

# Climate Change and Electricity

The European Carbon Factor

Comparison of CO<sub>2</sub> emissions of Europe's leading electricity utilities



Novembre 2010

## Report drawn up by PwC

*Les Cahiers du développement durable Collection*

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Thanks to its specialised editorial team and international network of correspondents, Enerpresse can provide a daily selection of the latest news from the French, European and international energy sectors. Enerpresse also publishes in-depth reports for all French-speaking members of the energy community on the challenges, industry players, markets and technologies that make it one of the most dynamic sectors in today's economy.

# The European Carbon Factor continued to decrease in 2009

## A reason to be optimistic

The year 2009 was the year of the demand crisis. The electricity utilities sector was not spared. As a result of the economic crisis, which has had a major impact on the industry, the electricity production of 18 companies fell nearly 6%, down 126 TWh compared to their 2008 production.

Following the same trend, related emissions fell by more than 8 points. 705 Mt CO<sub>2</sub> was emitted in 2009, which was 64 Mt CO<sub>2</sub> less than in 2008.

The more significant recorded decrease in CO<sub>2</sub> emissions means a decrease in the European Carbon Factor. It fell to 346 kg CO<sub>2</sub>/MWh in 2009, a decrease of nearly 10 kg CO<sub>2</sub>/MWh compared to 2008 (-2.7%).

The European Carbon Factor continued its decline in 2009, which began in 2008. For the first time since the start of the study in 2001, two consecutive years show the same trend. The carbon factor is falling to its lowest level since 2001. This is primarily a result of the simultaneous change to the electricity mix at several European electricity utilities, which decreased the use of coal to favour the use of natural gas and renewable energy, which emit much less CO<sub>2</sub>.

Should we presume that this decline in the Carbon Factor is a long-term trend? Will the development of renewable energy being anticipated by experts be enough to permanently alter the European Carbon Factor? We will find the answers to these questions by regularly monitoring short and medium term changes to the carbon factor.

The 18 companies studied generate more than 50% of the emissions in Europe's Power & Heat sector (27 countries).

### The most marked emissions increase from 2008 to 2009:

**Union Fenosa:** An increase of 2.2 MtCO<sub>2</sub>, or +31%, due to a 57% rise in electricity generation (an additional 10 TWh)

### Les fortes réductions d'émissions de 2008 à 2009:

**EDF Group:** A decrease of 15.7 MtCO<sub>2</sub>, or -15%. This decline is due to the drop in electricity generation (-7%) combined with an improved carbon factor (-8%).

**E.ON Group:** A decrease of 15.3 MtCO<sub>2</sub>, or -15%, directly related to the fall in production.

**RWE Group:** A decrease of 10.7 MtCO<sub>2</sub>, or -7%, related to the sharp decline in production (-12%) and the higher use of high carbon fuels (+5% in the carbon factor).

## What role will electricity from renewable sources play in the Europe of tomorrow?

From 2008 to 2009, the percentage of the electricity mix held by renewable energy in the panel of 18 companies went from 15.7 to 17.8%. Annual net production from renewable energy increased 23 TWh, mainly due to the commissioning of new wind power installations. Over the same period, non-renewable energy production fell 148 TWh.

Our analysis of the energy mix at major European electricity utilities shows that renewable energies have contributed to the decrease in the 2009 carbon factor. Renewable energies are emerging as a shift in the decline of the carbon factor of European electricity. In 2009, wind and photovoltaics represented two of the primary sources of energy used to install new electrical production capacities in Europe. Within two years, France has experienced a 85% increase in the size of its wind power fields, and its solar energy use has increased sevenfold.

The top 5 emitters are:	The 5 best carbon factors:	The 5 highest carbon factors:
<ul style="list-style-type: none"> <li>■ <b>RWE (DE, UK):</b> 134 MtCO<sub>2</sub>, -7%</li> <li>■ <b>EDF (FR, UK, DE, IT):</b> 88 MtCO<sub>2</sub>, -15%</li> <li>■ <b>E.ON (DE, UK, IT, FR):</b> 85 MtCO<sub>2</sub>, -15%</li> <li>■ <b>Vattenfall (DE, SE, FI):</b> 79 MtCO<sub>2</sub>, -3%</li> <li>■ <b>ENEL (IT, ES, PT):</b> 77 MtCO<sub>2</sub>, -7%</li> </ul>	<ul style="list-style-type: none"> <li>■ <b>Statkraft (NO):</b> 28 kg CO<sub>2</sub>/MWh, -6%</li> <li>■ <b>Fortum (FI, SE):</b> 41 kg CO<sub>2</sub>/MWh, stable</li> <li>■ <b>Verbund (AT):</b> 74 kg CO<sub>2</sub>/MWh, -26%</li> <li>■ <b>PVO (FIN, SW):</b> 131 kg CO<sub>2</sub>/MWh, stable</li> <li>■ <b>EDF (FR, UK, DE, IT):</b> 135 kg CO<sub>2</sub>/MWh, -8%</li> </ul>	<ul style="list-style-type: none"> <li>■ <b>DEI (GR):</b> 992 kg CO<sub>2</sub>/MWh, stable</li> <li>■ <b>Drax (UK):</b> 815 kg CO<sub>2</sub>/MWh, stable</li> <li>■ <b>RWE (DE, UK):</b> 792 kg CO<sub>2</sub>/MWh, +6%</li> <li>■ <b>CEZ (CZ):</b> 569 kg CO<sub>2</sub>/MWh, -5%</li> <li>■ <b>Scottish&amp;Southern (UK):</b> 496 kg CO<sub>2</sub>/MWh, -1%</li> </ul>



# Summary

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# 1. Context, Objectives and Limits of the Study

## 1.1 Regulatory Pressure facing the Electricity Production Sector in Phase III of the Quota Market

The Copenhagen conference leaves us with a feeling of incompleteness, producing a text that does nothing but recognise the goal of limiting global warming to +2°C, without a binding commitment from countries. Despite the European Union's proactivism and leadership in the fight against climate change, the poor coordination of European nations during the negotiations did little to convince the other countries.

As the only sector short of allowances during the first phase of the CO<sub>2</sub> market (EU ETS)<sup>1</sup>, the electricity production sector is also one of the most restricted between 2008 and 2012. It is also less exposed to international competition and is often designated to carry the efforts to reduce emissions.

The European Commission is about to adopt the key principles of Phase III of the European system for exchanging greenhouse gas allowances in order to improve and extend the ETS system, amending the currently effective Directive 2003/87/EC. In addition, they are likely to revise the European objective of reducing emissions from -20% to -30% by 2020, if other developed countries make similar commitments.

The European Commission will have to finalise the rules for Phase III before the end of 2011, mainly by introducing auctions quotas and rules on distributing free allowances to sectors that are exposed to carbon leakage.

As of 2013, over one billion allowances must be auctioned each year (compared to fewer than 150 million in Phase II 2008-2012). Representing major structural changes compared to Phase II, the rules for allocating and capping allowances will be set at the EU level. They are currently allocated based on activity compared to a performance benchmark, which is considered to be a greater and fairer motivator compared to simply reducing historical emissions.

The electricity production sector will not receive free allowances for avoiding any windfall profit; it will purchase 100% of its allowances. By comparison, industrial installations that are exposed to international competition will have to purchase 20% by 2013 (100% by 2027), and the recently included aviation must start with at least 15%.

To avoid creating unfair competition between onsite and offsite energy production, high efficiency cogenerations and heating networks will receive free allowances only on heat produced (when electricity production exceeds the site's energy consumption). CO<sub>2</sub> capture and storage initiatives will not receive any free allowances.

Within these directives, governments will be encouraged to devote 50% of their revenues to funding climate policies and renewable energy. Developing public policy incentives for limiting greenhouse gas emissions was identified<sup>2</sup> as a key factor in the development of renewable energy. Phase III of the EU ETS continues to place pressure on the electricity production sector, and it will certainly contribute to lowering the carbon factor for European electricity.

## 1.2 The Purpose of this Study

The purpose of this study is to identify, consolidate, harmonise and present exhaustive data on the CO<sub>2</sub> emissions of Europe's leading energy producers and analyse the main variations in data between 2001 and 2009.

## 1.3 The Limits of the Study

We do not provide comments or opinions on energy prices or the impact of CO<sub>2</sub> in the assessment of the companies included in this study.

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<sup>1</sup> Caisse des Dépôts et Consignations, 2008, Etude Climat n°16 – Développement des énergies renouvelables: quelle contribution du marché du carbone?

<sup>2</sup> PwC Energy departement, 2009, « Crisis or not, renewable energy is hot » Report

## 2. Methodology & Sources

### 2.1 Data Collection in Europe

Most of the companies in our panel have posted data directly on their Internet sites or in their annual reports and/or in their Environment/Sustainable Development reports. This level of transparency of the data published has not significantly improved since last year. We have noticed that although some companies explicitly publish the CO<sub>2</sub> emissions associated with their electricity production by geographical zone and their carbon factor, collecting information is more difficult for other companies that publish consolidated emissions data and do not distinguish emissions attributable to heat producers from those that produce electricity.

For companies that produce both electricity and steam, the overall CO<sub>2</sub> emissions have been allocated to electricity, in proportion to the amount of electrical production in the total energy production.

We know that some data may be approximate, particularly data that is calculated by extrapolation, but we estimate the margin of error as being no greater than 10%.

Lastly, the recent mergers and acquisitions within the energy sector has resulted in replacing some companies in the scope of the study and reprocessing data from previous years.

### 2.2 Coverage

The total CO<sub>2</sub> emissions of the European Union (EU27) in 2008 amount to approximately 4.94 Gt, about 1.3 Gt of which are attributable to the production of electricity and heat<sup>3</sup>. Emission reductions between 2007 and 2008 amounts to 60 million tonnes, a 6% decline. Spain and Germany are the top contributors, with relative contributions of 28% and 32%, respectively.

