How electricity utilities can make investment decisions for a low-carbon future

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As the debate over global warming grows ever-louder, the electricity industry faces growing pressure to reduce its carbon dioxide emissions. The industry is heading for a low-carbon future and knows it, and this article offers a way for utilities to make the investment decisions needed now that will help them face that future with confidence.

A growing body of scientific evidence is pointing to global warming as a real phenomenon. What cannot be in doubt is the substantial contribution of fossil fuels used in power generation to global CO_2 emissions. Its impact is compounded by rapidly growing global demand for electricity in the face of economic development in emerging countries.

As a consequence, international public and political pressure for the energy sector and energy-intensive industries to address climate change is mounting, forcing them to look at all available options for reducing carbon dioxide emissions. Furthermore, these issues are not simply to be addressed within national boundaries. Regional and international initiatives will need to work alongside national measures to tackle climate change.

There are two main options for reducing carbon dioxide emissions from power generation: reducing end-use demand, and lowering carbon intensity through such methods as fuel switching, using renewable energy sources, and carbon capture and storage. Both options pose challenges to traditional electricity utilities. They will need to decide on how to cope with major changes in a number of areas:

- **Customer behaviour.** Customers of the future could be consuming less electricity and demanding that the energy they do consume is low-carbon yet still cheap and reliable.

- **Mergers and acquisitions.** Carbon considerations could play a big part in future M&A activity. The carbon exposure of companies could affect their strategic attractiveness to potential suitors, and the value of carbon could have a large impact on the valuation of individual companies, for example through the market price of emission allowances they own.

- **Ownership unbundling.** The separation of generation and retail activities from transmission and distribution activities will change decision-making criteria, if companies no longer face the integrated consequences of their decisions. For example, while wind power is a critical low-carbon technology, its deployment is dependent on having suitable transmission and distribution networks that may no longer be under the control of the generation company. Furthermore, the ability to roll out smart meter technologies will depend on where responsibility for metering lies (with suppliers in the UK, and with integrated distribution companies in much of continental Europe).

- **Emerging technology.** Global shifts in the relative fortunes of different technologies (carbon capture and storage, renewable generation options, smart metering) could radically impact the competitiveness of individual electricity utilities. Technology choices and investments they made in the past may prove to have been either prescient or ill-informed.

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The purpose of this article is to explore these changes in more detail and analyse how electricity utilities can prepare for a low-carbon future through investment decisions today. To that purpose, we will:

- Set out the drivers that lead or force electricity utilities to reduce carbon emissions, and the mechanisms through which these reductions are achieved;

- Explain the strategies electricity utilities can pursue to respond to the need for reducing carbon emissions, starting from their current carbon exposure;

- Present a tool that enables electricity utilities to understand the carbon price-formation process and the relative merits of different carbon reduction technologies.

1. Drivers and mechanisms for reducing carbon emissions

Three forces are driving carbon emissions reduction by generators and retailers of electricity:

- Regulation
- Competitive pressure
- Consumer demand

Regulation

At the electricity generation level, there are many examples of regulation stimulating demand for low-carbon technologies. Many jurisdictions have introduced compulsory targets for green energy within the electricity mix.

Regulations to reduce carbon emissions span the entire value chain, impacting on consumers, retailers and generators of electricity.

At the consumer level, governments are tackling climate change through regulations, for example, to improve building standards or stimulate the use of energy-efficient products (e.g. the banning of old-style incandescent light bulbs in Australia and the UK).

At the electricity retail level, European Union requirements to label the sources of electricity on customer bills are intended to help raise consumer awareness. Smart meters, which show consumption in more detail, and in monetary terms rather than in kilowatt hours, have been installed extensively in some countries such as Italy, and will be commonplace in many others within a few years.

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Competitive pressure

As the traditional electricity utility business model moves away from vertically integrated monopolies and towards a deregulated marketplace, competitive pressure between firms is increasing. One mechanism to secure market position is through "green" branding. Utilities that have a greener portfolio, and therefore reduced carbon exposure, may have a competitive advantage over firms that rely more on a base of fossil fuel generation. A recent example

of a company promoting its climate change credentials is Sweden's Vattenfall, which has proposed a burden-sharing model for reducing carbon dioxide in order to manage emissions of greenhouse gases on a global scale. Another example is the UK-based Centrica, which is using its comparatively low carbon footprint as a differentiator.

Consumer demand

Consumer demand for lower-carbon energy is growing, driven by three concerns:

There is a growing awareness of the benefits of being seen to be environmentally responsible. As a result, such consumers are starting to have a strong interest in purchasing "green electricity".

