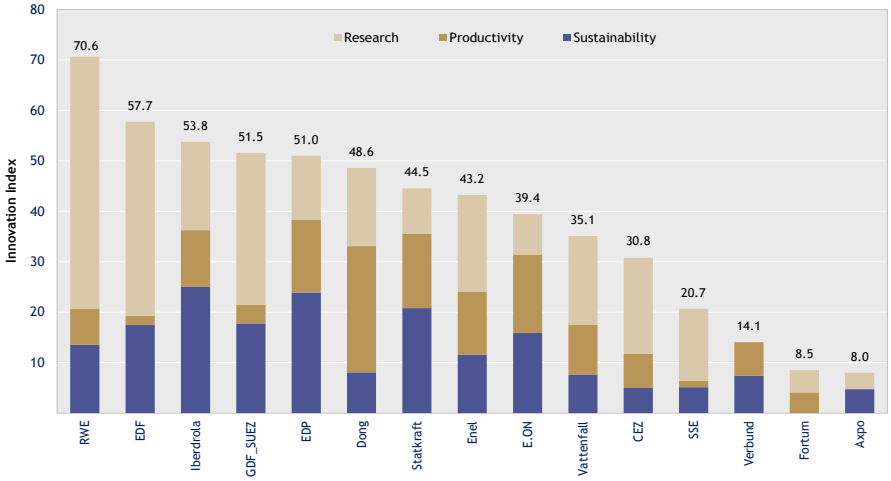
consolidating and developing a carbon-free energy mix; fostering flexible, low-carbon energy demand and adapting the electricity system in response to these issues. A new R&D center on the Paris-Saclay Campus shall be set up to benefit from stronger cooperation dynamics with the higher education and research establishments located nearby. To carry out its R&D, EDF has a total of 12 shared laboratories in France and sets up international partnerships with academic research partners and technical or industrial centers. Furthermore, two new R&D units were opened in Poland and the UK and further units abroad are envisaged. Yet, the number of new patents went down from 40 in 2009 to five in 2010. The utility's main drawback is its low performance in the Productivity Subindex, only SSE and Axpo perform worse. Public ownership, a comfortable domestic market share, and the role of a traditional state enterprise may exert less competitive pressures on the company than on the bulk of its peers.

A group of three further companies exceeds an *ESMT Innovation Index* score of 50. In the ranking, Iberdrola leads this cluster, driven by its results in the Sustainability Subindex, where the company improved significantly in both criteria: climate performance from 2.7 to 4.1 MWh/t CO_2 and generation of new renewables from 12.7 to 16.3 GWh. It is followed by GDF-Suez with the third-highest rank (after RWE and EDF) in the Research Subindex and EDP, which outperform all peers in the Sustainability Subindex.

Dong, Statkraft, Enel, E.ON, Vattenfall, and CEZ show moderate innovation activities with scores between 50 and 25.

The last cluster of companies, with scores below 25, does not excel according to our innovation criteria. It contains the utilities Verbund, SSE, Axpo and Fortum. An exception within this cluster is SSE with a comparatively high score in the Research Subindex. Figure 11 below summarizes the findings of the *ESMT Innovation Index 2010*.

Figure 11: Ranking and composition of *ESMT Innovation Index* (2010)



Source: ESMT analysis (2011).

It is important to note, though, that company strategies fundamentally differ across the sample. The index only captures one facet in a company's overall strategy. For instance, E.ON and EDF pursue a regional strategy. They aim to achieve and defend leading market positions in Europe and grow from there internationally. By contrast, EDP or Statkraft follow niche strategies, trying to achieve a leading renewable position on a more international scale. In all cases, it should be noted that the *ESMT Innovation Index* does not only measure organic efforts. It also reflects the option to improve the company position via mergers & acquisitions and integrates any result of M&A activities into its overall innovation performance. For example, if companies like Axpo and Fortum enlarge their domestically renewable-dominated generation portfolio by acquisitions of Italian gas power plants, as in the case of Axpo, or a predominantly fossil-based Russian utility, like Fortum, the scores of the individual subindices adapt accordingly.

To test whether variations of the weightages would alter the overall ranking of the index, we conducted a sensitivity analysis on the weightages allocated to the three subindices and to the timing of the data and found our results to be consistent and robust. Appendix 2 shows the details of the analysis.

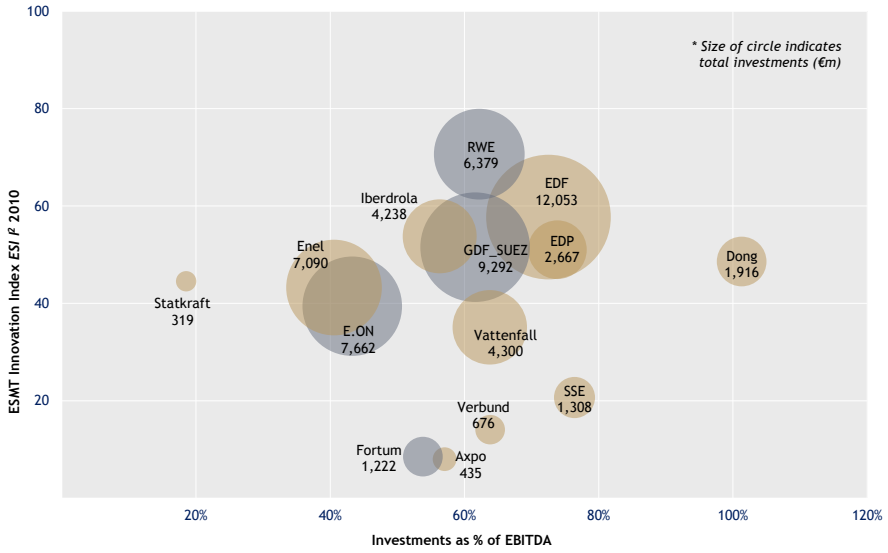
ESMT Innovation Index and investment activities