The European Commission projected Europe's total electricity production in 2009 to be around 3,041 TWh<sup>4</sup>, down 5.1% compared to 2008. The study panel is thought to represent 67% of Europe's electricity production.

The total volume of emissions analysed in this study is 705 Mt CO<sub>2</sub>/year, accounting for around 50% of the emissions generated by the European energy sector (EU27).

### 2.3 Scope

In an effort to fine-tune the results, we have only analysed:

- Strictly European emissions (by excluding emissions from subsidiaries outside Europe)
- Emissions only attributable to electricity production (we did not include emissions from other subsidiaries in multi-sector groups)

Wherever possible, we have also omitted emissions attributable to heat production.

When consolidated data on emissions were missing, we had to add figures for recently acquired companies. To do this, we used the "control-based" consolidation method, (rather than the "partial integration" method) as recommended in the GHG Protocol<sup>5</sup>. As an example, data from Edison, EDF Energy and EnBW are fully incorporated into the data for the EDF Group.

The primary modifications in the scope of the 2009 study following corporate buyouts are specified below:

- Nuon included within the scope of Vattenfall
- British Energy included within the scope of the EDF Group. British Energy is no longer treated as an independent entity in this study. Historical activity data (production, CO<sub>2</sub> emissions, etc.) for 2001-2008 has all been included with EDF.

The data for E.ON is questionable due to lack of details on the carbon factor for subsidiaries in Scandinavian countries, which significantly impact the group's results.

Whenever possible, the historical data on the companies studied were reprocessed for the period 2001-2008 in an effort to monitor their changes within a uniform scope.

Details on consolidations appear in Appendix B.

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<sup>3</sup> Agence Européenne de l'Environnement, 2010, Annual European Union greenhouse gas inventory 1990-2008 and inventory report 2010.

<sup>4</sup> Eurostat/Environment and energy, 2010, Electricity statistics – provisional data for 2009

<sup>5</sup> For further details: [www.ghgprotocol.org](http://www.ghgprotocol.org)



## 2.4 Published Data

### 2.4.1 European Analysis (18 companies)

We have analysed Europe's top 18 electricity producers using the following criteria:

- Production (in TWh). Note: We took into account the electricity generated, as opposed to the electricity sold, which factors in trading activities.
- Emissions (in t CO<sub>2</sub>/year) in terms of electricity generated
- Carbon Factor (in kg CO<sub>2</sub>/MWh produced)
- Percentage of energy produced from renewable energy<sup>6</sup>
- Major changes in the carbon factor, CO<sub>2</sub> emissions and the renewable energy ratio

### 2.4.2 Recalculation of Historical Data

We have updated and recalculated the historical data on production and emissions for some companies to account for the latest published data.

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<sup>6</sup> By renewable energy, we mean all of the diversified sectors whose implementation is renewable on a human scale (wind, solar, water, biomass, etc.).

### 3. Results for 2001-2009

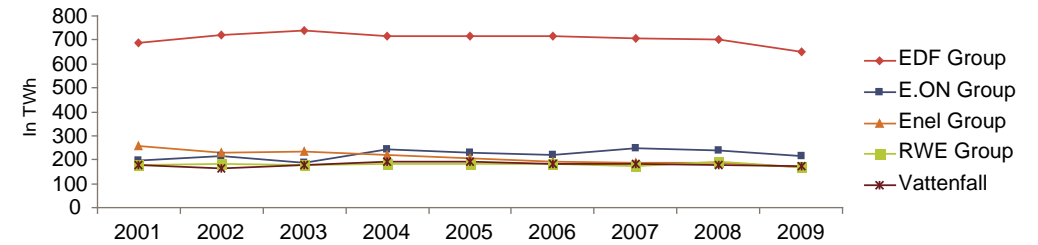
#### 3.1 Production – 2009 Data

The panel's production declined significantly over the year (a decrease of 126 TWh, or nearly 5.8% between 2008 and 2009). European electricity production has never decreased in that amount since the Carbon Factor project started. RWE, Scottish & Southern and Drax showed a record double-digit production decrease (nearly 15% for Scottish & Southern, 13% for RWE and 10% for Drax).

As in the previous two years, the EDF Group represents about 20% of all European production. With the acquisition of Nuon, Vattenfall has become the 3<sup>rd</sup> ranked European producer.

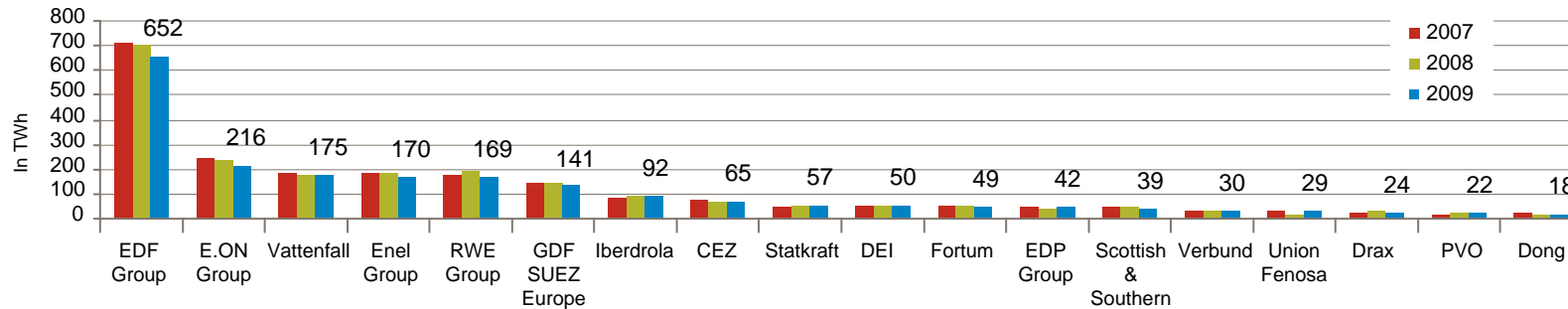
Electricity Production in Europe 2001-2009

(all companies on the panel)



Electricity Production in Europe 2007-2009

(all companies on the panel)

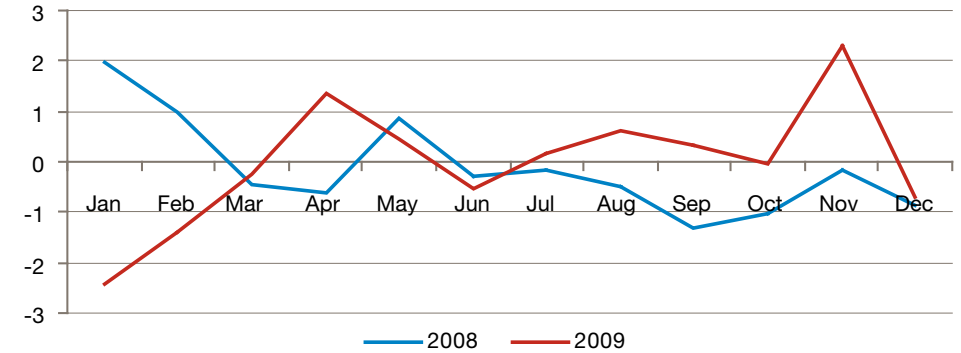


In addition to the demand crisis, the drop in electricity production between 2008 and 2009 can be explained by above-normal European temperatures after March 2009.

### 3.2 Emissions – 2009 Data

Proforma emissions within the sample decreased by 64.5 Mt CO<sub>2</sub> between 2008 and 2009. This one-year reduction, the largest ever recorded since 2001, represents a -8.4% decline compared to 2008. RWE remains the largest emitter in Europe with 133 Mt CO<sub>2</sub>, alone representing nearly 19% of the panel's total emissions and 10% of the 27 companies within the European sector.

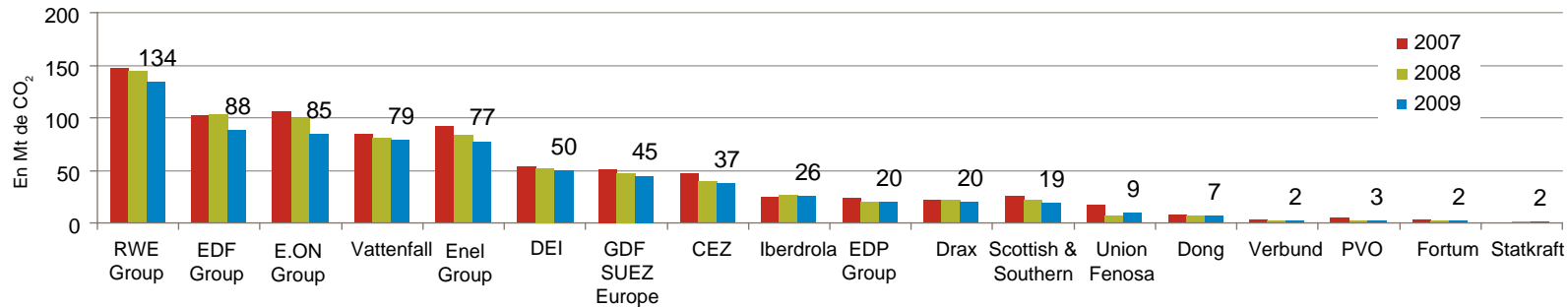
Difference between the annual temperature and the European 10-year average



Source: Caisse des Dépôts et Consignations, 2010, Tendances Carbone [cf. note 10] (mais sans le n°44)

