



THE °CLIMATE GROUP



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## FOREWORD

The °Climate Group publishes this first edition of *In The Black: The Growth of the Low Carbon Economy* to showcase the rapid growth experienced by companies providing innovative low carbon products and services. Over the last year in particular, action on climate change throughout the global economy has stepped up a gear. This is fuelling the uptake of the technological solutions and the provision of related financial services.

*In The Black* reflects the diversity of companies both driving and benefiting from the shift towards the low carbon economy – including electricity generators, the car industry, manufacturers of high-efficiency electrical products and the financiers and professional services companies involved in the money and carbon markets. The fundamental message of this report is clear – the economic opportunities of developing low carbon products and services are vast, both in terms of revenues and job creation.

*In The Black* provides an overview of the ‘supply-side’ of low carbon solutions, and builds on the ‘demand-side’ illustrated by the mass of pro-active organisations whose activities in emissions reductions were reported on earlier this year in the third edition of *Carbon Down Profits Up*. The °Climate Group was able to select from a host of organisations and choose only those demonstrating the most positive results in emissions reductions. *Carbon Down Profits Up* is testament to the fact that the benefits of early action far exceed the cost of doing nothing, while *In The Black* drives home the message that the low carbon economy is really the only place to be for any company with an eye to its future.

While not suggesting that mitigating global climate change will come without costs, it is clear that these will be outweighed by the benefits and that for many sectors the dichotomy between environmental protection and economic growth is a false one. *In The Black* demonstrates that action on climate change is more than ever a value proposition – emerging business strategies and entirely new companies across the economy have identified the advantages of offering low carbon products and services. The competitive edge these provide will support the upward spiral of growth within the exciting Low Carbon Economy.



STEVE HOWARD, CEO, THE °CLIMATE GROUP



JOHN VARLEY, GROUP CHIEF EXECUTIVE, BARCLAYS BANK PLC.

MAY 2007

**RENEWABLES  
PROJECTED  
TO SUPPLY  
20% OF  
GLOBAL POWER  
BY 2020, UP  
FROM 4% NOW\***

\*EXCL. LARGE HYDRO

#### FOCUS: PRINCETON WEDGES

EMISSIONS-SAVING SOLUTIONS ARE DIVIDED INTO CATEGORIES INCLUDING 'EFFICIENCY AND CONSERVATION' AND 'DECARBONISATION OF ELECTRICITY AND FUELS', AS WELL AS LAND-USE OPTIONS SUCH AS FORESTRY OFFSETS.

THE 'STABILISATION TRIANGLE' THE AUTHORS ENVISAGE REMOVES EXACTLY ONE-THIRD OF PROJECTED CUMULATIVE BUSINESS AS USUAL (BAU) EMISSIONS AND CAN BE DIVIDED INTO SEVEN EQUAL WEDGES. EACH WEDGE REPRESENTS AN ACTIVITY THAT, AS THE RELEVANT TECHNOLOGY IS REFINED AND INCREASINGLY ADOPTED, WILL DELIVER EVER-GREATER EMISSIONS REDUCTIONS, EVENTUALLY TOTALLING 1GTC/YEAR.

#### THESE WEDGES INCLUDE:

- INCREASED DEVELOPMENT OF WIND, SOLAR AND ULTIMATELY HYDROGEN AS ENERGY SOURCES AND CO<sub>2</sub> CAPTURE AND STORAGE.
- A REDUCTION IN EMISSIONS FROM BUILDINGS BY 25% BY UTILISING KNOWN AND ESTABLISHED APPROACHES TO REDUCING ENERGY USE VIA SPACE HEATING/COOLING, REFRIGERATION, WATER HEATING AND LIGHTING IN RESIDENTIAL AND COMMERCIAL BUILDINGS.
- IMPROVED FUEL ECONOMY FROM 30 MILES PER GALLON (MPG) TO AN AVERAGE OF 60 MPG FOR THE TWO BILLION CARS EXPECTED ON THE ROADS BY 2050 AND INCREASED UPTAKE OF BIOFUELS FOR TRANSPORTATION.

This report is the inaugural publication of a new series that The °Climate Group is launching, tracking the growth opportunities, jobs and value created by companies and organisations that are 'enabling' the shift towards a low carbon economy.

As the uncertainties around the science of climate change have been reduced, the terms of the debate have shifted to the costs of dealing with mushrooming emissions of greenhouse gases. There is a growing body of evidence that suggests that many of these costs – and the massive investment in technology needed – are being overblown and that, within a context of growing policies, incentives and consumer demand, a robust and profitable low carbon economy is emerging. *In The Black* aims to document the green shoots of this new low carbon world.

The pathway to a low carbon economy was described in a framework provided by a seminal 2004 Princeton University study<sup>1</sup> (see Focus). It describes technological options to stabilise greenhouse gas emissions at c.7 gigatonnes of carbon (GtC) per year (the 2004 emissions level) until 2054, during which time they would be expected to double, aiming to reach a level that scientists believe should avoid the worst effects of climate change.

The first three chapters of *In The Black* focus on three areas key to these wedges of carbon reductions: Low Carbon Power, Energy-Smart Products and Low Carbon Vehicle Technologies. The fourth chapter looks at the financing solutions and market creation required. Initially, we have focused on four countries – the UK, Germany, the US and Japan – but in future editions we will include other countries leading in specific areas.

Finally, a note on the data in this report: given the recent nature of the technologies and markets covered, it has been difficult to find consistent data that allows comparison between and across sectors and any data is time-limited in its accuracy. The broad brush nature of *In The Black* also means that we have had to exclude some detailed data. We will, however, publish more of this on our website and believe that, as the first attempt to draw data on the low carbon economy into one digestible report, the information provides one clear message: the shift away from a carbon intensive present to a clean low carbon future is an exciting one, full of opportunities and economic potential. We hope you agree.

## HIGHLIGHTS

### LOW CARBON POWER

- RENEWABLE ENERGY (EXCLUDING LARGE HYDRO-POWER) IS PROJECTED TO SUPPLY 20% OF GLOBAL POWER BY 2020, UP FROM 4% AT PRESENT.
- MORE THAN TWO MILLION PEOPLE ARE EMPLOYED IN THE RENEWABLES SECTOR GLOBALLY, AND MORE THAN 170,000 JOBS WERE CREATED IN 2006 ALONE.
- PRODUCTION OF SOLAR PHOTOVOLTAIC CELLS GREW 45% IN 2005, SIX TIMES THE LEVEL OF PRODUCTION IN 2000.
- THE MARKET CAPITALISATION OF THE 85 LARGEST RENEWABLE ENERGY COMPANIES REACHED US\$50 BILLION IN 2005, DOUBLE THAT OF 2004.