The *ESMT Innovation Index* reveals some further insights into a company's strategy when it is compared to a company's total investments. In this context, investments may be interpreted as the momentum that a company creates. Figure 12 plots the

scores of the index on the vertical axis against investment in intangible assets, property, plant and equipment as a percentage of earnings (EBITDA). The size of the circles indicates the total amount of the investments.

Considering total investments (in € billion), which could also be phrased "*absolute* momentum", EDF (12.1), GDF-Suez (9.3), E.ON (7.7) and Enel (7.1) lead the group of utilities under consideration. However, Dong with investments of 101.3 percent of its EBITDA clearly leads in some form of *relative* momentum, when the investments are expressed as the percentage of its absolute financial performance. The high result of GDF-Suez is a special case, because it most closely corresponds to a multi-utility and has important and diverse investment needs and strategies well beyond the electricity sector.

Figure 12: *ESMT Innovation Index* (2010) and investments



Source: ESMT analysis (2011).

Iberdrola and EDP pursue strategies to foster the expansion of renewable energy supply. Iberdrola, for example, already aimed in 2002 to double production capacity by new energy technologies until 2007, thereby creating a competitive advantage in sustainability. Indeed, over our sample horizon the utility was able to improve its climate performance from 2.98 MWh/t CO_2 in 2007 to 3.92 MWh/t CO_2 in 2010. As company officials state, it aims to further improve its position and cover its 20 percent capacity increase by 65 percent wind and hydro capacity and another 20 percent in CCGT, respectively. EDF, Enel and E.ON push their transformation with subsidiaries, EDF with EDF Energies Nouvelles, Enel with Enel

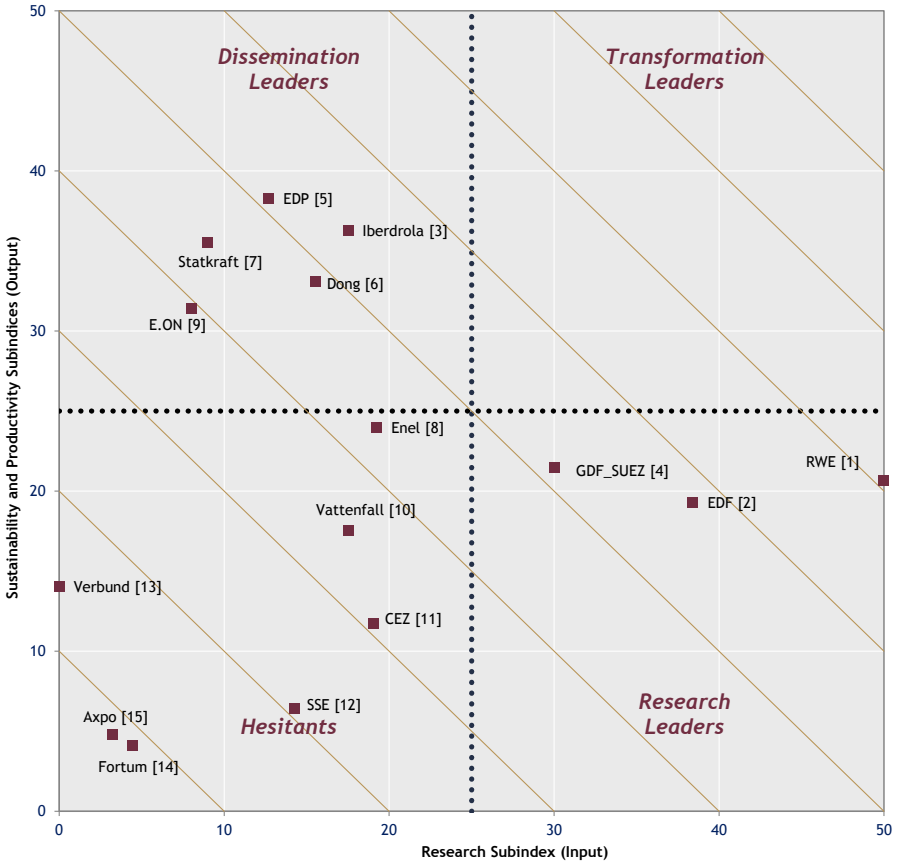
Green Power and E.ON with E.ON Climate & Renewables, where all activities in this regard are bundled.

Transformation, research, dissemination leaders, and hesitants

The *ESMT Innovation Index* can also be used to identify diverging transformation strategies within the European energy industry: When utilities – in their core function as service providers and infrastructure managers – score high in the Productivity and Sustainability Subindices, they exploit innovative processes and technologies developed by component suppliers that focus on machinery, electronics and information technology, and efficiently use and implement their innovations in the energy value chain without dedicating too many in-house resources to proper research. By contrast, if companies yield high values in the Research Subindex, they pursue a strategy that aims to achieve future competitiveness by strengthening leading-edge know-how within their organization.