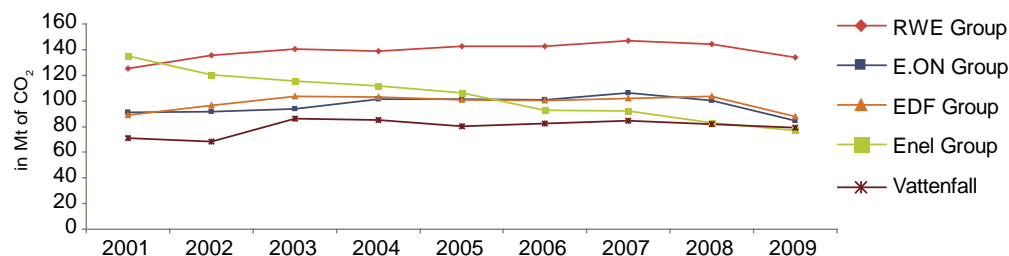
### CO<sub>2</sub> Emissions in Europe 2007-2009

(all companies on the panel)

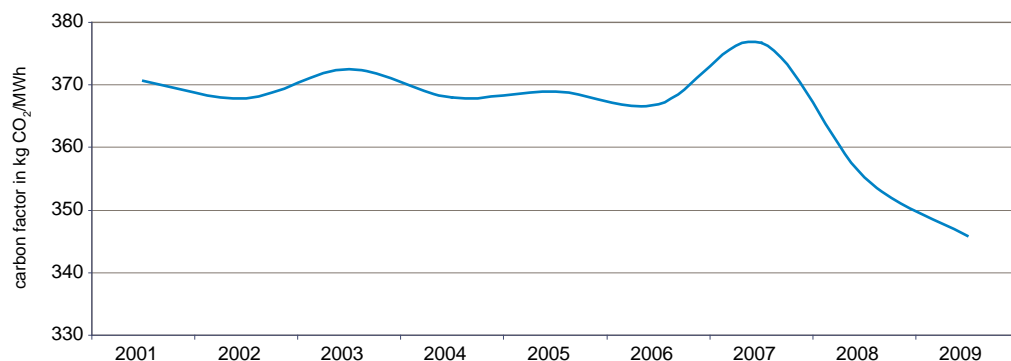


## CO<sub>2</sub> Emissions in Europe 2001-2009

(5 main groups)



## Change in the Carbon Factor



## 3.3 Carbon Factor

Europe's average carbon factor for 2009 was 345.5 kgCO<sub>2</sub>/MWh, compared to 355.3 kgCO<sub>2</sub>/MWh in 2008, a decline of 9.7 kgCO<sub>2</sub>/MWh (-2.7%).

Fifteen of the 18 companies studied decreased their carbon factor (up to -26.5% for Verbund).

Again this year, with its high production and its mainly nuclear facilities (fewer CO<sub>2</sub> emissions), EDF Group significantly contributes to Europe's lower carbon factor. (Without EDF, emissions are 445 kgCO<sub>2</sub>/MWh).

### The most marked increases in the Carbon Factor in 2009 vs. 2008

**RWE** saw a 45 kgCO<sub>2</sub>/MWh, or +6%, increase in its carbon factor. According to RWE<sup>7</sup>, the large fluctuations in their carbon factor in recent years is highly influenced by the availability of primary energy sources.

**Enel** states that the increase in its carbon factor (up 6 kgCO<sub>2</sub>/MWh, or +1.5%) is mainly due to worsened specific consumption within its plants (2,186 kcal/kWh in 2008 compared to 2,258 kcal/kWh in 2009).

### The most marked reductions in the Carbon Factor in 2009 vs. 2008

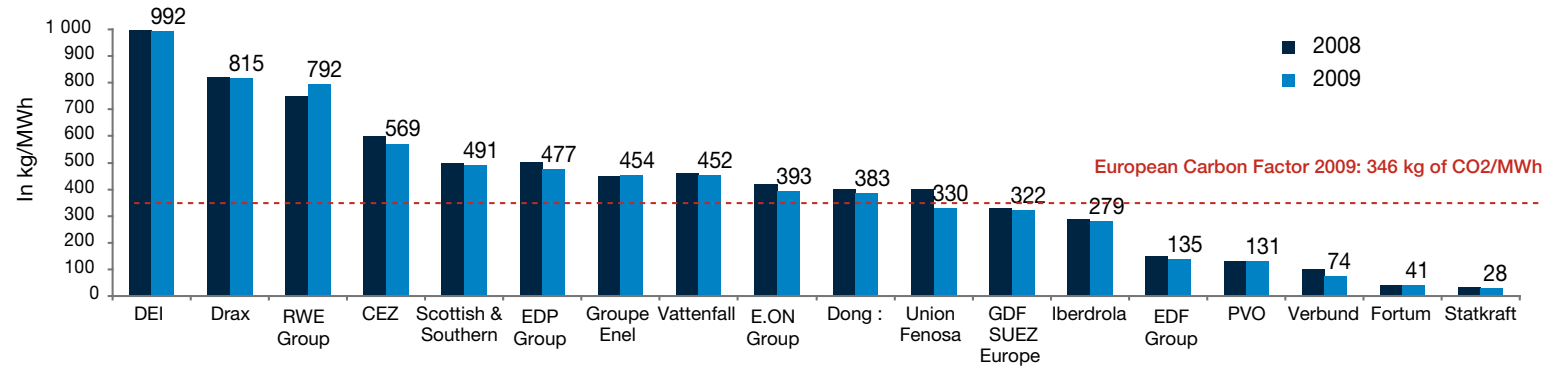
**Verbund** experienced a 27 kgCO<sub>2</sub>/MWh, or -26%, drop in its carbon factor due to a nearly 30% decrease in the use of fossil fuels in the electricity mix.

**Union Fenosa** explains a 17% improvement in its carbon factor (68 kgCO<sub>2</sub>/MWh) by environmentally efficient measures, particularly in the yields of some of its plants and by the increase in its use of renewable energy.

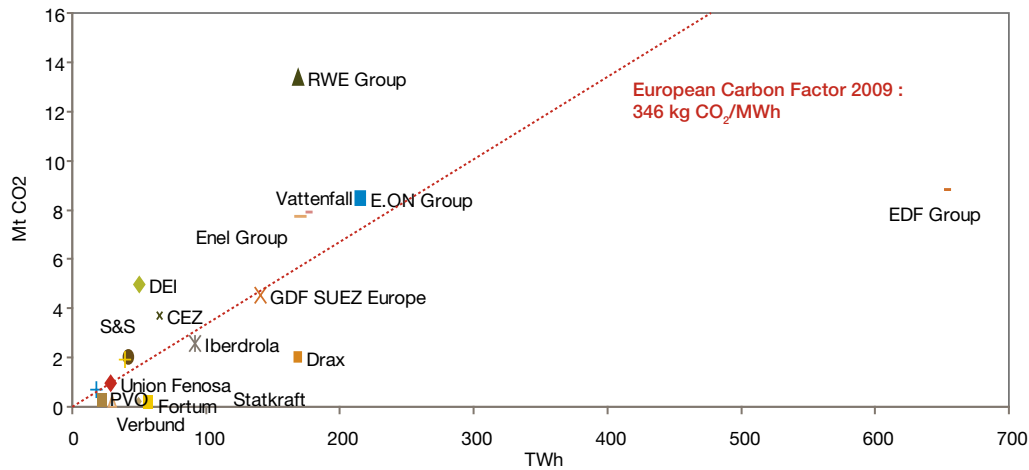
**The EDF Group** had a 12 kgCO<sub>2</sub>/MWh, or -8%, drop in its carbon factor, mainly due to a significant reduction in its use of coal.

### European Carbon Factor 2009

Some companies recorded a lower carbon factor than the European carbon factor, mostly because of their energy mix, which is primarily composed of hydraulics and/or nuclear power. These companies are the same as last year: Statkraft, Fortum, Verbund, PVO, EDF, Iberdrola, and GDF Suez Europe.



### Position of the top 18 companies compared to the European Carbon Factor



### 3.4 Major Trends in CO<sub>2</sub> Emissions for 2008-2009

The companies record varying CO<sub>2</sub> emissions levels from year to year. We attempted to recognize the major trends during the course of 2009:

#### The most marked emissions increase from 2008 to 2009:

**Union Fenosa:** An increase of 2.2 MtCO<sub>2</sub>, or +31%, due to a 57% rise in electricity generation (an additional 10 TWh)

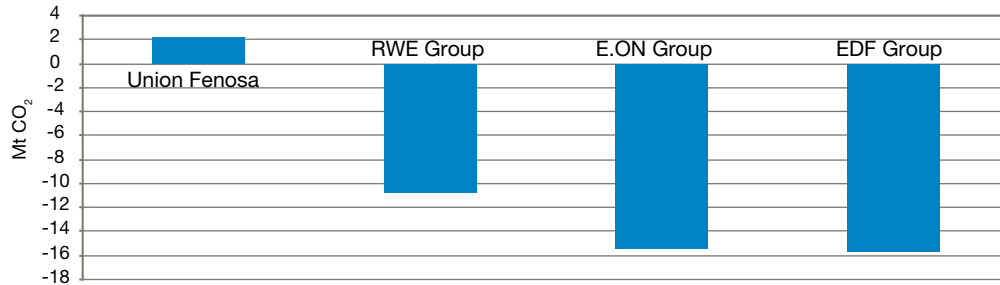
#### The most marked emissions reductions from 2008 to 2009:

**EDF Group:** A decrease of 15.7 MtCO<sub>2</sub>, or -15%. This decline is due to the drop in electricity generation (-7%) combined with an improved carbon factor (-8%).

**E.ON Group:** A decrease of 15.3 MtCO<sub>2</sub>, or -15%, directly related to the fall in production.

**RWE Group:** A decrease of 10.7 MtCO<sub>2</sub>, or -7%, related to the sharp decline in production (-12%) and the higher use of carbon (+5% in the carbon factor).