### ENERGY-SMART PRODUCTS

- SPEND ON ENERGY-EFFICIENT PRODUCTS IN THE UK DURING 2005 GREW 11% BETWEEN 2004 AND 2005 TO £1.6 BILLION.
- BY 2012, ENERGY-STAR LABELLED PRODUCTS WILL HAVE PROVIDED US CUSTOMERS CUMULATIVE NET SAVINGS OF MORE THAN US\$84 BILLION.
- IN THE UK, RESIDENTIAL ENERGY-EFFICIENCY HAS DOUBLED SINCE THE 1970S, SAVING CONSUMERS £10 BILLION, WHILST REDUCING CARBON DIOXIDE EMISSIONS BY 28MT CO<sub>2</sub> PER ANNUM; ALMOST AS MUCH AS THE COMBINED EMISSIONS OF THE UK'S COAL POWER STATIONS.

### LOW CARBON VEHICLE TECHNOLOGIES

- PRODUCTION OF BIOFUELS GLOBALLY HAS GROWN 95% BETWEEN 2000 AND 2005.
- MORE THAN 200,000 US JOBS IN ETHANOL PRODUCTION AND CAPACITY CONSTRUCTION ARE EXPECTED TO BE CREATED BY 2015.
- IN THE US, HYBRID CAR SALES HAVE GROWN BY 2,200% SINCE 2000, AND HYBRIDS ARE EXPECTED TO REACH 1 MILLION IN UNIT SALES GLOBALLY BY 2010 AND MORE THAN 7.5 MILLION BY 2020.
- EVEN THE NEWEST TECHNOLOGY, CARS USING ZERO-EMISSIONS FUEL CELLS, ARE EXPECTED BY MANUFACTURERS TO BE IN MASS COMMERCIAL PRODUCTION BY 2015-2020.

### FINANCING THE SOLUTIONS

- IN 2006, INVESTMENTS IN RENEWABLE POWER REACHED US\$71 BILLION, ALMOST 50% UP ON THE PREVIOUS YEAR.
- CLEAN TECHNOLOGY, PARTICULARLY ENERGY-RELATED, IS THE FASTEST-GROWING SECTOR IN VENTURE CAPITAL AND PRIVATE EQUITY, AND IS NOW THE FIFTH LARGEST SECTOR FOR VC IN THE US.
- IN 2006, TRANSACTIONS ON THE GLOBAL CARBON MARKET REACHED US\$29.7 BILLION IN VALUE – OVER TRIPLE THE VALUE FOR 2005.
- MORE THAN US\$8.5 BILLION HAS BEEN RAISED INTO AN ENTIRELY NEW INVESTMENT VEHICLE – THE CARBON FUND.

The global economy is on the verge of a revolution. The growing scientific alarm about global warming – further underlined in the Intergovernmental Panel on Climate Change's (IPCC) Fourth Assessment Report – has concentrated minds around the need to cut man-made emissions of greenhouse gases (GHGs). This is increasingly being met with a policy response designed to encourage a shift in economic activity away from a dependence on fossil fuels, and towards a low carbon future. And companies from all sectors are responding too – not yet on a scale commensurate with the problem but in a way that demonstrates that action to mitigate the build-up of GHGs in the atmosphere can bring economic, social and environmental benefits.

*In The Black: The Growth of the Low Carbon Economy* highlights the startling growth generated by the companies active in renewable energy, biofuels, the manufacture of energy-smart products and low carbon vehicles, and the emerging clean energy and carbon trading markets. These companies – and the growth in revenue, profits and jobs they are generating – are in turn exciting interest from investors and financial institutions that recognise these companies' growing need for capital, and the opportunities for value creation they present. And these are no longer niche markets for a handful of specialised risk-loving investors; major pension funds, insurance companies and investment banks are ploughing money into what are currently the most dynamic sectors of the world economy.

This should not come as a surprise. Numerous recent pieces of research have suggested that much of the challenge of cutting GHGs to safe levels can be met with existing technologies at little or even negative cost. Pacala and Socolow's 2004 work on the 'Princeton Wedges' showed how GHG emissions could be stabilised at current levels – a first step towards the deeper reduction required – using currently available technologies. More recently, work by McKinsey and Vattenfall indicates that at least a quarter of the required emissions reduction can come with a positive economic benefit and that we can avoid dangerous global temperature increases with measures costing less than €40 a tonne of CO<sub>2</sub>e (carbon dioxide equivalents).<sup>2</sup> In total, the cost is likely to be far less than the world spends on defence or insurance and around a third of the estimated impact of recent oil price rises. Moreover, these are solutions that can be adopted now; nearly three-quarters of them require little or no additional R&D investment.

These are the opportunities being grasped by a growing band of entrepreneurs and investors. It is becoming increasingly evident that shifting towards a low carbon economy offers substantial economic benefits. Such an economy has been suggested by the Stern Review to be eventually capable of providing as much as US\$2.5 trillion a year in economic benefits, with the global environmental market projected to be around US\$700 billion by 2010 (or roughly equivalent to the aerospace or pharmaceuticals markets today).<sup>3</sup>

*In The Black* shows how this is happening on the ground, taking as examples Germany, Japan, the United Kingdom and the United States and focusing on low carbon power, energy-smart products, low carbon vehicle technologies and the financial services that underpin them. And the evidence we have found is dramatic. The response to the challenge of global climate change has to date been inadequate, with the costs of action seen as a major impediment. *In The Black* and *Carbon Down Profits Up* show that this is not the case. With courage, vision and ingenuity, leaders can lay the foundations for a low carbon economy that marries economic efficiency and sound stewardship of the earth's climate – in other words, follow the lead of the pioneers showcased in this report. In all cases, low carbon sectors are growing faster than the surrounding economy, generating better returns and creating more jobs per dollar, euro or yen invested.

These findings and the examples presented in this report illustrate the range of opportunities presented by the low carbon economic revolution. For this to be successful, corporate innovation and leadership is paramount, supported by the correct market incentives and regulatory regimes. There are also some other emerging characteristics of this revolution, which are worth drawing attention to:

- Low carbon business strategies, particularly those focused on promoting energy-efficiency within individual businesses, can significantly boost productivity, including increased product output, shorter process cycle times, increased reliability in production, improved product quality, improved working environments, and better morale among workers.<sup>4</sup>
- Energy-efficiency policies tend to go hand in hand with securing jobs and increasing employment.
- Reducing GHG emissions is linked to other significant environmental benefits, particularly in the area of air pollution, but also more generally in cutting waste.
- Partnerships within and across sectors are already and will increasingly be crucial if the initiatives reported here are to be both deepened and scaled up. Indeed, many of the successes of *In The Black* are based on the creation of such partnerships, be they formal or informal; those between local governments, fuel producers and vehicle manufacturers in the case of low carbon fuels and between tax authorities, financial institutions and energy companies for the promotion of energy-smart solutions being but two examples.