The following figure sketches these diverging strategies by plotting the individual company scores of the Research Subindex on the horizontal axis and the sum of the Productivity and Sustainability Subindices on the vertical axis. The diagonal lines indicate the relative position of each company on the path from “Hesitants” in the bottom left corner to “Transformation Leaders” in the top right corner.

Figure 13: Company clusters based on *ESMT Innovation Index* (2010)



Source: ESMT analysis (2011).

Note: Numbers in [brackets] denote overall rank in current year.

According to the scatter plot, we are able to distinguish four transformation clusters:

Transformation leaders (high scores in research and high scores in productivity and sustainability): These companies lead the energy transformation not only via past results but also based on R&D investments. Unfortunately, in the 2010 index no company is positioned in this group.

Research leaders (high scores in research and low scores in productivity and sustainability): These companies do not score high on sustainability and productivity – partially due to their generation mix, or caused by recent acquisitions. However, they aim to shape the energy transformation, which is

reflected in the high score in the Research Subindex. The leaders in this group are RWE, EDF and GDF-Suez.

Dissemination leaders (low scores in research and high scores in productivity and sustainability): These companies focus on the dissemination of product and process innovations, thus achieving high scores in productivity and sustainability. The leaders in this group are EDP and Iberdrola. They undertake first attempts to establish their transformation position

Hesitants (low scores in research and low scores in productivity and sustainability): The companies in this quadrant show low scores in research as well as productivity and sustainability.

While some companies appear to be at the start of their efforts, still benefiting from their current positions, others try to rapidly adjust to move into the direction of transformation leaders. Enel, Iberdrola and Dong can be found among these latter companies.

Outlook

Electricity markets have entered a second phase of transformation: After one decade of European liberalization, the centralized generation is challenged by new technologies such as wind or solar power as well as small-scale combined heat and power units for local, autonomous supply. Moreover, markets for energy efficiency and e-mobility are added to a new decentralized generation market.[12] To cope with a range of new players, predominantly stemming from manufacturing, ICT, and transport sectors, incumbent energy utilities have to find innovative solutions, strengthen their positions in strategic fields, and accelerate their transformation speed. Meanwhile, they are confronted with (or actively take part in) increasing consolidation in the field of centralized energy production.[13]

It is therefore no surprise that the overall trend in the *ESMT Innovation Index* is positive – incumbents have realized that if they do not invest in future product and process innovations, new entrants may take their place, or they may be the next ones to be integrated into a larger company.

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[12] Burger, C., M. Holtermann, and G. Kalny (2008). *On the verge of a paradigm shift in the energy sector? From centralized to decentralized energy generation*. ESMT Business Brief No. BB-108-004.

[13] Burger, C. (2008). *Consolidation index: Critical success factors for industry consolidation*. ESMT Business Brief No. BB-108-001.

As a measurement tool for the role of utility incumbents within the energy transformation, the *ESMT Innovation Index* shall be updated on an annual basis to keep track of these transformations. It is primarily designed as an industry-specific tool to provide insights into the dynamics of innovation. However, it will also serve as a key variable in future investigations on the performance and dynamics of organizational change in the electricity supply industry, in particular, how long it takes for R&D efforts to get translated into actual performance improvements and the industry-specific lag effects associated to it.

Appendix 1 Technical notes

The *ESMT Innovation Index* is intended to provide a basis for comparison and discussion while assuring maximum transparency by revealing each step of its construction process.

Apart from research diversity, all indicators of three subindices are based on continuous and verifiable numbers, either in units like Euros per GWh, or in percentages. Research diversity, however, follows a dummy variable approach, because its base units only allow for the values zero and one.

As described above, the proxy for research diversity consists of two factors: First, "Research Coverage" measures the number of sub-fields in which a company undertakes R&D efforts. It is divided by the total available number of sub-fields (currently 15). Second, "Research Depth" represents the ratio of a company's number of activities in sub-fields over the number of main research fields (currently 8). In a final step, "Research Coverage" and "Research Depth" are multiplied to yield the final score of the Research Diversity Index.

For example, company X has four R&D projects related to renewable energies, say wind, ocean power, solar energy, and biofuels. In addition, two of its research activities are related to the field of thermal efficiency, for example, thermal process optimization and improvements in energy efficiency. Company X also pursues two further projects, of which one focuses on intelligent grid design and the other on e-mobility. Then its "Research Coverage" would correspond to eight projects in the research sub-fields divided by the total of 15 possible sub-fields equaling 0.53. The company's "Research Depth" would amount to eight projects in the research sub-fields divided by the total of five main research areas covered, equaling 1.60. The overall score of the Research Diversity Index of company X would then correspond to 0.53 * 1.60 = 0.85.

For the construction of the final index, all indicators are standardized. This additional step is necessary because the indicators are measured in differing units. The standardization yields the result that the mean of each indicator across the whole sample is zero, while the distance from the mean, that is, the spread of the observations, is measured in unit-free standard deviations. Under the assumption of normality, around 95 percent of the observations would then be found within plus or minus two standard deviations from the mean.

The next step consists of adding the standardized indicators within each subindex. For example, if company X has a standardized value of 1.0 in the indicator measuring the total share of non-fossil generation, and a standardized value of 1.5

in the indicator measuring the electricity output per carbon dioxide emissions, it implies that company X is 1 and 1.5 standard deviations above the sample average, respectively. The overall score of the Sustainability Subindex would then amount to 1.0 + 1.5 = 2.5 for company X.