### Major Changes in CO<sub>2</sub> Emissions between 2008 and 2009



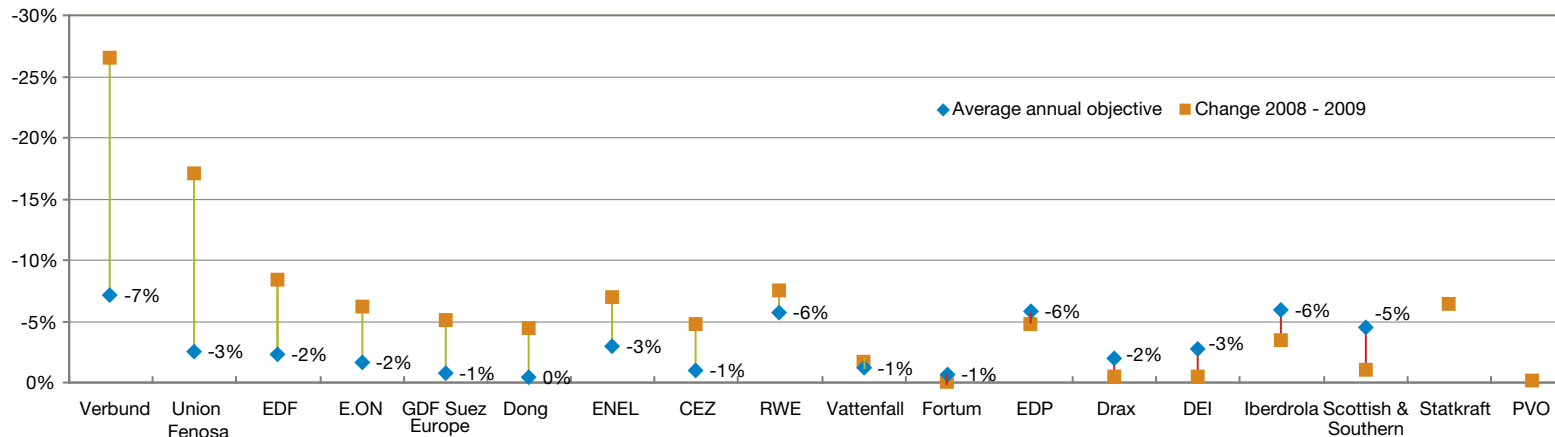
### 3.5 Current Effort for an Overall Reduction ahead of Company Schedules

Most of the companies on our panel have a goal for reducing their emissions of CO<sub>2</sub><sup>8</sup>. Their scorecards include a baseline, a target year and a total (CO<sub>2</sub> emissions) or relative (carbon factor) reduction objective<sup>9</sup>. The figure below compares the reduction objective from one year with the change observed during our analysis.

The combined objectives represent an annual decrease of about 20 million tonnes of CO<sub>2</sub> in 2009, or 3% of the amount emitted by the companies. Verbund, Iberdrola, EDP and RWE are the most ambitious companies, with yearly objectives of over 5.5%.

Between 2008 and 2009, the decrease in emissions represents nearly three times the predefined objectives, with over 65 million tonnes. The performance of Verbund, Union Fenosa, and the EDF Group is 6% ahead of schedule. By contract, EDP, Iberdrola, Vattenfall, Scottish & Southern, DEI, Drax and Fortum could not reach their expected performance for Europe in 2009.

### Comparison between the Annual CO<sub>2</sub> Reduction Objective and Efforts Made between 2008 and 2009



<sup>8</sup> No reduction objective has been identified for PVO and Statkraft. GDF Suez's objective relates specifically to its Electrabel subsidiary, with no objective identified at the Group level.

<sup>9</sup> Sources used for the objectives: Carbon Disclosure Project 2009 and 2010 and corporate communications from Dong, GDF Suez and DEI.

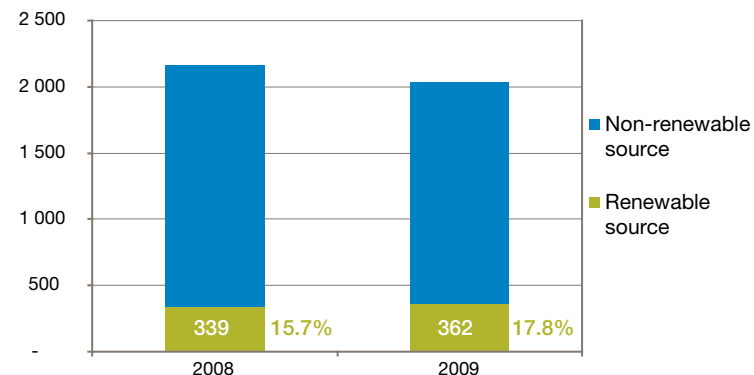
### 3.6 Use of Renewable Energy: An Upward Trend

#### 3.6.1 Increase in Electricity Produced from Renewable Sources

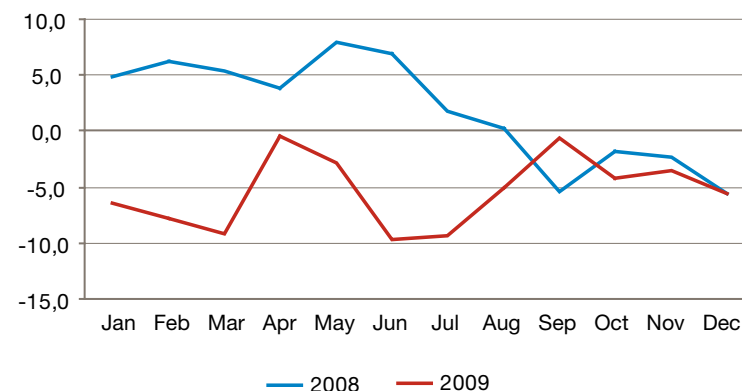
An analysis of the 18 key players in the market shows an increase of nearly 7% in terms of electricity produced from renewable energy (23 TWh more in 2009, from 339 to 362 TWh, or 17.8% of the panel's total production). This increase in production comes primarily from structural factors, including new renewable energy production installations.

As the main source of renewable energy (11.6% of total energy production for 2009), hydropower did not experience a good weather condition. Water reserves were filled in 2009 at a rate that falls below the ten-year average for Europe. This is explained by an extremely low level of precipitation in the Scandinavian countries<sup>10</sup>. In 2009, dams were filled at an even lower rate than in 2008.

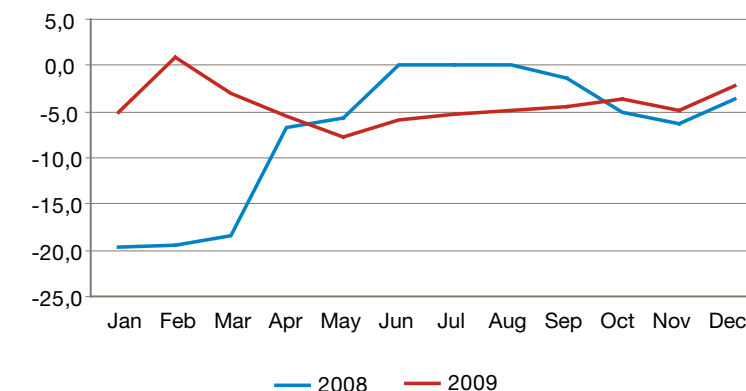
Change in the % of Renewable Energy Sources for Electricity Production 2008 and 2009



Difference between the Monthly Filling (%) and the 10-year Average (%) for Water Reserves – Scandinavian Countries



Difference between the Monthly Filling (%) and the 10-year Average (%) for Water Reserves – Spain



<sup>10</sup> Caisse des Dépôts et Consignations, 2010, Tendances Carbone n°44.

The increase in renewable electricity production in 2009 was mainly explained by Enel and E.ON, who produced 5.9 TWh and 5 TWh more from renewable sources, respectively, compared to 2008.

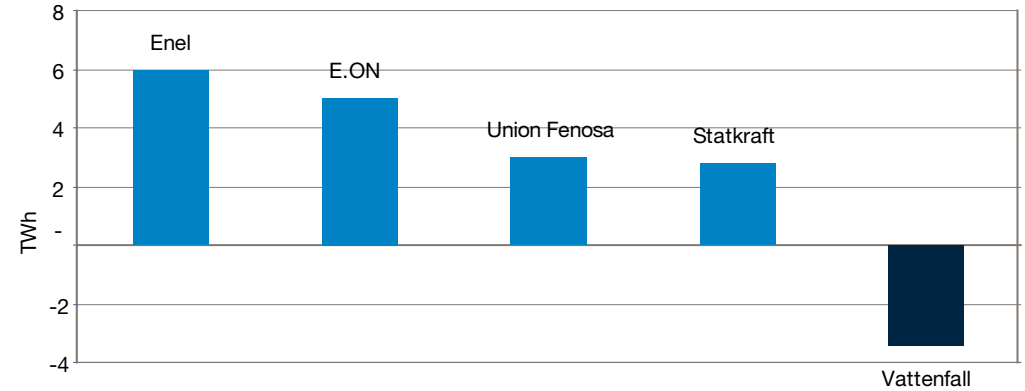
For this, E.ON created new renewable energy production capacities. In Europe, new wind farms in Spain, Portugal and the United Kingdom (offshore, 180 MW) started producing in 2009.

Enel's increased production from renewable energy is the result of multiple factors, including external growth in Greece and the UK (hydro and wind energy) and a greater availability of water in Italy (temporary factor).