Lower energy bills through higher energy efficiency: Recent high and sustained international prices for coal, oil and gas have led to higher electricity prices for many end-users. Combined with increased awareness, this has encouraged consumers to revisit options for reducing their consumption through, for example, improved insulation, higher-efficiency appliances and low-energy lighting. It has also shown the need for improved information about consumption that can be provided by smart meters.

Ownership control through distributed generation: Technology developments are making consumer-owned generation a viable option. International demand for small-scale wind, photovoltaic and combined heat and power units is growing. As a result, the need for centrally delivered electricity not only will drop, but will also require more investment and development within distribution networks in order to manage swings from consumption to injection of excess power generation back into the grid. Demand for distributed energy is also creating new markets for small-scale heat technologies such as heat pumps.

Environmentally responsible behaviour through energy from renewable sources: More and more consumers are looking to purchase low-carbon electricity, and are fuelling demand for energy from renewable sources. For many large non-domestic consumers this concern is driven by their own branding requirements. There is a growing awareness of the benefits of being seen to be environmentally responsible. As a result, such consumers are starting to have a strong interest in purchasing "green electricity". In the European Union and the USA, players such as Tetra

Pak, Timberland, Ikea and Nutreco purchase significant amounts of green electricity.

Even as consumers are demanding cheap, reliable and low-carbon energy, they recognise that it comes at a price higher than that of dirtier fossil fuels. Research has shown that there is a willingness to pay for greener energy. This willingness to pay varies from country to country and within consumer groups in a country (as shown in Exhibit 1 below). These differences reflect cultural and economic differences, as well as overall awareness of environmental issues and the role of green energy. Utilities that engage with their customers, raising their awareness and helping them understand the issues, will therefore be in a better position to capitalise on this willingness to pay, creating an opportunity to offset some of the higher investment costs they will undoubtedly face moving towards a low-carbon future.

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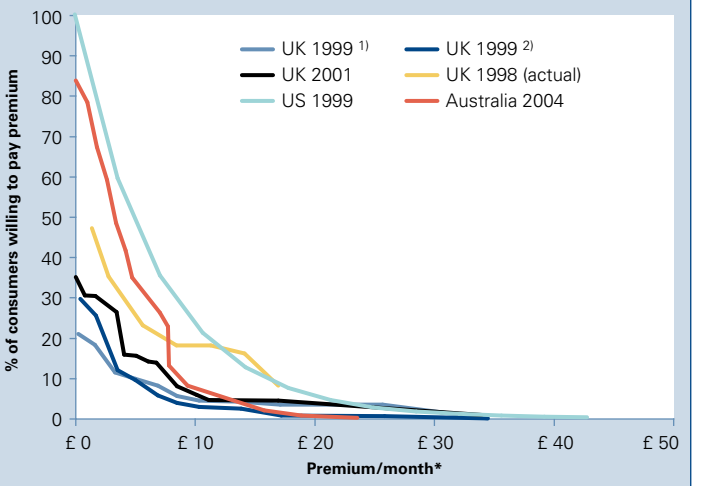
Exhibit 1 **Consumer willingness to pay for green energy**



*Normalised to 2006 UK Pounds Sterling; 1) and 2) refer to different consumer groups
Source: UK: Batley et al. (2001); US: Farhar (1999) and American Wind Energy Association (2001); Australia: Ivanova (2004); Japan: Nomura and Akai (2004); Arthur D. Little analysis

If the drivers for reducing carbon emissions are fairly well understood and globally applicable, market mechanisms to achieve these reductions have developed through two routes: government and private initiatives. The European Union's Emissions Trading Scheme (ETS) is the most visible example of a government-established market mechanism

for the trading of greenhouse gases. It is a cap-and-trade mechanism which leaves it up to participants to decide how best to reach emission reduction targets. Under the ETS, carbon allowances are distributed to EU member states which then, in turn, allocate them to industry. Over successive compliance periods of the scheme, the number of carbon allowances granted is expected to decrease, thereby reducing overall carbon emissions. These reductions are also likely to increase the value of carbon allowances.

While government-led market mechanisms can be seen to be working, there is also a place for private initiatives. The Chicago Climate Exchange (CCX) is an example. Launched in 2003, the CCX is a voluntary collaboration between North American firms which commit to make a voluntary but legally binding commitment to meet annual greenhouse gas emission reduction targets. Membership of the exchange has grown from its original 13 charter members in 2003 to now more than 300 members.