In a third step, the results of each subindex are calibrated. Similar to benchmarking practices, the highest-ranking company is assigned the score one and the lowest-ranking company the score zero, while the relative values of the companies between the minimum and the maximum of the sample are allocated according to the absolute level with respect to the total distance between minimum and maximum. For example, if company X has an overall score of 1.0 in the Productivity Subindex, while the lowest-ranking company in the sample reaches only -1.0 and the highest-ranking company gets a value of 2.0, company X would yield an overall score of (|-1.0| + 1.0)/(|-1.0| + 2.0) = 0.67 for the Productivity Subindex, for it is twice as distant from the minimum than from the maximum.

The next step only puts the pre-determined weight according to the 50-25-25 rule to the three subindices. They are then added to produce the final score of the company. If a company scored highest in all three categories, it would hence achieve an *ESMT Innovation Index* score of one. Similarly, if a company performed worst in all three categories, it would end up with a score of zero.

Finally, to facilitate the intuitive understanding of the values of the index, the above scores between zero and one are multiplied by 100. The index values are thus ultimately presented, as throughout this report, on a scale of zero to 100.

Appendix 2
Sensitivity analysis of results

The three subindices of the *ESMT Innovation Index* have been allocated weightages as follows: Research Subindex 50 percent, Productivity Subindex 25 percent and Sustainability Subindex 25 percent. The rationale behind this allocation is that criteria determining future progress – captured in the Research Subindex – obtain the same weight as criteria representing the results of past efforts, which are reflected in the Productivity and Sustainability Subindices.

One could argue that in practice, these "past" and "future" related activities are interdependent and that it is not realistic to make such a clear segregation. For example, the successes or failures in past activities pertaining to the Productivity and/or Sustainability Subindex can have an impact on the level and content of future activities pertaining to the Research Subindex.

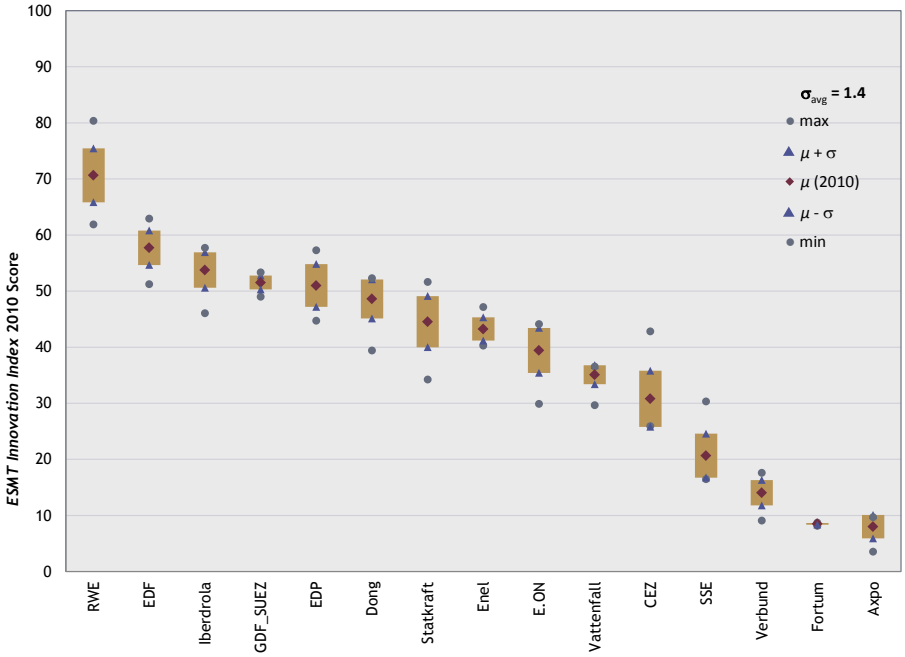
Likewise, the allocation of 75 percent weightage to the input data of the most recent year and of the balance, 25 percent to the changes from the inception year of the *ESMT Innovation Index* up to the second most recent year is based upon the authors' best estimate for such weightages under the given circumstances. Consequently, there may be suggestions to apply a different allocation of weightages, say 60 percent and 40 percent respectively.

To test the overall robustness of the index and the effects of such variations on the value of the index, the weightage allocated to the Research Subindex (currently 50%) was varied between 40 percent and 60 percent. The balance weightage was split equally (30%/30% and 20%/20% respectively) between the Productivity and Sustainability Subindices.

Simultaneously, the weightage allocated to the data parameters from the most recent year (currently 75%) was varied between 60 percent and 80 percent. The changes over the preceding period, that is, from inception of the *ESMT Innovation Index* to the second most recent year, correspondingly received weightages varying between 40 percent and 20 percent.

The results of this two-way sensitivity analysis are shown in figure 14 below. The standard deviation of the output was 3.9. For each company in the sample, the figure shows the current index value, the bandwidth of the current value plus/minus one standard deviation, as well as the maximum and minimum values according to this sensitivity.

Figure 14: Sensitivity of the *ESMT Innovation Index* (2010) values to simultaneously changing weightages of Research Subindex and stock/flow variables



The results indicate that changing the weightage scheme does not alter the ranking among the leading companies, and has little impact on the remainder of the sample.