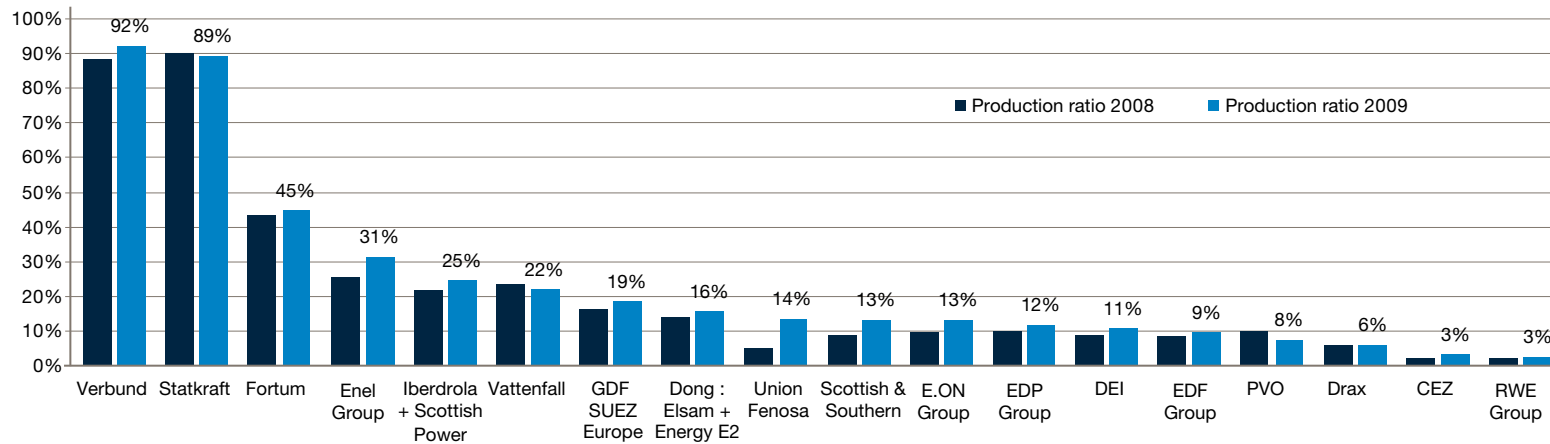
Union Fenosa started with renewable energy production resources in 2009.

By contrast, Vattenfall opted to respond to market needs by promoting the supply of gas power (doubled in one year), at the expense of its focus on renewable energy.

### Major Developments in the Production of Electricity from Renewable Energy between 2008 and 2009



### Renewable Energy % in Electricity Production 2008-2009





### 3.6.2 Increase in Renewable Energy in the Electricity Mix

In Europe, renewable energy made up 17.8% of electricity production in 2009. This is a significant increase compared to 2008 (15.7%), with an additional 22.7 TWh in renewable energy produced in 2009. The year 2009 also saw an increase in the use of renewable energy.

Verbund, Statkraft, and to a lesser extent, Fortum are clearly aimed at renewable energy in their production, particularly with their hydropower. However, CEZ and RWE have done little with renewable energy, with a production ratio of no more than 3% of their energy mix. The EDF Group is the top renewable energy producer in terms of volume, with over 61.8 TWh produced in 2009.

The concessions of dams in France will be renewed between 2013 and 2015. These concessions are currently held by EDF and GDF SUEZ. Some new players seem to be interested in this industry, with its already depreciated production base. The first wave of tender will involve 5 GW.

### 3.6.3 Relationship between the Use of Renewable Energy and the Carbon Factor?

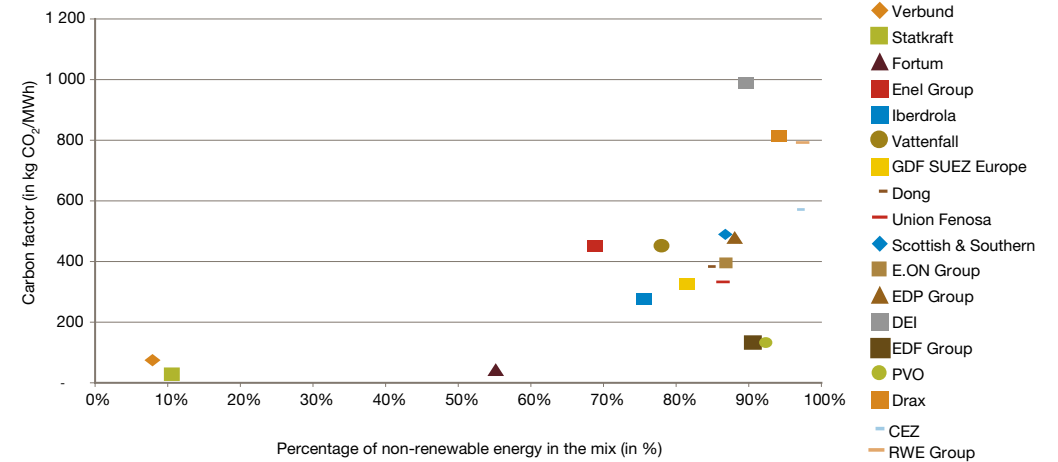
We are interested in the possible existence of a relationship between the carbon factor and the use of renewable energy. The figure on the right shows the carbon factor in relation to the renewable energy ratio in the company energy mix:

We find a significant correlation between the two criteria. That is, companies that heavily use non-renewable energy usually have a higher carbon factor.

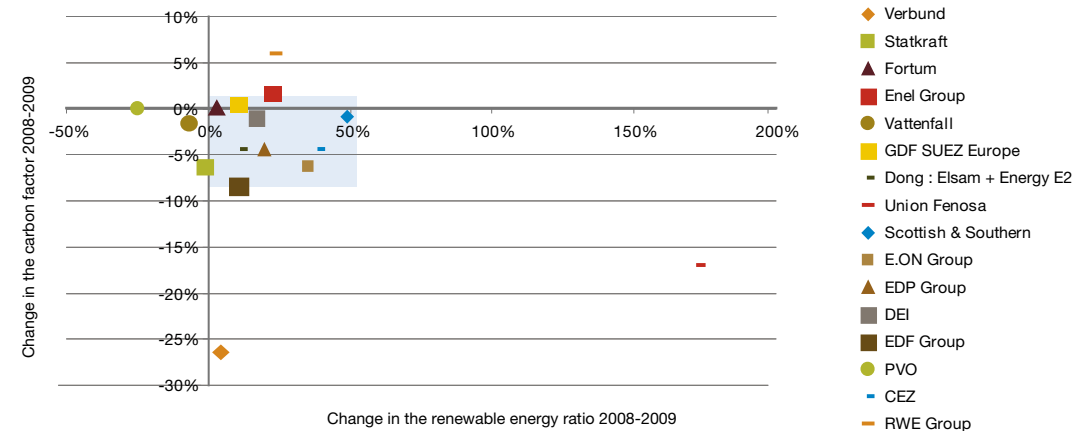
Most of the analysed companies (blue area on the right graphic) show a 3% to 50% increase in their renewable energy ratio between 2008 and 2009, combined with a decrease in their carbon factor of up to -8%.

Among companies that differ from this general finding, only PVO and Vattenfall have not added renewable energy to their energy mix between 2008 and 2009. Vattenfall's production of hydropower actually fell by 12%, while its production from fossil fuels increased by 8%. PVO had a similar situation, with its share of hydropower (93% of the Group's renewable energy) falling from 8% to 5% of its energy mix.

### Carbon Factor in terms of % of Non-Renewable Energy



### Change in the Carbon Factor related to the Change in Renewable Energy



Other values require more information:

- Union Fenosa nearly tripled its production of renewable energy, mainly due to the 2009 acquisition of hydropower production resources in Spain (1 TWh).
- Verbund's carbon factor plummeted 25%, combined with an increase in its share of renewable energy in the mix. The reduction is limited when expressed as a percentage (from 88 to 92%, or a 4% increase), but corresponds to a 30% decrease in electricity produced from fossil fuels.
- The RWE Group significantly increased its carbon factor, despite its use of renewable energy. With the new low-emitting production resources (particularly 1 GW in renewable energy) started at the end of 2009, RWE will not see a drop in its carbon intensity before 2011/2012.

Theoretically, renewable energy is an undeniable factor in reducing the carbon factor. However, despite the emerging trend, there is not an automatic correlation between a reduced carbon factor and an increased use of renewable energy. The increased use of nuclear energy, the substitution of coal with gas (compounded by a drop in gas prices in 2009), and improved energy efficiency also contribute to a lower carbon factor. For some companies on the panel (Enel and RWE), their ratio is moving toward renewable energy, while their carbon factor is also increasing. Conversely, the rising share of non-renewable energy in Vattenfall and PVO's production has not increased their carbon factor.

## 4. Renewable Energy in Europe: 2020 and Later

In 2010, PwC carried out a study<sup>11</sup> in cooperation with the European Climate Forum and the Potsdam Institute to explore opportunities in developing the electricity production sector through renewable energy. The main findings of the study are described below, along with a short-term description of Europe's position in terms of renewable energy.