We hope that this report will help inform the corporate leaders of today and tomorrow, and the policy-makers who will be responsible for creating the regulatory landscape in which they operate.



## HIGHLIGHTS

- TOTAL GLOBAL INSTALLED CAPACITY FOR RENEWABLES (EXCL LARGE HYDRO) REACHED 182GW IN 2005, OR OVER 4% OF TOTAL ELECTRICITY CAPACITY.
- PROJECTIONS ARE FOR THESE RENEWABLES TO REACH 20% OF POWER CAPACITY WORLDWIDE BY 2020.
- GLOBAL RENEWABLES CAPACITY OVERALL GREW 14% BETWEEN 2004 AND 2005, BUT WIND GREW AT 24%, AND SOLAR AT 60% – COMPARED WITH JUST 2% FOR COAL POWER.
- IN 2006, INVESTMENT IN RENEWABLE POWER REACHED US\$71 BILLION, OUT OF TOTAL ENERGY INVESTMENT OF US\$500-600 BILLION.
- PRODUCTION OF ELECTRICITY-GENERATING SOLAR CELLS IS ONE OF THE WORLD'S FASTEST GROWING INDUSTRIES, UP 45% IN 2005, SIX TIMES THE LEVEL IN 2000.
- BY 2005, MORE THAN 85 RENEWABLES COMPANIES WERE WORTH US\$40 MILLION OR MORE, UP FROM 60 IN JUST ONE YEAR.<sup>5</sup> THE COMBINED MARKET CAPITALISATION OF THE SECTOR REACHED US\$50 BILLION, DOUBLE THAT OF 2004.
- MORE THAN TWO MILLION PEOPLE ARE DIRECTLY EMPLOYED IN THE RENEWABLE ENERGY INDUSTRY WORLDWIDE,<sup>6</sup> OF WHOM 40% ARE BASED IN FOUR COUNTRIES – GERMANY, JAPAN, UK AND THE US. THIS EQUATES TO MORE THAN THE TOTAL NUMBER OF PEOPLE EMPLOYED IN THE ENTIRE ELECTRICITY, GAS AND WATER SUPPLY INDUSTRY IN THE EU-25 COUNTRIES.<sup>7</sup>
- IN GERMANY, THE RENEWABLES INDUSTRY IS THE NUMBER ONE SOURCE OF NEW JOBS.
- BY 2006, THE EUROPEAN RENEWABLE ENERGY INDUSTRY HAD REACHED AN ANNUAL TURNOVER OF €20 BILLION AND EMPLOYED MORE THAN 300,000 PEOPLE, UP FROM €15 BILLION AND 250,000 EMPLOYEES IN 2005.<sup>8</sup>
- EMPLOYMENT LEVELS IN THE US FOR CONSTRUCTION AND INSTALLATION OF RENEWABLE ENERGY TECHNOLOGY REACHED 125,000 BY THE END OF 2005.

Power generation contributes more than 40% of global carbon dioxide (CO<sub>2</sub>) emissions annually,<sup>9</sup> and with global energy demand projected to grow by more than 50% between now and 2030, CO<sub>2</sub> emissions could increase 55% compared to 2004 levels.<sup>10</sup>

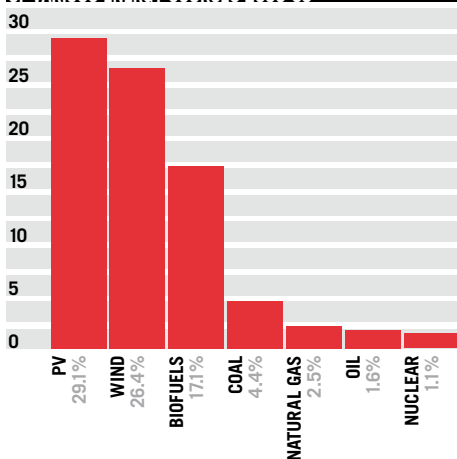
The search for low or zero-carbon power supplies therefore presents one of the greatest challenges – and one of the greatest opportunities – in tackling climate change. The centrality of the challenge was recognised by the leaders of the EU in March 2007 when they agreed a mandatory EU-wide target of meeting 20% of the bloc's electricity demand from renewable sources by 2020. The effort is, however, underpinned by other drivers beside the environmental imperative – security of supply and rising and volatile energy prices are also key concerns for many governments.

Zero-carbon power solutions, with the potential of providing up to 5GtC annual emissions reductions by 2050, include renewable energy, hydrogen and carbon capture and storage (CCS). Of the many forms of renewable power, the two renewable technologies with the most potential for widespread scale-up are wind electricity and solar power. Both solar and wind power are highlighted in the Princeton University study as being capable of providing 1GtC each of the required reductions by 2050.

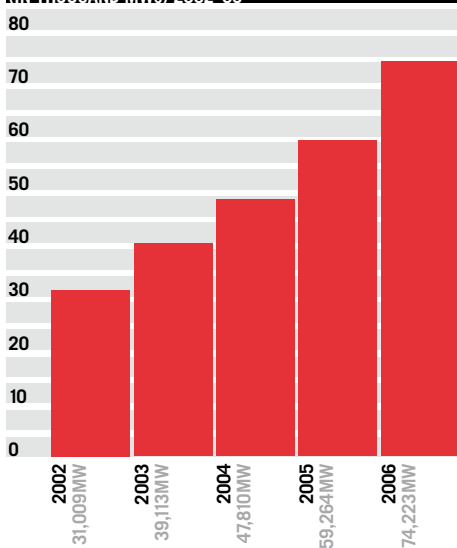
The good news is that the wind and solar power industries are already thriving, with double-digit growth in annual installation, and deployment has brought with it significant net economic benefits.

The Princeton study also highlighted the potential for hydrogen and CCS, in providing up to three of the 1GtC wedges. These options include the further development and use of hydrogen as a fuel for power generation, and the use of carbon capture and storage both in fossil power generation and in hydrogen stations – these are exciting significant interest and, at least for the former, examples of cost-effective uptake are beginning to be seen.