Appendix 3
Alternative innovation indices

The *ESMT Innovation Index* focuses on the role of energy incumbents with regard to the energy transformation lying ahead. It therefore differs from current innovation indices that cover countries, regions, industries or companies. As an overview of current innovation indices, examples of the above four classes are described below.

- **Country level:**
  - The Global Innovation Index (GII) was conceived at INSEAD as a formal model to help to illuminate the degree to which individual nations and regions are currently responding to the challenge of innovation. The framework upon which the GII model rests relies upon eight pillars made up of five inputs (institutions and policies, human capacity, infrastructure, technological sophistication, business markets and capital) representing aspects that enhance the capacity of a nation to generate ideas and leverage them for innovative products and services, and three outputs (knowledge, competitiveness, and wealth) that underpin the factors that enhance innovative capacity and demonstrate results from successful innovation. The model uses a combination of objective data drawn from various public and private sources such as the World Bank, International Telecommunications Union (e.g., university enrollment rates, GDP growth rates, penetration level of new technologies) and subjective data drawn from the World Economic Forum's annual Executive Opinion Survey. The average scores for Input and Output pillars together give an overall score – the Global Innovation Index.[14]
  - Another example is INNO-Metrics, an initiative by the European Union. INNO-Metrics is composed of two instruments, the European Innovation Scoreboard (EIS) and the Innobarometer.[15] The EIS attempts to benchmark, annually, the innovation performance of member states, drawing on statistics from various sources, primarily the Community Innovation Survey. The Innobarometer complements the EIS results by analyzing specific aspects of innovation through a survey of 3,500 randomly selected companies in the EU.

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[14] http://www.globalinnovationindex.org/gii/ (accessed September 29, 2011).

[15] http://www.proinno-europe.eu/page/innobarometer (accessed September 29, 2011).

- **Regional level**
  The innovation index of the regional census bureau of the state Baden-Württemberg covers R&D efforts, employment in high-tech industries, in knowledge-focused service industries, in technical industries and research as well as patents.[16] It compares countries and regions within the European Union and has so far been conducted in 2006, 2008 and 2010.
- **Industry level**
  The IBM – Melbourne Institute's 'Innovation Index of Australian Industry' covers R&D, patent, trademark and design intensity as well as organizational/managerial innovation and productivity. It is based on a multi-indicator methodology to measure innovation effort across 13 industries. The data stems from the Melbourne Institute of Applied Economic and Social Research through its annual enterprise level 'Management and Innovation Survey' which has been conducted since 2001. The index has been calculated twice so far (2007, 2008).[17]
- **Company level**
  - The 'Innovation Index Report' by the Innovation Index Group is a compilation of the top 20 innovators in North America. Most of these are prestigious companies including GE, 3M, HP, IBM, and Proctor & Gamble. The IIR, released quarterly, incorporates three objectives. First to report, analyze, and project the stock performance of these innovators in North America every week, and compare their performance to S&P, NASDAQ and Dow Jones. Second, to compare and contrast best practices, successes, new products, strategies, leadership, and insights on Creativity and Innovation at these companies. Third, to showcase disruptors challenging the innovators, their disruptive innovation strategy, their current and potential impact on the Innovators' customer base and market share.[18]
  - More broadly, UK-based NESTA (National Endowment for Science, Technology and the Arts) has launched an innovation index project. Its website covers innovation index working papers and useful links.[19]

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16 http://www.statistik.baden-wuerttemberg.de/Veroeffentl/Monatshefte/PDF/Beitrag10_12_01.pdf, (accessed September 29, 2011).

17 http://melbourneinstitute.com/miaesr/publications/reports/innovation.html, (accessed September 29, 2011).

18 http://creativityandinnovation.blogspot.com/2010/02/innovation-index-strikes-back-in-2009.html, (accessed September 29, 2011).

19 http://www.nesta.org.uk/areas_of_work/economic_growth/the_innovation_index, (accessed September 29, 2011).

Appendix 4 Input data

Figure 15: Summary of key input parameters of *ESMT Innovation Index*, 2007-2010, by company