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<sup>11</sup> PwC, 2010, 100% Renewable Electricity, A Roadmap to 2050 for Europe and North Africa

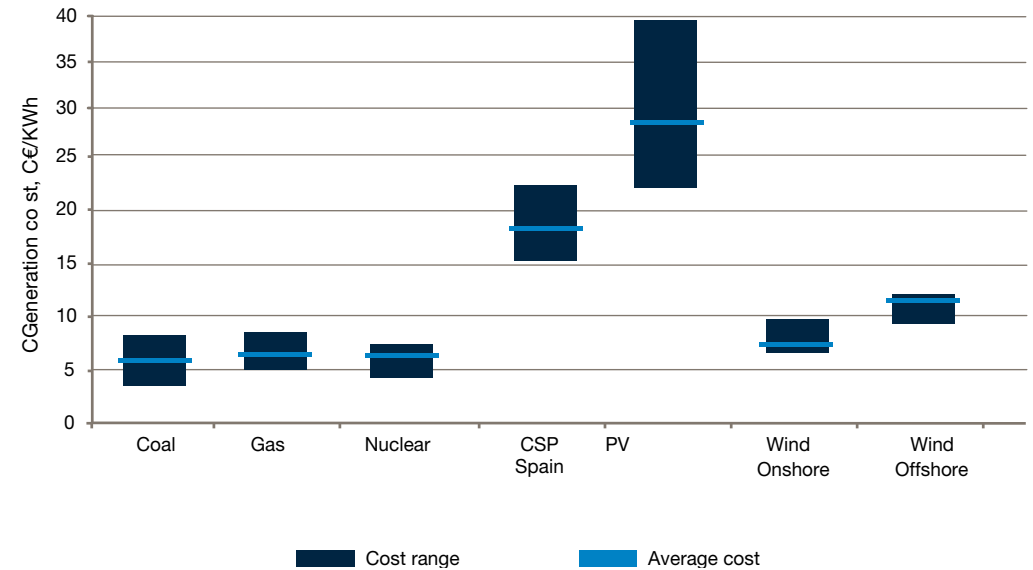
## 4.1 100% Renewable Electricity in Europe: A Roadmap to 2050

### Summary of Europe's Situation in 2010

- In Europe, the power system is dominated by fossil fuel (55%) and nuclear (30%) electricity.
- By far, the largest part of the renewable electricity comes from old hydropower stations. There has been some expansion of renewable energy, mainly onshore wind and biomass power, in Europe over the last 10 years but this has been focused on a few EU15 countries.
- The European grid is split into 5 asynchronous blocks, connected with a few HVDC interconnections\*.
- The market is fragmented, consisting of a large number of national markets, which are dominated by a few very large companies. The Scandinavian market remains the only international power market. The pricing at the European power exchanges is based on marginal costs.
- Most countries are self-sufficient in electricity, but very dependent on fuel imports. Less than half of the European power plant fuel comes from domestic EU sources.
- Electricity policy is still largely a national matter, rather than a European one. With the Lisbon Treaty, the CO<sub>2</sub> quota market and the Renewables Directive, the European dimension has gained importance, but the impact of this is not yet clear. Support systems and renewables policy implementation instruments are still strictly national.
- Renewable electricity is still more expensive than conventional power, with the exception of wind power at very good sites. This is in part due to explicit and implicit subsidies for fossil and nuclear power (see figure).
- A renewable energy industry is emerging in Europe, and is rapidly gaining importance as an employer.

\* HVDC: high voltage direct current

### Electricity Production Costs in 2010, by Technology



Source: PwC, 100% Renewable Electricity, A Roadmap to 2050 for Europe and North Africa

### Vision for 2050

- The electricity supply system is 100% renewable.
- HVAC and HVDC interconnection strengthen the intelligence of the European grid. The supply-and-demand relationship between electricity producers and consumers is optimised by Smart Grids.
- The renewable power mix is geographically optimised, with wind generation in the windy North Sea region, concentrating solar power in the sunny south, biomass and wind in the Baltic Sea region and eastern Europe, and hydro in the mountainous regions of Scandinavia and the Alps.
- The European market is unified and united with the North African market through a gradual unification of regional markets.
- All renewable technologies in use have experienced significant cost reductions in capital and operational costs along with improvements in efficiency. The supply chain is a mature market and an important employer.
- Electricity is affordable for every European country.
- The ETS market and price of carbon have played a key role in encouraging a shift to greater use of renewable energy.

The 2050 vision requires continuous progress on several fronts simultaneously, including finance, technology, R&D, development of an adequate supply chain, etc. The main resources that have been proposed relate to the following themes:

**Policy:** Current directives should be the basis for a more ambitious European policy in terms of reducing emissions, including the incorporation of directives sanctioning new fossil fuel power plants.

**Investment:** Better information on plans, a commitment with renewable energy industries and technological improvements will provide greater credibility for renewable energy projects.

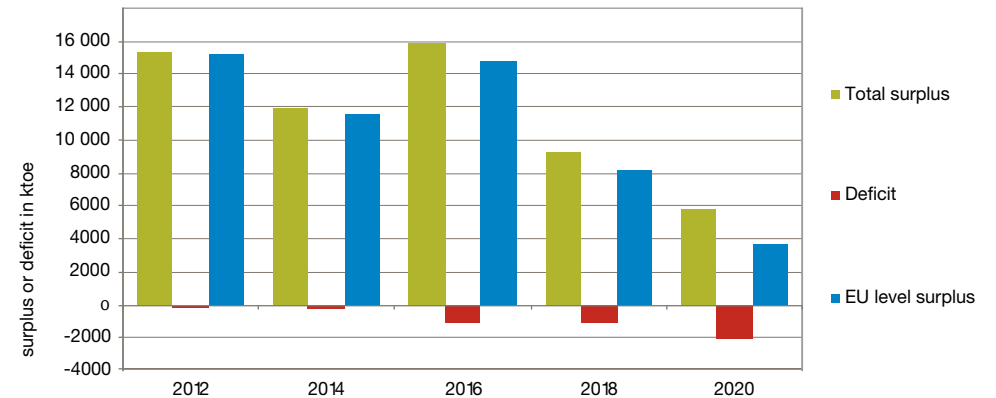
**Market Structure:** Unification is a major structural condition for reaching the 2050 objectives. Long-distance transmission infrastructures will be encouraged, especially with the North African market.

## 4.2 Renewable Energy in Europe: Europe's Goal for 2020

In June 2010, the Member States submitted their national action plan on renewable energy to the European Commission<sup>12</sup>, targeting a 20% share for renewable energy in the European energy mix by 2020. In parallel, through its REPAP 2020 – Renewable Energy Policy Action Paving the Way Towards 2020 project, the European Commission invited other stakeholders, such as renewable energy industries and NGOs, to propose their own vision.

Early analysis<sup>13</sup> identifies optimism on the part of most of the Member States with respect to their ability to reach their assigned climate and energy objective. Their forecasts include a net surplus, not only for the final objective with renewable energy consumption reaching 20.3% by 2020, but also throughout the 2010-2020 period (figure below).

### Renewable Energy Consumption Surplus and Deficit Planned by the Member States between 2010 and 2020



Source: Joint Research Centre of the European Union, 2010, Renewable Energy Snapshots 2010

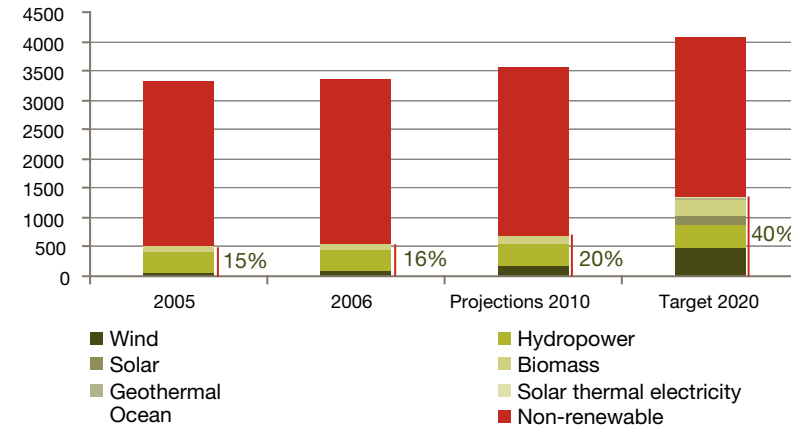
<sup>12</sup> National Renewable Energy Action Plan (NREAP)

<sup>13</sup> Joint Research Centre of the European Union, 2010, Renewable Energy Snapshots

In its "20% by 2020" report, the European Renewable Energy Council provides targets to be achieved in order to reach the objective of 20% renewable energy. Assuming that the European Union reaches its objectives, there must be a 33-40% ratio of renewable energy compared to total energy production.

This 2020 target is over and above the objectives of many countries. In its The China Greentech Report 2009, PwC reminds us that China seeks to reach a 20% share from renewable energy by 2020 (specifically through a 300 GW production capacity in hydropower, 100 GW in windpower, and 20 GW in solar power).

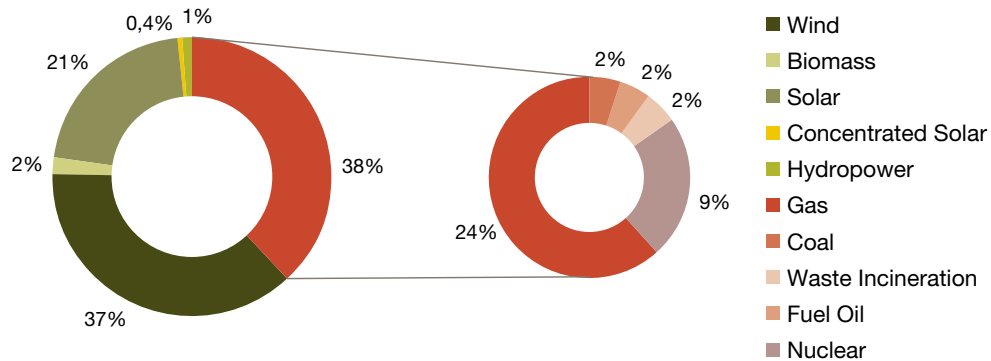
### Share of Renewable Energy in Energy Consumption related to Electricity Production



Source: EREC, 2010, 20% by 2020

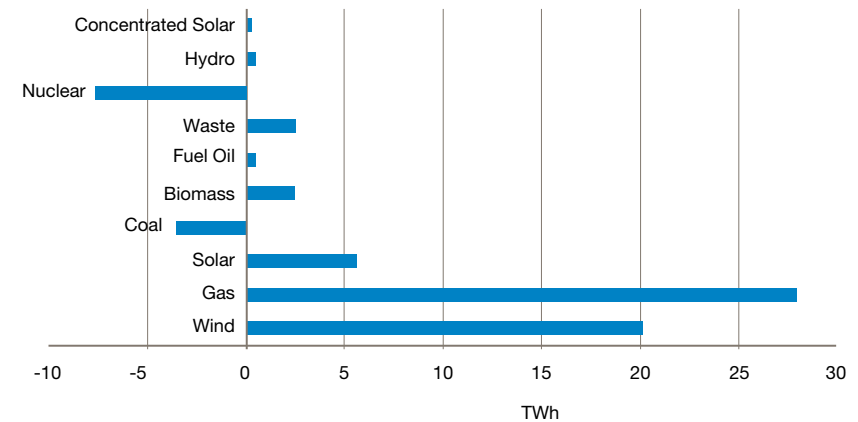
### 4.2.1 All Systems Go in 2009

#### Capacity for Electricity Production Installed in 2009



Source: Joint Research Centre of the European Union, 2010, Renewable Energy Snapshots 2010

### Electricity Production Forecasts for the New Capacity Installed or Removed in the EU in 2009



Source: Joint Research Centre of the European Union, 2010, Renewable Energy Snapshots 2010

In 2008, wind power was the second largest source of energy in terms of newly installed capacity, after gas (with 6.9 GW compared to 8.5 GW for gas). In 2009, according to the Joint Research Centre of the European Union<sup>14</sup>, 62% (17 GW) of Europe's newly installed electricity production capacity is believed to be for renewable energy. This new renewable capacity includes mainly windpower, representing 38% of these new production resources, with 10.2 GW out of 27.5 GW. At the current pace of growth, this means 35-40% of total electricity consumption in the European Union by 2020, a massive contribution to the 20% objective that was set for energy production from renewable sources.