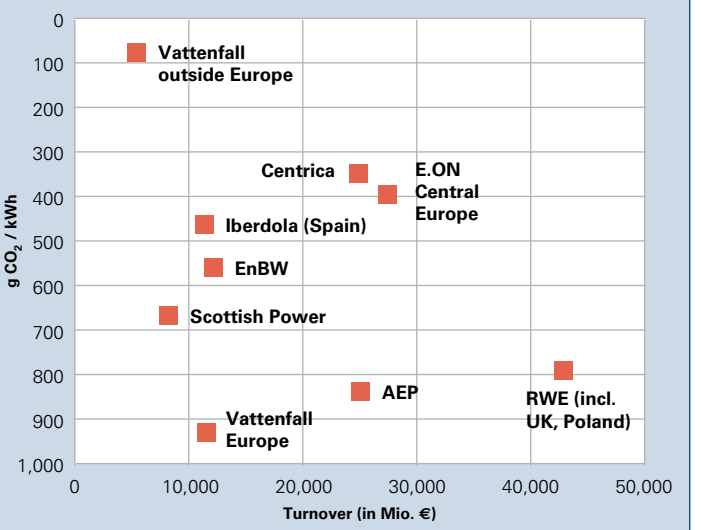
Once you have a clear view of your current carbon exposure position, you can determine feasible carbon reduction goals and the challenges and opportunities to achieve these.

2. Strategies for reducing carbon emissions

Given these unmistakable drivers to reduce carbon emissions, electricity utilities need to establish a carbon reduction strategy. The first step in establishing such a strategy is to determine where you stand today in terms of carbon exposure. Arthur D. Little, in conjunction with E-capital Partners, has developed a standardised methodology for ranking firms based on their "carbon intensity". It is defined as the ratio of the firm's carbon emissions to its economic activity (energy produced). It reflects the efficiency of its business with respect to carbon emissions (based on public information). For illustrative purposes, the carbon intensity of five large European utilities is presented in Exhibit 2.

Once you have a clear view of your current carbon exposure position, you can determine feasible carbon reduction goals and the challenges and opportunities to achieve these. The most appropriate route will depend on your company's position within the value chain, the available options and the technologies that exist or are in development to assist you in the transition.

Exhibit 2 **Carbon Intensity vs. Turnover**



Source: Annual Financial Statements 2005/2006; Arthur D. Little analysis

To see how different starting positions lead to different strategies, let's look at a number of examples. For a company such as Centrica, which already has a low-carbon fuel mix (something it uses to support its brand reputation and strong national retail position) there is an opportunity to engage more with consumers through its New Energy business. The company "offers green, low carbon products and services to customers who want to manage their impact on climate change."

At the other end of the spectrum are companies that have large historical coal-fired generation bases, such as AEP in the United States and RWE and Vattenfall in Europe. They all have significant coal reserves and, perhaps unsurprisingly, are looking more at technology developments, such as higher-efficiency coal technologies linked to carbon capture and storage (CCS). While it is by no means certain that these technologies will be economic on an industrial scale, companies that have built expertise in them will be better positioned should they be proven viable and adopted on a wider scale. This being said, these companies are also pursuing other options, including investment in renewables.

In between these two ends of the spectrum are companies that have a mixture of generating plant and a wide

geographic spread. They have been focusing more clearly than others on power generation from renewable sources. For example, Scottish Power and Iberdola, two companies with proven track records in renewable energy that merged, have a business model in which they invest in different renewable technologies in different national markets. Iberdola now has large development programmes in the US, the UK and Spain, and is considering an IPO of 20 per cent of its renewables business (something seen also elsewhere with EDF's Energies Nouvelles IPO in 2006). In addition, the business model does not focus purely on wind and hydro – two proven technologies – but looks also at emerging technologies through Scottish Power's investment in wave.

One approach available to help management develop a strategy to respond to changes in the carbon price is the use of so-called marginal abatement curves. At the basis of marginal abatement curves are alternative technological options to reduce CO_2 emissions (e.g. a new nuclear power plant, carbon capture, or wind turbines at sea).

3. The relative merits of different carbon-reduction technologies

Whichever of the above strategies an electricity utility pursues, it must understand the carbon price-formation process and the relative merits of different carbon-reduction technologies.

The experience with the European Union's ETS market mechanism has shown that the price of CO_2 emission allowances can change wildly. The price has been on somewhat of a rollercoaster in the two and a half years since the scheme opened. Allowances had traded as high as €30/tonne CO_2 until data showed that more allowances had been allocated than were required by industry. As a result, prices for the remainder of Phase I (2005-2007) are only just trading above €0/tonne CO_2. The European Commission has demanded a greater reduction in national allocations during Phase II (2008-2012) and as a result prices for Phase II have recovered to €20/tonne CO_2. But this is a market view. It's difficult to tell whether the price is "correct".