		Axpo	CEZ	Dong	E.ON	EDF	EDP	Enel	Fortum	GDF_SUEZ	Iberdrola	RWE	SSE	Statkraft	Vattenfall	Verbund
Electricity Production																
Total (TWh)	2007	33.08	73.79	20.53	239.80	610.60	48.59	150.79	52.20	239.60	124.42	216.10	47.93	44.90	180.00	28.31
	2008	37.20	67.60	18.54	317.60	610.60	48.91	253.20	64.20	276.00	141.27	224.10	39.70	53.40	173.00	28.66
	2009	38.31	65.34	18.07	300.90	618.50	54.78	267.80	65.30	295.60	142.78	187.20	47.06	56.90	164.00	29.92
	2010	36.60	68.43	20.14	275.50	630.40	59.57	290.18	69.80	335.00	154.07	225.30	47.68	57.40	170.00	31.08
Thermal (TWh)	2007	1.26	45.95	17.30	134.00	119.10	28.51	92.24	6.20	150.90	73.01	178.50	43.50	1.50	95.09	3.99
	2008	5.54	39.50	15.96	209.62	114.18	26.81	146.30	16.60	171.74	87.93	169.00	34.10	5.40	90.23	3.35
	2009	6.88	35.54	15.26	199.90	95.80	26.34	149.30	21.80	189.18	86.49	146.80	42.00	6.10	86.25	2.71
	2010	7.04	37.33	16.14	172.40	96.50	20.00	156.70	25.80	214.40	80.44	171.20	42.90	6.60	88.61	4.26
Nuclear (TWh)	2007	23.24	26.17	-	77.60	440.30	-	15.53	26.00	40.78	22.22	32.40	-	-	50.66	-
	2008	22.79	26.55	-	76.22	439.02	-	32.90	24.70	46.30	24.74	49.80	-	-	45.06	-
	2009	22.28	27.21	-	71.80	466.10	-	31.84	21.40	56.41	22.83	33.90	-	-	42.32	-
	2010	21.38	28.00	-	72.00	475.60	-	41.15	22.00	50.25	26.11	45.20	-	-	44.19	-
Hydropower (TWh)	2007	8.42	1.22	0.60	21.70	48.70	14.99	35.49	20.00	43.13	15.88	3.70	3.52	42.70	31.00	24.32
	2008	8.69	1.13	0.59	22.23	53.12	12.89	64.30	22.90	49.68	11.60	3.40	3.32	47.40	34.00	25.31
	2009	8.91	2.11	0.53	18.50	49.90	15.78	76.10	22.10	41.96	11.97	3.40	3.02	50.10	32.00	27.10
	2010	7.99	2.33	0.54	16.90	49.80	23.31	80.80	22.00	56.95	22.12	3.50	2.56	50.10	32.00	26.71
New Renewables (TWh)	2007	0.16	0.45	1.96	6.50	2.50	5.10	7.52	-	4.79	13.31	1.50	0.91	0.70	3.25	-
	2008	0.19	0.42	1.99	9.53	4.27	9.20	9.70	-	8.28	17.00	1.90	2.28	0.60	3.71	-
	2009	0.24	0.50	2.28	10.70	6.70	12.66	10.56	-	8.05	21.49	3.10	2.04	0.70	3.43	0.11
	2010	0.18	0.78	3.46	14.20	8.50	16.26	11.53	-	13.40	25.41	5.40	2.22	0.70	5.20	0.11
CO_2 Emissions (mt CO_2)																
	2007	0.51	38.83	13.80	121.00	57.95	23.42	59.80	10.40	89.91	41.70	187.10	22.70	0.29	94.90	3.41
	2008	2.25	33.77	12.60	155.00	91.60	19.78	110.60	17.60	99.57	40.80	172.10	19.30	1.60	91.40	2.89
	2009	2.80	37.18	11.90	160.00	72.50	20.01	122.20	22.00	98.23	39.90	149.10	23.10	1.60	89.70	2.09
	2010	2.84	38.85	11.80	126.00	75.70	14.70	116.20	22.00	111.41	39.30	164.90	24.50	1.69	91.50	2.89
EBITDA (€m)																
	2007	954.7	2,712.0	1,281.8	13,649.0	16,549.0	2,628.3	9,800.0	2,298.0	12,539.0	5,279.5	7,915.0	1,774.4	1,200.6	4,188.0	1,099.1
	2008	836.8	3,556.9	1,683.3	11,836.0	14,240.0	3,154.9	14,318.0	2,478.0	13,886.0	6,412.5	8,773.0	1,730.2	1,692.9	4,201.0	1,321.8
	2009	713.4	3,442.6	1,187.0	17,767.0	15,929.0	3,362.9	16,371.0	2,292.0	14,012.0	6,815.0	9,165.0	1,658.3	1,440.6	5,752.0	1,251.5
	2010	762.2	3,523.5	1,892.0	17,704.0	16,623.0	3,612.8	17,480.0	2,271.0	15,086.0	7,528.0	10,256.0	1,711.7	1,720.9	6,744.0	1,059.2
Employees																
	2007	3,369	30,094	5,042	88,102	158,640	13,097	73,500	8,304	196,560	23,199	63,054	16,892	2,287	32,396	2,441
	2008	3,698	27,232	5,644	93,868	160,913	12,245	75,981	14,077	234,653	32,993	65,254	18,795	2,633	32,801	2,541
	2009	4,092	32,985	5,865	88,557	169,139	12,096	81,208	13,278	242,714	32,424	70,726	20,177	3,378	36,593	2,820
	2010	4,386	32,627	5,874	85,406	158,764	12,096	78,313	11,156	218,350	29,641	70,856	20,249	3,301	38,459	3,015
Total Investments (€m)																
	2007	401	1,104	1,397	6,623	7,261	2,700	4,929	655	2,999	4,967	4,065	1,045	248	1,679	238
	2008	350	1,855	1,286	8,806	9,489	3,618	6,502	1,108	8,997	7,333	4,454	1,519	241	2,711	393
	2009	337	2,140	2,103	7,522	11,576	3,235	6,825	862	9,310	4,645	5,913	1,126	412	4,967	440
	2010	435	2,441	1,916	7,662	12,053	2,667	7,090	1,222	9,292	4,238	6,379	1,308	319	4,300	676
R&D Budget (€m)																
	2007	7.05	20.83	64.24	83.00	401.00	13.31	29.00	21.00	203.00	65.00	74.00	5.41	12.23	119.16	9.00
	2008	6.54	11.40	154.65	106.00	449.00	23.69	68.00	27.00	127.00	73.10	105.00	5.54	19.14	155.76	4.60
	2009	6.80	20.60	140.18	105.00	438.00	31.04	86.00	30.00	218.00	90.53	110.00	4.18	19.81	146.86	4.30
	2010	8.91	28.04	104.88	93.00	486.00	36.53	87.00	30.00	222.00	130.00	149.00	10.59	16.37	171.63	4.80
No. of Patents																
	2007	-	-	3	23	31	-	7	1	19	3	32	-	-	6	-
	2008	1	-	1	15	45	-	4	-	7	3	44	-	3	7	-
	2009	-	1	-	12	40	-	12	2	22	6	47	-	1	6	-
	2010	-	-	2	4	5	-	3	1	6	-	32	-	1	-	-