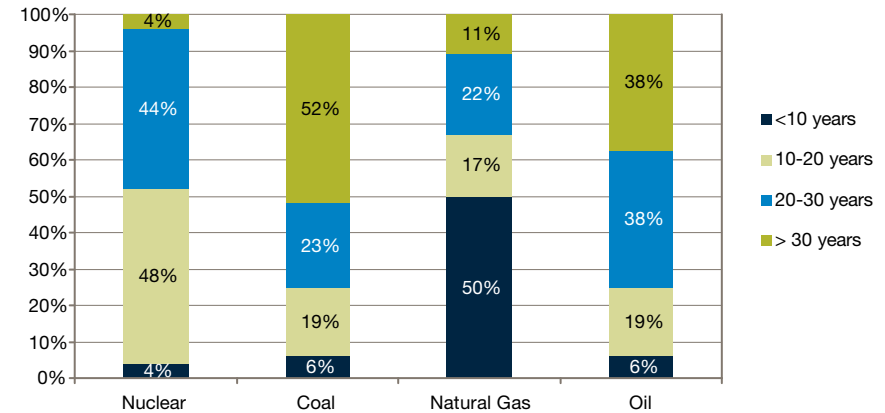
#### 4.2.2 Leveraging the Deployment of Renewable Energy: Renovating the Aging Infrastructure over the Next Decade

Past Carbon Factor studies have revealed a clear growth in renewable energy in Europe's energy mix. However, this development is measured as the increase in the contribution of renewable energy, which amounted to only two points between 2000 and 2007. The use of renewable energy seems to have grown since 2008 in terms of electricity production. After an increase of 2 points over that period, the trend is increasing, with a similar gain in the span of just one year.

However, this acceleration toward renewables has not yet been shown in the medium term. With installations at an average age of 40, and given the age of coal installations<sup>15</sup> (see figure XX), the increase in power from renewable energy in the medium term depends greatly on the renovation of several European plants, as planned for the next decade<sup>16</sup>.

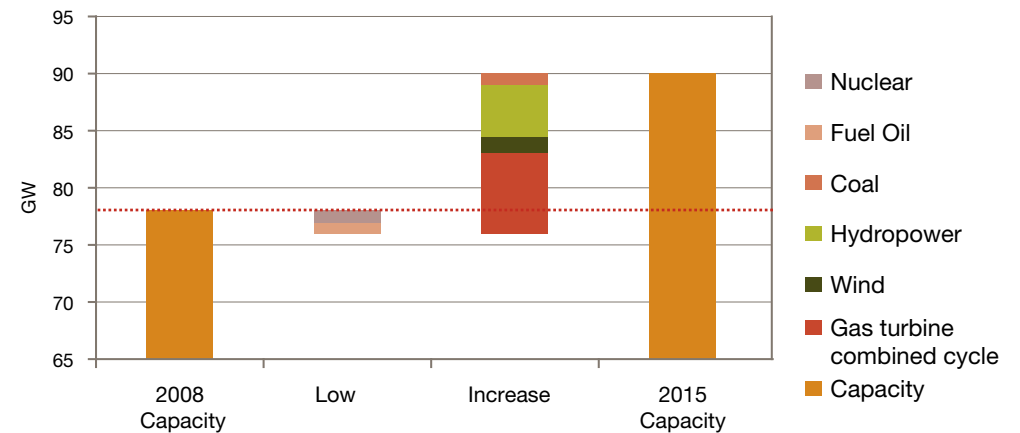
To this end, investments in electricity production resources by five major European companies (representing an installed power of 78 GW in 2008) were analysed. Planned investments by five major European companies<sup>17</sup> appear to focus on gas before 2015, as the figure shows the cons.

#### Age of European Electricity Production Installations in 2010



Source: PwC, 100% Renewable Electricity, A Roadmap to 2050 for Europe and North Africa

#### New Production Capacity Planned by Five European Companies by 2015



Source: Carbon Disclosure Project 2009, Europe 300

14 Joint Research Centre of the European Union, 2010, Renewable Energy Snapshots

15 PwC, 2010, 100% Renewable Electricity, A Roadmap to 2050 for Europe and North Africa

16 World Energy Council, 2008, Europe's Vulnerability to Energy Crises

17 Carbon Disclosure Project, 2009

The massive deployment of renewable energy in the energy production sector will not happen without a political incentive. The next decade will be decisive. Renewable energy sources will require significant public support, particularly in terms of R&D and grid access so that renewable energy can be absorbed.





# Appendices A

## Data by Company

Country	Company	2002			2003			2004			2005			2006			2007			2008			2009		
		Production (TWh)	Emission (kt CO <sub>2</sub> )	kg CO <sub>2</sub> /MWh	Production (TWh)	Emission (kt CO <sub>2</sub> )	kg CO <sub>2</sub> /MWh	Production (TWh)	Emission (kt CO <sub>2</sub> )	kg CO <sub>2</sub> /MWh	Production (TWh)	Emission (kt CO <sub>2</sub> )	kg CO <sub>2</sub> /MWh	Production (TWh)	Emission (kt CO <sub>2</sub> )	kg CO <sub>2</sub> /MWh	Production (TWh)	Emission (kt CO <sub>2</sub> )	kg CO <sub>2</sub> /MWh	Production (TWh)	Emission (kt CO <sub>2</sub> )	kg CO <sub>2</sub> /MWh	Production (TWh)	Emission (kt CO <sub>2</sub> )	kg CO <sub>2</sub> /MWh
Fr/UK/All/It	EDF Groupe	650	91,348,027	141	669	96,341,336	144	647	95,735,673	148	647	93,515,968	145	655	93,345,822	142	706	101,911,108	144	704	103,791,689	147	652	88,085,881	135
All/UK	RWE Groupe	184	135,500,000	738	179	140,500,000	787	183	139,100,000	761	182	142,700,000	784	185	142,400,000	771	173	147,060,000	848	194	144,460,000	747	169	133,700,000	792
Eastern/Central/Northern Europe/UK/Fr	E.ON Groupe	216	91,778,921	425	186	93,828,200	504	245	101,385,062	413	229	101,174,880	442	221	100,795,400	456	247	106,043,010	429	239	100,074,100	418	216	84,700,000	393
It/Spain/Port	Enel Groupe	228	120,400,000	529	232	115,506,560	499	222	111,917,253	514	206	106,523,438	528	193	92,992,808	495	185	92,252,200	498	186	83,000,000	447	170	77,286,959	454
Port/Spain	EDP Groupe	39	26,899,200	690	43	23,249,000	536	39	23,893,710	614	42	28,255,000	677	43	24,484,000	565	43	23,422,000	544	40	19,783,000	500	42	20,007,000	477
Sweden/All/UK	Vattenfall	166	68,282,636	411	160	71,471,000	448	174	69,971,000	403	175	71,768,500	410	165	74,500,000	450	184	84,502,500	459	178	81,717,000	459	175	79,046,000	452
Europe	GDF Suez Europe	115	44,481,000	387	130	41,587,000	320	125	40,825,000	327	123	39,361,000	319	129	40,403,000	314	148	50,520,233	341	145	47,575,442	327	141	45,443,000	322
Spain/UK	Iberdrola + Scottish Power	56	13,549,831	242	64	7,465,495	117	66	11,899,215	179	88	29,649,833	338	95	28,161,442	297	84	24,716,124	294	94	27,212,240	289	92	25,550,820	279
Czech Republic/Poland/Bulgaria	CEZ	54	34,699,655	643	61	34,000,000	557	62	35,706,546	575	60	33,300,000	555	66	36,261,327	553	73	46,853,740	640	68	40,375,540	597	65	37,195,443	569
Greece	DEI	49	51,345,000	1,050	52	52,408,800	1,004	53	53,287,500	1,015	53	52,592,000	994	52	50,483,000	969	54	53,040,000	984	52	52,200,000	996	50	49,700,000	992
Finland	Fortum	48	7,000,000	146	53	9,142,857	172	56	7,928,571	143	52	1,993,708	38	54	5,820,800	107	52	3,340,800	64	53	2,156,600	41	49	2,021,300	41
Norway/Sweden/Finland	Statkraft	49	0	0	42	0	0	34	0	0	49	0	0	46	0	0	45	229,000	5	53	1,604,700	30	57	1,600,000	28
UK	Scottish & Southern	19	9,346,800	487	23	12,239,400	531	23	12,184,800	524	39	18,900,000	486	41	25,210,000	622	47	25,880,000	555	46	22,720,000	496	39	19,300,000	491
Spain	Union Fenosa	24	16,380,300	683	26	15,098,000	584	27	16,539,300	612	29	16,487,000	572	31	15,822,000	514	34	18,203,375	535	18	7,263,102	398	29	9,480,240	330
Austria	Verbund	35	3,654,000	105	28	5,000,000	178	30	4,437,000	149	29	3,810,000	131	28	3,701,000	132	28	3,407,000	120	29	2,885,000	101	30	2,213,932	74
UK	Drax	19	16,350,000	840	26	21,642,000	833	25	20,519,000	838	25	20,519,000	830	27	22,764,847	840	27	22,503,000	844	27	22,299,000	818	24	19,845,250	815
Denmark	Dong	30	17,529,897	584	36	21,470,000	591	29	15,766,397	552	29	15,766,397	552	26	11,874,624	464	20	8,547,437	432	19	7,433,436	401	18	6,928,622	383
Finland/Sweden	PVO	16	6,000,000	375	18	6,073,529	337	18	4,950,000	280	13	1,671,585	126	18	4,731,278	264	17	4,250,000	250	22	2,916,788	131	22	2,875,309	131
	Total	2,066	759,943,167	368	2,118	788,861,178	373	2,142	788,222,027	368	2,137	793,852,468	372	2,146	788,890,347	368	2,168	816,681,526	377	2,166	769,467,637	355	2,040	704,979,756	346