**AVERAGE ANNUAL GLOBAL GROWTH RATES OF VARIOUS ENERGY SOURCES 2000-05<sup>11</sup>**



**GROWTH IN GLOBAL INSTALLED WIND CAPACITY (IN THOUSAND MWs) 2002-06**



## GROWTH TO DATE

As of 2005, total renewable capacity excluding large hydro had reached 182GW, or 4% of total global power generation. This had increased by 14% in just one year.<sup>12, 13</sup> Wind power accounts for 50% of this figure, and solar for 5%.<sup>14, 15</sup>

Our four countries of focus hold 30% of this capacity – Germany and the US each account for 13%, Japan 3%, and the UK around 2.5%.<sup>16</sup> Clear government commitments to renewable energy have helped to overcome barriers to technology uptake, creating demand to underpin dramatic growth, while advancing technological development and driving down costs. Hence, in 2005, of the total global renewables workforce of over 1.7 million, 700,000 people were employed in Germany, UK, Japan and the US.<sup>17</sup>

## FOCUS: WIND POWER

Wind power is clearly the most mature non-hydro renewable energy technology. More than 15GW of new wind energy development in 2006, in more than 70 countries around the world, brings the total of installed wind energy capacity to 74.2GW.<sup>18</sup> Germany and the US have the highest amount, with 20.6GW and 11.6GW respectively. The UK, meanwhile, recently passed the 2GW mark.

About two-thirds of current global capacity is in Europe, including 7.6GW installed in 2006, at a cost of €9 billion.<sup>19</sup> This represented an increase of 23% compared to 2005. However, in terms of the rate of new installations in 2006, the US led with 2.5GW, followed by Germany, at 2.2GW. The chart to the left illustrates the 20%-plus annual growth rate in global wind installation over the past few years,<sup>20</sup> and in particular, the 27%-plus global wind capacity growth rate for the last three years.

The wind industry delivered a 32% increase in installed capacity in 2006 despite supply chain constraints.<sup>21</sup> The total value of new generating equipment installed in 2006 reached €18 billion, or US\$23 billion.

## FOCUS: SOLAR POWER

While much smaller in terms of installed capacity, solar is set to play a fast-growing role in tackling climate change – and solar energy companies have recently delivered substantial returns to investors. In 2005, 1GW of new grid-connected solar came online worldwide, representing a 60% growth rate.<sup>22, 23</sup> At the end of that year, solar had reached more than 5GW in installed capacity. In total, about 90% of solar photovoltaic (PV) installations were in Europe (mainly Germany), US and Japan. These countries have dominated the global PV market and, driven by generous government subsidy programmes, should continue to lead until 2010.<sup>24</sup>

Germany stood out by 2005 with 57% of the global market for PV, up from 50% just one year previously, while Japan, which was the largest market in 2003, now stands at only 20%; the next largest country market is the US, at 7%.<sup>25</sup>

In terms of growth in corporate value, the estimated 2006 year-end market

capitalisation in the global solar sector was US\$22 billion, up from US\$6 billion a year earlier.<sup>26</sup> This increase was partly due to three large solar Initial Public Offerings (IPOs) in 2005: Q-Cells, SunPower and Suntech Power, which raised a total of US\$800 million on the Frankfurt, NASDAQ and NYSE exchanges, where they were respectively listed, and by the end of their first trading day, each had market capitalisations exceeding US\$1.5 billion.<sup>27</sup>

Between 2003 and 2006, the combined average growth rate of the market capitalisation of the global solar sector was 290%.<sup>28</sup> By the end of 2006, the solar PV industry was expected to have invested record amounts in new plant and equipment, about US\$8-9 billion.<sup>29</sup> Investments by the end of 2010 in Germany's solar PV industry alone are expected to reach US\$20 billion.<sup>30</sup>

While support programmes encourage retail uptake of small-scale systems, larger installations are becoming more attractive to corporate consumers. Costs have come down and new business models have evolved to support this uptake – see case study below.

## CASE STUDY: INNOVATIVE PARTNERSHIP FOR SOLAR PV – STAPLES AND SUNEDISON (US)

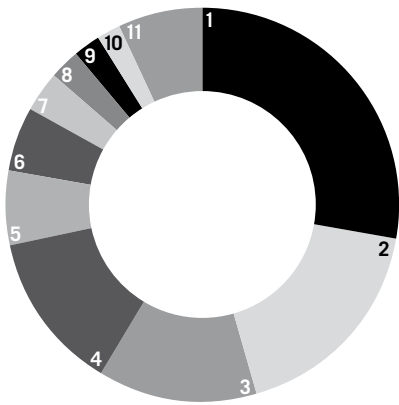
When evaluating options for on-site power generation, many companies have in the past declined to install solar PV systems due to their high capital costs and financial rates of return that typically fall below minimum requirements. As a result, many large power consumers have opted for other clean energy choices, such as wind.

Staples is one of the first major corporations to utilise the 'solar services business model', in which the power customer hosts an on-site generation system and purchases its power but does not own the PV equipment. By eliminating up-front capital expenses, this innovative model provides a financially attractive means to purchase on-site zero-carbon power.

In 2004, Staples signed contracts for two 280 kW on-site solar PV projects at two of its distribution centres in California.

The project developer, SunEdison, arranged the financing, design, equipment supply, and construction of both arrays. In return, Staples signed a 10-year, fixed-price power purchase agreement (PPA) with SunEdison, with the option to renew at five year intervals. Hudson United Capital, an investment company specialising in renewable energy projects, provided construction and senior term loans, while a Goldman Sachs affiliate provided the equity. The PV units were manufactured and installed by BP Solar.

The solar services model provides Staples with several benefits. The PV systems reduce the amount of power Staples buys from its retail electricity provider during the peak hours of the day. They reduce the company's greenhouse gas emissions, helping Staples to meet one of its major environmental goals. The negotiated price for power is competitive with market rates, and the fixed price provides a hedge against retail electricity price increases. Furthermore, Staples avoids capital expenditures and maintenance costs for the PV system.