Figure 16: Summary of R&D activity areas, 2007-2010, by company (1/2)

		Thermal Process Optimization	Energy Efficiency	General Renewable Energies	Wind Power	Ocean Power	Solar Energy	Biofuel	Nuclear	Decentralized Generation	Smart Grid	E-Mobility	Energy Storage	Carbon Sequestration / CCS	Clean Coal / IGCC	Biodiversity, reduction of nuisances, etc.	Sum
1 **Axpo**																	
	2007	1	-	1	1	-	1	1	-	-	-	-	-	1	-	-	6
	2008	1	-	1	1	-	1	1	-	-	-	-	-	1	-	-	6
	2009	1	-	1	1	-	1	1	-	-	-	1	-	1	-	-	7
	2010	1	-	1	1	-	1	1	1	1	1	1	-	1	-	-	10
2 **CEZ**																	
	2007	1	-	1	-	-	-	-	1	-	1	1	-	-	-	-	5
	2008	1	-	1	-	-	-	-	1	-	1	1	-	-	-	-	5
	2009	1	-	1	-	-	-	-	1	-	1	1	-	-	1	1	7
	2010	1	-	1	-	-	1	1	1	-	1	1	1	1	1	1	11
3 **Dong**																	
	2007	1	1	-	1	-	-	1	-	-	-	1	-	1	-	-	6
	2008	1	1	-	1	-	-	1	-	-	-	1	-	1	-	-	6
	2009	1	1	-	1	-	-	1	-	-	-	1	-	1	-	-	6
	2010	1	1	-	1	-	-	1	-	-	-	1	-	1	-	-	6
4 **E.ON**																	
	2007	-	1	-	1	1	-	1	1	1	-	-	-	1	1	-	8
	2008	-	1	-	1	1	-	1	1	1	-	-	-	1	1	-	8
	2009	-	1	-	1	1	1	1	1	1	1	1	-	1	1	-	11
	2010	1	1	-	1	1	1	1	1	1	1	1	-	1	1	-	12
5 **EDF**																	
	2007	-	1	1	-	-	-	-	1	-	-	-	1	-	1	1	6
	2008	-	1	1	-	-	-	-	1	-	-	-	1	-	1	1	6
	2009	1	1	1	-	1	1	-	1	1	1	1	1	-	1	1	12
	2010	1	1	1	-	1	1	1	1	1	1	1	1	1	1	1	14
6 **EDP**																	
	2007	1	1	1	-	1	1	-	-	1	1	-	-	-	-	-	7
	2008	1	1	1	-	1	1	-	-	1	1	-	-	-	-	-	7
	2009	1	1	1	1	1	1	-	-	1	1	1	-	1	1	-	11
	2010	1	1	1	1	1	1	-	-	1	1	1	-	1	1	-	11
7 **Enel**																	
	2007	1	1	1	-	-	-	-	-	-	-	-	-	1	-	-	4
	2008	1	1	1	-	-	-	-	-	-	-	-	-	1	-	-	4
	2009	1	1	1	1	-	1	1	-	-	1	1	-	1	-	-	9
	2010	1	1	1	1	-	1	1	-	1	1	1	1	1	-	-	11
8 **Fortum**																	
	2007	-	-	-	-	1	-	1	1	-	-	1	-	1	-	-	5
	2008	-	-	-	-	1	-	1	1	-	-	1	-	1	-	-	5
	2009	-	-	-	-	1	-	1	1	-	1	1	-	1	-	-	6
	2010	-	-	1	-	1	-	1	1	1	1	1	-	1	-	-	8

Summary of R&D activity areas, 2007-2010, by company (2/2)