# Appendices B

## Consolidated Results

Country	Company	2002			2003			2004			2005			2006			2007			2008			2009			
		Production (TWh)	Emission (kt CO <sub>2</sub> )	kg CO <sub>2</sub> /MWh	Production (TWh)	Emission (kt CO <sub>2</sub> )	kg CO <sub>2</sub> /MWh	Production (TWh)	Emission (kt CO <sub>2</sub> )	kg CO <sub>2</sub> /MWh	Production (TWh)	Emission (kt CO <sub>2</sub> )	kg CO <sub>2</sub> /MWh	Production (TWh)	Emission (kt CO <sub>2</sub> )	kg CO <sub>2</sub> /MWh	Production (TWh)	Emission (kt CO <sub>2</sub> )	kg CO <sub>2</sub> /MWh	Production (TWh)	Emission (kt CO <sub>2</sub> )	kg CO <sub>2</sub> /MWh	Production (TWh)	Emission (kt CO <sub>2</sub> )	kg CO <sub>2</sub> /MWh	
France	EDF-France	509	23,690,000	47	513	22,893,000	45	487	20,470,800	42	494	23,707,200	48	491	19,632,000	40	483	20,523,250	43	484	18,436,590	38	454	18,506,880	41	
UK	EDF Energy	20	15,754,611	772	23	17,460,000	776	25	20,477,828	812	23	18,480,300	807	25	20,777,200	818	26	21,060,450	826	27	21,900,000	805	72	23,795,870	330	
Germany	EnBW	65	16,766,516	488	75	20,858,100	277	73	19,229,245	263	74	17,811,200	242	75	18,050,900	241	74	17,713,500	241	67	16,967,200	254	66	15,850,445	241	
Italy	Edison Group	56	35,136,900	624	57	35,130,236	613	61	35,557,800	583	56	33,517,268	597	64	34,885,722	542	66	34,790,908	531	63	32,431,858	514	61	29,932,686	495	
	Edison	35	20,589,000	588	36	21,136,136	587	36	20,648,000	580	33	22,135,218	663	39	21,407,916	542	41	22,015,791	531	NC	NC	NC	42	20,218,086	486	
	Edipower	21	14,547,900	683	21	13,994,100	657	25	14,909,800	587	23	11,382,050	539	25	13,477,806	542	24	12,775,117	531	NC	NC	NC	19	9,714,600	514	
	<b>EDF Group</b>	<b>720</b>	<b>96,745,927</b>	<b>134</b>	<b>669</b>	<b>96,341,336</b>	<b>144</b>	<b>647</b>	<b>95,735,673</b>	<b>148</b>	<b>647</b>	<b>93,515,968</b>	<b>145</b>	<b>655</b>	<b>93,345,822</b>	<b>142</b>	<b>647</b>	<b>94,088,108</b>	<b>145</b>	<b>641</b>	<b>89,735,648</b>	<b>140</b>	<b>652</b>	<b>88,085,881</b>	<b>135</b>	
Germany	RWE	149	114,000,000	765	141	113,000,000	803	149	116,000,000	779	149	120,000,000	808	148	117,700,000	794	176	158,000,000	897	180	141,000,000	785	128	107,900,000	845	
UK	RWE UK	35	21,500,000	623	38	27,500,000	726	34	23,100,000	681	33	22,700,000	680	37	24,700,000	677	34	22,000,000	651	38	25,000,000	665	27	16,600,000	622	
	<b>RWE Group</b>	<b>184</b>	<b>135,500,000</b>	<b>738</b>	<b>179</b>	<b>140,500,000</b>	<b>787</b>	<b>183</b>	<b>139,100,000</b>	<b>761</b>	<b>182</b>	<b>142,700,000</b>	<b>784</b>	<b>185</b>	<b>142,400,000</b>	<b>771</b>	<b>173</b>	<b>147,060,000</b>	<b>848</b>	<b>187</b>	<b>138,460,000</b>	<b>742</b>	<b>169</b>	<b>133,700,000</b>	<b>792</b>	
Central Europe	E.ON	156	52,260,000	335	123	47,158,200	383	127	52,215,190	410	130	53,200,000	410	132	54,000,000	410	136	57,100,000	420	138	54,000,000	390	130	50,600,000	390	
UK	E.ON UK	37	23,132,702	632	36	26,683,000	743	35	25,086,000	719	37	28,000,000	750	36	25,500,000	710	41	30,000,000	730	44	25,700,000	580	37	19,500,000	530	
Scandinavia	E. ON Nordic	0	0	0	0	0	0	53	3,164,557	60	30	300,000	10	20	400,000	20	40	400,000	10	30	300,000	10	20	NC	NC	
Italy	ex Endesa Italia	18	10,881,620	620	18	10,919,000	610	21	11,484,000	550	23	11,681,000	500	25	13,307,240	530	22	11,707,170	530	22	11,707,170	530	17	7,500,000	450	
France	ex SNET	6	5,504,599	971	9	9,068,000	956	10	9,435,315	985	9	7,993,880	920	8	7,588,160	920	8	6,835,840	880	8	8,166,930	972	NC	NC	NC	
	<b>E.ON Group</b>	<b>216</b>	<b>91,778,921</b>	<b>425</b>	<b>186</b>	<b>93,828,200</b>	<b>504</b>	<b>245</b>	<b>101,385,062</b>	<b>413</b>	<b>229</b>	<b>101,174,880</b>	<b>442</b>	<b>221</b>	<b>100,795,400</b>	<b>456</b>	<b>247</b>	<b>106,043,010</b>	<b>429</b>	<b>243</b>	<b>99,874,100</b>	<b>411</b>	<b>216</b>	<b>84,700,000</b>	<b>393</b>	
	Vattenfall	166	68,282,636	411	177	86,209,000	486	193	84,992,000	442	190	80,417,500	422	183	82,659,300	452	184	84,502,500	459	178	81,717,000	459	175	79,046,000	452	
	GDF Suez Europe	115	44,481,000	387	130	41,587,000	320	125	40,825,000	327	123	39,361,000	319	129	40,403,000	314	148	50,520,233	341	145	47,575,442	327	141	45,443,000	322	
Italy	Enel Provisone	137	75,000,000	547	138	71,467,560	518	126	63,408,000	503	112	56,200,000	501	104	48,500,000	467	94	46,723,200	496	96	44,500,000	462	84	37,076,701	441	
Spain	Viesgo generacion	6	5,013,000	823	6	5,013,000	823	6	5,013,000	823	7	6,000,000	823	7	6,000,000	823	0	4,200,000	0	NC	NC	NC	61	31,050,467	507	
Spain	Enel Union Fenosa Renovables	0	0	0	0	0	0	2	631,000	262	1	6,000,000	262	24	28,756,537	1,190	3	0	0	NC	NC	NC	NC	NC	NC	
Spain/Portugal	ex Endesa	91	45,400,000	500	94	44,039,000	470	96	48,509,253	507	94	50,323,438	538	89	44,492,808	501	91	45,529,000	500	101	38,500,000	383	NC	NC	NC	
	<b>Enel Group</b>	<b>228</b>	<b>120,400,000</b>	<b>529</b>	<b>232</b>	<b>115,506,560</b>	<b>499</b>	<b>222</b>	<b>111,917,253</b>	<b>514</b>	<b>206</b>	<b>106,523,438</b>	<b>528</b>	<b>193</b>	<b>92,992,808</b>	<b>495</b>	<b>185</b>	<b>92,252,200</b>	<b>498</b>	<b>197</b>	<b>83,000,000</b>	<b>422</b>	<b>170</b>	<b>77,286,959</b>	<b>454</b>	
Portugal	EDP P	25	15,025,600	601	29	11,400,000	400	26	12,051,710	465	25	14,880,000	590	NC	12,701,000	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Spain	Hydrocantabrico	14	11,873,600	848		11,849,000	935	13	11,842,000	913	15	12,920,000	873	NC	11,775,000	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	
	<b>Groupe EDP</b>	<b>39</b>	<b>26,899,200</b>	<b>690</b>	<b>43</b>	<b>23,249,000</b>	<b>536</b>	<b>39</b>	<b>23,893,710</b>	<b>614</b>	<b>42</b>	<b>28,255,000</b>	<b>677</b>	<b>43</b>	<b>24,484,000</b>	<b>565</b>	<b>43</b>	<b>23,422,000</b>	<b>544</b>	<b>40</b>	<b>19,783,000</b>	<b>500</b>	<b>42</b>	<b>20,007,000</b>	<b>477</b>	

## Appendices C

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