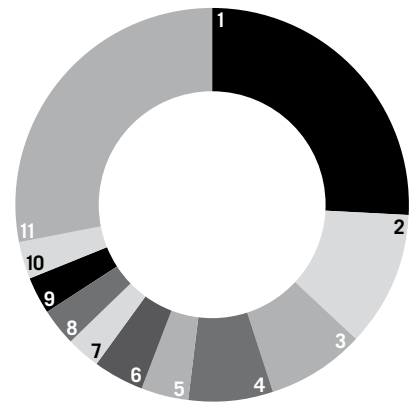
TOP 10 WIND TURBINE SUPPLIERS IN 2005			
Company	Cumulative Capacity	Market Share	
1	Vestas	3,183MW	28%
2	GE Wind	2,019MW	18%
3	Enercon	1,506MW	13%
4	Gamesa	1,472MW	13%
5	Suzlon	696MW	6%
6	Siemens	627MW	5%
7	Repower	354MW	3%
8	Nordex	297MW	3%
9	Ecotecnia	240MW	2%
10	Mitsubishi	228MW	2%
11	Others	785MW	7%
TOTAL		11,407MW	100%

YEAR END 2005

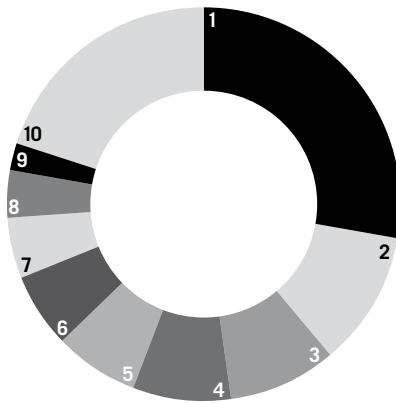
### MAJOR PLAYERS

The wind industry is relatively concentrated, with the top 10 wind turbine suppliers in 2005 claiming more than 95% market share (see table to the left).<sup>31</sup> Likewise, the solar PV manufacturing industry is concentrated among the top 10 PV cell and module producers with 80% and 70% of the world's market respectively (see tables below and to the right).

- JAPAN'S SHARP AND KYOCERA INCREASED THEIR PRODUCTION OF SOLAR PV CELLS BY MORE THAN 30% IN 2005.<sup>32</sup>
- GERMANY'S Q-CELLS, THE TOP EUROPEAN SOLAR PV CELL PRODUCER, MORE THAN DOUBLED PRODUCTION IN 2005.<sup>33</sup>
- SOLARWORLD AG ACQUIRED SHELL SOLAR IN JULY 2006 TO BECOME THE WORLD'S THIRD LARGEST SOLAR POWER COMPANY (SEE GROWTH STORIES: SOLARWORLD AG PAGE 12).
- GERMANY'S ALEO SOLAR COMPLETED A US\$120 MILLION IPO IN THE THIRD QUARTER OF 2006.



MARKET SHARE: SOLAR PV MODULE PRODUCERS (2005) <sup>35</sup>		
1	SHARP	28%
2	KYOCERA	11%
3	SANYO ELECTRIC	8%
4	MITSUBISHI ELECTRIC	7%
5	SOLO	4%
6	MSK	4%
7	SHELL SOLAR	3%
8	BP SOLAR	3%
9	SOLARWATT	3%
10	ISOFOTON	3%
11	OTHERS	28%
TOTAL		100%



MARKET SHARE: SOLAR PV CELL PRODUCERS (2005) <sup>34</sup>		
1	SHARP	28%
2	Q-CELLS	11%
3	KYOCERA	9%
4	SANYO ELECTRIC	8%
5	MITSUBISHI ELECTRIC	7%
6	RWE SCHOTT	6%
7	BP SOLAR	5%
8	ISOFOTON	4%
9	PHOTOWATT INTERNATIONAL	2%
10	OTHERS	20%
TOTAL		100%

### NEW ARRIVAL - CLIPPER WINDPOWER (US)

Clipper Windpower is a rapidly growing wind energy technology, turbine manufacturing, and wind project development company. With offices in California, Colorado, Maryland, Mexico and the UK, and manufacturing and assembly facilities located in Iowa, the company designs advanced wind turbines, manufactures its 2.5MW Liberty wind turbine and actively develops wind power generating projects in the Americas and Europe. Clipper's project development activities include approximately 6,000MW of wind resource rights, with new project sites being actively pursued. In September 2005, Clipper was listed on the London Stock Exchange's Alternative Investment Market (AIM), raising just over US\$85 million. Since the listing, the company has become the best performing renewable energy stock on AIM. Shares in Clipper jumped more than 75% in July 2006 when the company announced a deal with BP to jointly develop five wind farms in the US.<sup>36</sup>

While the renewable energy space is spawning technology start-ups, niche developers, and fast-growing equipment manufacturers, the sector is also providing opportunities to more established players. Several of the companies noted here are conglomerates, with industrial divisions focusing on R&D, installation and scale-up of many different energy technologies. As it is impossible to predict which technologies are to be the most successful in the future, a number of companies, such as Mitsubishi, BP, Shell and GE are hedging their bets somewhat by taking a portfolio approach.

To take two examples:

**GE** is the world's second largest company, and one of the leading suppliers of power generation and energy delivery technologies. Its 2005 sales reached US\$150 billion with net earnings of US\$16.4 billion. The company has created a new product range called Ecomagination, which gathers together all its products with environmental and energy-efficiency benefits, including wind turbines. This had generated revenues of US\$10 billion by mid-2006, following just one year's stand-alone operations. The 38 products it currently offers in the Ecomagination range are to increase to 60 by 2007. US\$1.5 billion of GE's R&D budget will be committed to this segment annually by 2010. In February 2007, GE signed a deal to hand over its 165MW of German wind farms to a French developer called Theolia in return for an equity stake of up to 22%, and it is also buying a 70% stake in the Class A equity of six wind farms of 410MW in the US. The company is developing a diversified energy strategy.

**BP** is one of the world's largest energy companies, with interests in more than 100 countries and more than 96,000 employees. BP Alternative Energy was formed in 2005 and brings together all BP's interests in low and zero-carbon power generation: BP Solar, the company's photovoltaic business; wind power generation; hydrogen power – which combines fossil fuel power generation with carbon capture and storage; and BP's natural gas-fired power interests. BP Alternative Energy has an active wind development portfolio in Europe, North America and Asia; the company's hydrogen business includes two announced projects (in Los Angeles and in Peterhead, Scotland).

## GROWTH PROJECTIONS

Wind power generation is expected to almost double between 2006 and the end of 2009, reaching a total installed capacity of 124GW, and close to double again by 2012, to 200GW.<sup>37</sup> To put this in context, 200GW would provide enough power for more than 100 million homes in Europe, from a total in the EU-25 of c.195 million.<sup>38</sup>

In terms of the global power generation mix, wind is likely to achieve the biggest percentage increase in market share, from 0.5% now to 3.4% in 2030.<sup>39</sup>

The global solar PV industry is also expected to expand manufacturing capacity by several hundred MWs, to potentially 2GW during the period from 2006 to 2008,<sup>40</sup> and up to 3.9GW in 2010.<sup>41</sup> By 2010, worldwide solar industry revenues are forecast to reach US\$18.6-US\$23.1 billion, virtually doubling in five years, from US\$12 billion in 2005.<sup>42, 43</sup> (see Case Study: UK Wind Developer Green Peninsula Sees High Growth in Demand).