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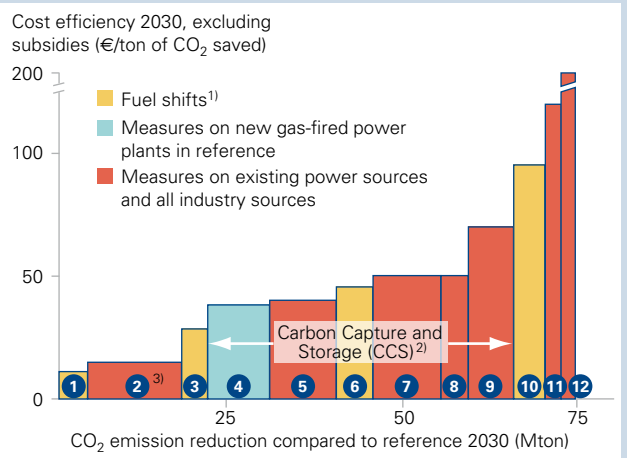
option, the marginal abatement curve shows the volume of CO_2 that can be saved (in tonnes) and the cost per tonne required to achieve that saving.

In order to illustrate the concept, let's look at an example of a marginal abatement curve as applied to a country as a whole. Exhibit 3 shows a result from recent Arthur D. Little work that aimed at informing environmental policy. The vertical axis shows, for each of 12 possible measures, how much money it costs to save 1 tonne of CO_2. The horizontal axis shows, again for each of the 12 possible measures, the total volume of CO_2 that could be saved.

Exhibit 3 **Marginal abatement curve**



Industrial reduction measures

1. New nuclear power plant (1000MWe)
2. Energy demand management in manufacturing industry3)
3. New gas power plant (1000MWe)
4. CCS to new gas plants (4000MWe)
5. CCS to industry sources of non-combustion CO_2 refineries, ammonia)
6. CCS to new coal IGCC plants (1000MWe)
7. CCS to existing coal plants (2000MWe)
8. CCS to existing gas plants (2000MWe)
9. CCS to new large scale CHP (industry)
10. New wind turbines at sea (1000MWe)
11. Biomass purified co-firing (500MWe)
12. Biomass conventional co-firing (500MWe)

1) Competing alternatives to replace new coal-fired power plants up to a total capacity of 4000 MWe. Cost efficiency data relates to the cost differential between the proposed solution and the baseline new coal alternative, not to the absolute cost of the proposed solution.
2) Sum of CCS measures corresponds to annual storage capacity of 45 Mton of CO_2 by 2030
3) Demand savings assumed at 1% CAGR on top of autonomous savings. Consists of industry-specific measures with varying cost efficiencies

Source: ECN/MNP, EU IPPC BREF, expert interviews, Arthur D. Little analysis and estimates

Whilst Exhibit 3 only shows data for the Netherlands, expanding the scope to, for example, all 27 member states within the ETS would enable companies to assess the impact of overall caps on emissions and potentially form a view on the price of carbon.

Just as abatement curves help inform government policy at country level, so can abatement curves at company level help companies assess their own technology options. By assembling available options (such as switching to cleaner fuels, building renewable generation and investing in CCS)

into their own abatement curve, company decision-makers can easily review and rank different options on a level playing field, quickly establishing a way forward in meeting their carbon-reduction goals at the lowest cost.

Obviously, producing a marginal abatement curve is only a good start. Additional effort will have to be spent on mapping dynamics such as the links between consumer demand and fuel mix. Furthermore, an assessment of future technology developments should come into play. For example, for carbon capture and storage there are several technologies available, but which will become the dominant technology? Will it be the first available technology which is currently the cheapest, or will it be the longer-to-develop but ultimately cheaper technology? Finally, key uncertainties such as the cost of nuclear fuel and future prices of oil, coal and gas should be considered.

Insights for the Executive

Changes in the political and public mindset have left electricity utilities facing a future where continued high levels of carbon emissions are untenable. Understanding the drivers that lead or force electricity utilities to reduce carbon emissions is vital to help leaders of today's global electricity utilities make difficult and long-lived investment decisions. By knowing their current carbon exposure and by understanding the carbon price-formation process and the relative merits of different carbon-reduction technologies, they can make these decisions with confidence and devise clear low-carbon strategies.

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