		Thermal Process Optimization	Energy Efficiency	General Renewable Energies	Wind Power	Ocean Power	Solar Energy	Biofuel	Nuclear	Decentralized Generation	Smart Grid	E-Mobility	Energy Storage	Carbon Sequestration / CCS	Clean Coal / IGCC	Biodiversity, reduction of nuisances, etc.	Sum
9 **GDF_SUEZ**																	
	2007	1	1	1	-	-	-	1	1	-	1	1	1	1	-	-	9
	2008	1	1	1	-	-	-	1	1	-	1	1	1	1	-	-	9
	2009	1	1	1	1	1	1	1	1	-	1	1	1	1	1	1	14
	2010	1	1	1	1	1	1	1	1	-	1	1	1	1	1	1	14
10 **Iberdrola**																	
	2007	-	1	1	-	1	1	1	-	-	1	1	-	1	-	-	8
	2008	-	1	1	-	1	1	1	-	-	1	1	-	1	-	-	8
	2009	-	1	1	1	1	1	1	-	-	1	1	1	1	-	-	10
	2010	-	1	1	1	1	1	1	-	-	1	1	1	1	1	-	11
11 **RWE**																	
	2007	1	-	-	-	-	-	-	-	-	1	1	-	1	1	-	5
	2008	1	-	-	-	-	-	-	-	-	1	1	-	1	1	-	5
	2009	1	1	-	1	-	1	-	-	-	1	1	1	1	1	-	9
	2010	1	1	1	1	1	1	1	-	1	1	1	1	1	1	1	14
12 **SSE**																	
	2007	1	1	1	-	-	-	-	-	-	1	-	-	1	1	-	6
	2008	1	1	1	-	-	-	-	-	-	1	-	-	1	1	-	6
	2009	1	1	1	1	-	-	-	-	-	1	-	1	1	1	-	8
	2010	1	1	1	1	-	-	-	-	-	1	-	1	1	1	1	9
13 **Statkraft**																	
	2007	-	1	1	-	1	1	-	-	-	-	-	-	-	-	-	4
	2008	-	1	1	-	1	1	-	-	-	-	-	-	-	-	-	4
	2009	-	1	1	-	1	1	-	-	-	-	-	-	-	-	1	5
	2010	-	1	1	1	1	1	1	-	-	-	-	-	-	-	1	7
14 **Vattenfall**																	
	2007	1	1	1	1	1	1	1	-	-	1	-	-	1	-	1	10
	2008	1	1	1	1	1	1	1	-	-	1	-	-	1	-	1	10
	2009	1	1	1	1	1	1	1	1	1	1	1	-	1	-	1	13
	2010	1	1	1	1	1	1	1	1	1	1	1	-	1	-	1	13
15 **Verbund**																	
	2007	-	1	1	-	-	1	-	-	-	-	-	-	-	-	1	4
	2008	-	1	1	-	-	1	-	-	-	-	-	-	-	-	1	4
	2009	-	1	1	-	-	1	-	-	1	1	1	1	-	-	1	8
	2010	1	1	1	-	-	1	-	-	1	1	1	1	-	-	1	9

Appendix 5 Key assumptions

1. **Information sources**: Input data of the companies is primarily based on the information provided in the respective published documents like the annual report and Sustainability Report. Other sources used (e.g., for Patents) are mentioned below.
2. **Patents**: Information on the number of patents has been gathered from the information databases of sources like the German Patent and Trade Mark Office (DPMA) and the European Patent Office (EPO).
3. **Superiority of updated information**: For any given parameter, the information has been treated as superior if it was available in a more recent or updated publication than in the original one. Companies in our sample have made retrospective adjustments to figures previously published in their own annual reports, so wherever available and possible, we have used the latest published figures for any given parameter. For example, if a company, in its 2010 Annual Report, has reported (retrospectively) adjusted figures for, say, its own EBITDA in the previous year 2009, then the EBITDA figures reported in the 2010 Annual Report have been used in our calculations, as we have treated these figures as superior to the EBITDA figures reported originally in the 2009 Annual report.
4. **Superiority of non-adjusted figures over proforma ones**: To the extent possible, for any given input parameter, we have used figures that are better comparable across all companies than *proforma* figures which a company may have reported after making certain adjustments. For example:
   (i) E.ON (Adjusted) EBITDA: Instead of EBITDA, E.ON has reported *Adjusted* EBITDA, that is, EBITDA after making adjustments for one-time and extraordinary items. To make the comparison like for like with other companies, we have used figures for a comparable entry in E.ON's Income Statements: Income/Loss from continuing operations before financial results and Income taxes.
   (ii) RWE R&D expenses: The R&D figures that we have used for RWE only include the R&D expenses for that year. They *exclude* capitalized development costs (which are approximately as high as the R&D costs) and are disclosed alongside the R&D expenses.
5. **Reporting period**: The reporting period is considered on a "last 12 months" (LTM) basis rather than on the calendar year basis (January through December). For example, Axpo's financial year ends on

September 30 each year. The latest annual report is for the period October 1, 2009, through September 30, 2010. Since the majority (nine of 12 months) of this period falls in 2010, the figures from this Annual Report have been captured under the year 2010 in our calculations. No interpolations or extrapolations for fractional parts of years have been made.

6. **Currency conversions**: Monetary amounts have been converted from local currency and have ultimately been expressed in Euro (€ or EUR). Conversions for (flow) variables like EBITDA are based on the average exchange rate for the respective 12-month reporting period under consideration. Conversions for (stock) variables like Market Capitalization are based on the spot exchange rate on the last day of the reporting period. Historical exchange rates have been taken from the currency converter of the "O and A" website: http://www.oanda.com/currency/historical-rates/.

7. **Electricity generation**: Companies report their electricity output, that is, total electricity produced/generated in MWh/GWh/TWh etc., as *full* data or *share* data – at times providing both figures. Full data refers to the total production from 100 percent of the capacities of the assets controlled by the company, irrespective of what the actual holding may be. Share data refers to the production after taking account of the actual holding. We have used those figures

   (i) which the companies consistently reported in their publications, and

   (ii) for which we could obtain the requisite breakup data, say for generation according to fuel type. For example, GDF-Suez reported full and share data in 2008 and 2010. We have used full data, based on the reasoning just mentioned.

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ESMT European School of Management and Technology was founded in October 2002 by 25 leading global companies and institutions. The international business school offers Full-time MBA and Executive MBA programs, as well as executive education in the form of open enrollment and customized programs. The business school works closely together with E.CA Economics, which provides research-oriented consulting services in the areas of competition and regulation. ESMT is a state-accredited private business school based in Berlin, Germany, with an additional location in Schloss Gracht near Cologne.

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