Drivers of distributed energy take-up include a desire among high-energy users to control their own power supplies. Momentum on the introduction of carbon-pricing via tax or trading is unstoppable and companies recognise that both energy and carbon represent a business risk. Many are now looking to future-proof themselves against energy-price volatility. A further benefit to the use of renewable energy, is the positive impact on reputation, experienced by those companies who choose to install highly visible wind turbines or solar panels.

The projected growth of the renewables industry, due to the current support measures in place, is expected to give rise to a net increase of hundreds of thousands of jobs in the EU by 2020 (of which 70% will be in the renewables industry – mainly wind – and 30% in agriculture – mainly producing feedstocks for biofuels). In Germany alone, 100,000 jobs in renewables are expected to come online by 2020. In terms of the proportion of the labour force supporting renewable energy by 2010, it is projected to reach up to 1% in the EU as a whole, more than employed in the entire electricity, gas and water supply industries in 2005. Job creation in the US is expected to reach 50,000 by 2010.<sup>44</sup>

## CASE STUDY: UK WIND DEVELOPER GREEN PENINSULA SEES HIGH GROWTH IN DEMAND

Green Peninsula is a specialist development company that helps businesses and organisations make the transition from passive consumers to active generators of green power – primarily from large wind turbines on their own land. The company provides a complete project development service from initial feasibility studies through to operation. The need has arisen as business has become increasingly focused on environmental issues – in particular climate change. Large turbines are a graphic demonstration of green credentials. Recent fluctuations in energy prices have also been a key driver as wind generation offers an opportunity to hedge against fluctuations in fuels and electricity prices.

Longer term, Green Peninsula says it makes sense that companies generate their power close to where they are using it. The company currently has a 2MW turbine site in planning for its major retail client Asda at a refrigerated distribution depot at Falkirk, which has met with a positive response from the local community.

As well as increased levels of control over energy prices for high energy users, another major bottom-up driver for the uptake of distributed generation includes the property development market, which has challenging targets to reduce energy use. Low carbon developments with renewable energy requirements are becoming more common – the UK government is keen to progressively tighten building codes in order to achieve zero-carbon new buildings by 2016. Many property developers are therefore in talks with renewables providers.

The wind industry and wind turbine technology has matured significantly this decade, and is the fastest growing of the new renewable technologies. Demand for turbines has in fact outstripped supply and many customers have been told they will have to wait up to two years for turbines. Particularly noticeable has been the US market growth, which has been hoovering up turbine output, and in the first-quarter of 2006, turbine prices went up by 25%. Commodity and parts prices have now levelled off somewhat – manufacturers are rapidly building plants in China and buying up the component supply chain to increase vertical integration.

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**UK: WIND  
TURBINES  
CAN NOW  
GENERATE  
ENOUGH  
POWER FOR  
1.1 MILLION  
HOMES**

## COUNTRY-LEVEL OVERVIEWS

### UK

#### RENEWABLES SUCCESS

In February 2007, operational wind capacity in the UK passed the 2GW milestone, meaning that the UK has now joined only seven countries in the world with 2GW or more of installed wind turbine capacity. Turbines can now generate sufficient electricity for 1.1 million homes and it is expected that total cumulative wind capacity will have increased threefold by 2010, to reach 6GW.

Solar power generation capacity, on the other hand, is still very limited, with just 10.7MW installed at the end of 2005.<sup>45</sup> While Germany is on course to install up to 12GW of solar PV capacity by 2012, the UK – which has a similar sunshine profile to Germany – could also produce 12GW of solar electricity by 2023 (the same amount as its current nuclear generation capacity) if production is expanded by 40% per year, less than the world increase of 57% in 2004.<sup>46</sup>

However, in contrast to other developed countries, the UK has curtailed its major PV demonstration programme. The programme to install roof panels ran from 2002, ending in March 2006 after a total spend of £31 million for only 3,500 roofs. However, this has been replaced by the Low Carbon Buildings Programme, which allocates grants for a range of building-related micro-generation technologies, and reports a high demand from applicants.

#### DRIVEN BY

- Concerns over energy security and increasing reliance on non-domestic gas.
- 10% target for renewables in power generation by 2010 – via the 2002 Renewables Obligation (RO).
- A recent extension of the RO to a 20% target by 2020, providing longer-term stability to the renewables industry.
- The 2001 Climate Change Levy (a tax on the use of fossil fuels) encouraging companies to undertake carbon-reduction strategies in exchange for an 80% reduction in the CCL. A total of 3,000 such Climate Change Agreements have been entered into, which will cut emissions by six million tonnes a year by 2012.<sup>47</sup>
- The proposed climate change bill will continue to drive progress, aiming for a 60% cut in emissions by 2050.

## CREATING DOMESTIC VALUE

Together, the Renewables Obligation and the Climate Change Levy will help support green power markets of £1 billion a year by 2010,<sup>48</sup> and demand for these new technologies has supported significant job creation. The 17,000 firms that constitute the UK environmental industries sector, including energy, employed 400,000 people in 2004, up from 170,000 in 2001.<sup>49</sup>

Collectively, these companies were worth £25 billion in 2004, up from £16 billion in 2001, and projections are for them to increase in value to £34 billion by 2010 and to further rise to £46 billion by 2015, employing an additional 100,000<sup>50</sup> workers. The total number of jobs will comprise nearly 1.8% of the entire UK workforce, the same as employed now in all agriculture, fishing, forestry, mining and quarrying activities combined.<sup>51</sup>

These high rates of growth compare with the overall rate of growth of the UK economy of 2.7% in 2006, and 1.9% in 2005.<sup>52</sup> The offshore wind industry alone will employ up to 19,000 people within the next 10 years, according to the British Wind Energy Association.<sup>53</sup>

Scotland, in particular, is playing a crucial role in the future expansion of renewables given its large marine and wind resources – the forecast is for 3.4GW of the UK's total expected 6GW in wind power to be installed in the country.<sup>54</sup> The Scottish renewable energy sector encompasses approximately 2,000 businesses including multinationals, large Scottish global companies, and a strong SME base. Estimates put output at £63 million, with direct employment of 1,500; these figures are forecast to rise to £353 million of output and 8,600 jobs by 2015.<sup>55</sup>

## GERMANY

### RENEWABLES SUCCESS

As of the end of 2006, Germany's installed wind energy capacity exceeded 20GW, up from 18.4GW in 2005 (representing a 30% share of the world's capacity and 45% of Europe's). In 2006, the sector generated 5.7% of Germany's electricity. Despite having only a fraction of the US potential for wind power, Germany has more than twice as much installed capacity, as the country has led the way in installing and developing wind power since the 1990s.

Furthermore, some 40 German offshore projects are planned, including a 400MW offshore wind farm due to start construction in 2008/9. By 2030, offshore wind will provide up to 25GW of capacity, from up to a third of all European offshore wind facilities.<sup>56</sup>

Solar PV capacity now stands at 1.54GW (a 50% share of the world's capacity and 86% of Europe's). In 2005, Germany became the world leader in solar PV installations, surpassing the former leader Japan, when a new total of 837MW of solar PV capacity came online.<sup>57</sup> Up to 2004, annual installation of PV capacity in Germany increased almost thirtyfold to 363MW, and system price has decreased by more than 20% since 1999.

It is predicted that Germany will have 12GW of PV generating capacity by 2012, or the same capacity as the entire of the UK's nuclear power plant fleet, if it continues to expand its solar energy programme at the present rate.

### DRIVEN BY

- A goal for 12.5% of power generation to come from wind and other renewables by 2010.
- Moves to cut reliance on foreign sources for energy – Germany imports all of its uranium for its nuclear power plants, and more than 83% of its natural gas.
- Provision of support to grow successful industries to create jobs and economic wealth, in response to an average unemployment rate of 12%.
- The 2004 introduction of high feed-in tariffs under the German Renewable Energy Law (EEG), proving the most successful renewables support system implemented in Europe.
- The 100,000 roofs programme, providing low-interest credits for the operators of solar systems.

### CREATING DOMESTIC VALUE

A significant amount of national renewables capacity is manufactured and installed by between 800 and 1,000 domestic companies.<sup>58</sup> Germany has 10% of the global renewables workforce, with 170,000 people, and renewable energy is the country's number one job creator. Between 2004 and 2005, employment rose by 13,000, an 8% increase, against a backdrop of 12% unemployment. 100,000 new jobs are expected to come online by 2020.

Furthermore, skills developed by Germany's renewables industry are highly valued and have created significant opportunities in the export of goods and services relating to renewables.<sup>59</sup> For example, German turbine manufacturers and suppliers produced over half of the turbines and components manufactured worldwide in 2004.

With a turnover of €4.5 billion in 2005, the wind industry in particular is a major employer in the German renewables landscape, with 64,000 jobs<sup>60</sup> at the end of 2004 accounting for more than 40% of all renewables jobs in the country. Another 10,000 jobs are expected to be created by the ongoing development of the offshore wind industry.<sup>61</sup>

As of 2005, the solar industry (comprising production, installation, trade and maintenance) employed 30,000.<sup>62</sup> Annual turnover in the solar sector reached €3 billion in 2005,<sup>63</sup> up from €1.5 billion in 2004.<sup>64</sup> Double-digit growth is expected in the solar industry in Germany in the coming years. In fact, two of the world's three largest solar companies, Q-Cells and SolarWorld, are based in Germany and the country is the second-largest producer of cells and modules in the world, accounting for 23% and 18% respectively in 2005.<sup>65</sup>

### GROWTH STORIES: SOLARWORLD (GERMANY)

SolarWorld, headquartered in Bonn, was founded in 1999 as a distributor of solar PV modules. Gradually, the company evolved into a fully integrated solar energy company, having added to its operations cell and module production, 'plug and play' system marketing, as well as development and installation of solar projects.

Among the numerous divisions of SolarWorld, Deutsche Solar is the largest wafer manufacturer in Europe, while Deutsche Cell had almost tripled its PV cell manufacturing capacity to 160MW by the end of 2006 from 60MW at the end of 2005. In July 2006, SolarWorld acquired Shell Solar's crystalline-silicon solar business, which makes solar-grade silicon, wafers, cells and modules in California, Washington and Germany, becoming the world's third largest solar energy company. In 2005, before acquiring Shell's solar assets, the company employed 760 staff and it created an additional 140 jobs in 2006. Together with Shell Solar, the combined company now employs a total of 1,300 people.<sup>66</sup>

Prior to the acquisition of Shell Solar, SolarWorld's revenues had grown on average by 40% a year since 2000. In 2004, helped by the introduction of EEG, Germany's renewable energy law, the company's sales doubled. It is forecast that the company will continue to enjoy robust sales growth of more than 30% each year to 2010. Moreover, 2007 revenues are expected to increase 43%, to US\$630 million, which after Sharp, would make the company the second largest integrated solar company in the world.

**GERMANY:**

**RENEWABLE**

**ENERGY IS THE**

**NUMBER ONE**

**JOB CREATOR**

**100,000**

**NEW JOBS**

**ARE EXPECTED**

**BY 2020**

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**US:**

**RENEWABLES**

**TO GROW**

**FASTER THAN**

**ANY DOMESTIC**

**ENERGY SOURCE**

**– US\$3.5BN**

**INVESTED JUST**

**IN 2005**

## US

### RENEWABLES SUCCESS

Compared to the EU, the US had been lagging in terms of wind power, with just a third of the former's capacity. However, there has been a significant shift in the balance of the global market for renewables – the size and resources available to the US makes it a strong draw for domestic and foreign players. As an illustration, US\$3.5 billion was invested in US renewable energy generating capacity in 2005, making it third in the world for investment after Germany and China.

Today, renewable resources provide just over 6% of total US power, and renewable domestic power production is expected to grow at a higher growth rate than any other domestic energy source. In 2006, US wind capacity grew by 27%, as developers installed 2,454MW of new wind plants, investing approximately US\$4 billion. Capacity is forecast to grow another 26% during 2007.<sup>67</sup>

California has the most ambitious renewable goals in the country and already gets 12% of its power from non-hydro renewables. However, Texas is now the most active state for wind development; the state accounted for one-third of wind development in 2006 and has 2.8GW of wind generation installed, compared with 2.4GW in California. Texas is also home to the largest US wind farm, the 735MW Horse Hollow Wind Energy Centre.

The US is also the third largest producer of solar PV cells and modules globally.<sup>68</sup>

### DRIVEN BY

- The 2005 national energy bill, providing tax concessions for the purchase of equipment and renewables generation plant.
- The Production Tax Credit, established in 1992 and recently extended to the end of 2008, which provides 1.9 cents/kWh of renewable power generated.
- Renewable portfolio standards, adopted by 13 US states, require retail electricity suppliers to supply a certain minimum from renewables.
- Government R&D budgets – the solar PV industry has received US\$170 million in public-private partnerships to help make solar PV cost competitive by 2015.<sup>69</sup>
- All but four US states have incentives in place to promote renewable energy. More than a dozen have enacted new renewable energy laws in the past few years, or strengthened targets. For example, California's governor has set a new goal requiring utilities to obtain 33% of their power from renewable sources by 2020, and the 'California Solar Initiative', a US\$3 billion programme, aims to foster the development of 3GW solar PV capacity in the US state by 2017.<sup>70</sup>

### CREATING DOMESTIC VALUE

Employment levels in the US just for construction and installation of renewable energy technology reached 125,346 by the end of 2005 – and the country could add between 240,850 and 355,000 new jobs if it generated 20% of its electricity from renewables by 2020.<sup>71, 72</sup>

When compared with fossil fuel generation, renewable energy is the greater job creator. For example, the solar industry creates 5.65 jobs per million dollars in investment (over 10 years), the wind energy industry 5.7 jobs, and the coal industry only 3.96.<sup>73</sup> Furthermore, employment in the coal industry has been in steady decline for many years, due to growing automation of coal mining and other processes. Between 1980 and 1999, while US coal production increased 32%, related employment declined 66%, from 242,000 to 83,000 workers. The coal industry is expected to lose an additional 30,000 jobs by 2020, even if coal demand continues to rise.<sup>74</sup>

It is also likely that manufacturing jobs in the renewable industry would go to the states that have suffered the greatest job losses over the last decade, including California, Ohio, Texas, Michigan and Illinois. In fact, the 20 states that would attract the most wind manufacturing jobs account for 76% of manufacturing jobs lost. In addition to direct jobs in the industry, clean energy also has the potential to support rural development in the US up to a potential total of US\$1.2 billion in new income for landowners and farmers from wind turbine revenues.<sup>75</sup>

- US states currently with the greatest amount of renewable technology manufacturing, installation and supporting activities include California and Massachusetts. These clusters of activities help to brand an industry, raising its profile for investors, entrepreneurs and consumers.
- The Northeastern US, including Massachusetts, attracts 25% of the total US venture capital investment in clean energies – parts of the industry are growing at annual rates of between 25% and 35%. In 2002, 40 core clean energy firms reported annual growth rates of 40% to 77%. By comparison, the textiles and apparel industry, a key industry in Massachusetts, lost 7% of its jobs in recent years as a result of globalisation.<sup>76</sup>
- California attracts c.29% of the national venture capital for clean technologies and the industry employs 170,000 people.<sup>77</sup> Estimates for job creation in California from renewable energy include a construction employment rate ranging from 2.57 jobs/MW for wind to 7.14 jobs/MW for PV, and an operating employment rate ranging from 0.12 jobs/MW for PV to 2.28 jobs/MW for landfill gas.<sup>78</sup>

## JAPAN

### RENEWABLES SUCCESS

Japan was one of the first countries to adopt a range of policies and incentives to support the development of renewable energy, driven mainly by the aim of achieving greater energy independence. Until 1997, Japan's renewable energy policies focused on public-private collaboration for R&D, primarily for PV and wind power. The only significant non-R&D programme before 1997 was the '10,000 Roofs Programme', a successful subsidy programme funded by electricity surcharges to pay one-third of the installation costs of household PV, with utilities purchasing any excess power at the retail price of electricity. The 'New Energy Law' of 1997 focused on technology deployment with the goal then that 3.1% of Japan's primary energy supply would come from renewables by 2010. The primary method of implementation featured powerful requirements on energy suppliers to buy electricity generated by renewables.

The country saw a fourfold increase in power generation from renewables between 1992 and 2000. Installed wind capacity has now reached 1.23GW, of which 240MW was installed in 2005 alone.<sup>79</sup> Japan hopes to more than double its total installed wind capacity to reach 3GW by 2010. The country is also the second largest producer of solar cells and modules, and uses more solar cells than any other country. It has already completed the installation of solar panels on 70,000 roofs.

### DRIVEN BY

- The New National Energy Strategy, released in May 2006 and focusing on energy security and meeting Japan's Kyoto targets.
- Support measures from the national government's New Energy and Industrial Technology Development Organisation (working on activities to promote new energy and energy conservation technology and now also responsible for R&D project planning), and the New Energy Foundation (working to promote energy diversity and security).
- The Renewable Portfolio Standard, requiring electricity suppliers to source a percentage of power from wind, solar, biomass, medium/small hydro and geothermal energy. The target is for 12.2TWh or 1.35% of electricity to be provided from these renewables by 2010.
- A tax credit programme that has accelerated market adoption and helped lower costs through volume.
- Government subsidies, available for field testing or promotion of certain renewable technologies such as solar or fuel cells.
- Net metering arrangements allowing consumers to sell back excess supplies in return for a guaranteed premium – instrumental in inspiring consumer interest in solar power.

### CREATING DOMESTIC VALUE

More than US\$2 billion was invested in renewables in 2005, and more than 3,400 jobs created by the renewables sector.<sup>80</sup>

Some of Japan's top companies have carved out world-leading businesses in renewable energy. Since the 1980s, Mitsubishi has pioneered the development of high-efficiency wind turbines that make wind power generation more productive and profitable. Currently, more than 1,380 Mitsubishi wind turbines are in operation worldwide, providing 587MW.

Sharp began developing solar cells in 1959, reaching mass production in 1963. The company now makes a range of PV systems and solar cells, tailored to specific applications, from several materials, such as silicon (single-crystal, polycrystalline and thin-film) and compounds. It leads the market in PV power systems for housing and industry, and is the world's largest producer of solar cells, producing 428MW in 2005 alone, up from 324MW in 2004.<sup>81</sup>

**JAPAN: FOUR  
OF THE WORLD'S  
FIVE LARGEST  
MAKERS OF  
SOLAR PANELS  
ARE JAPANESE,  
WITH SHARP  
THE WORLD  
LEADER.**

## HYDROGEN POWER AND CARBON CAPTURE AND STORAGE (CCS)

Hydrogen is not a fuel per se, but is classified as an energy carrier, like electricity.

It requires energy to form it – either through splitting water into its components of hydrogen and oxygen using renewable energy (in the best-case scenario) or through reforming hydrocarbons such as gaseous methane or gasified coal, or liquid methanol (created from biomass). Hydrogen can be burnt in large power plants just as methane is used in a Combined Cycle Gas Turbine plant.

Another key use for the gas is in fuel cell systems designed for stationary power, generally applied on a much smaller scale than plants used for base-load grid electricity (see Chapter Two). By combining this with carbon capture and storage (CCS) technology, whereby the CO<sub>2</sub> also formed in the creation of hydrogen is stored long term in geological aquifers, rather than released, would allow fossil fuels such as coal or gas to continue to be used without potentially damaging the climate.

The use of CCS technology, both by hydrogen-fuelled plants and also traditional fossil-power or synfuels plants (turning coal into oil), could form up to 3GtC of the 9-10GtC annual emissions savings that will be necessary by 2050.

## GROWTH TO DATE

Interest in hydrogen has grown as it has become clear that the use of carbon-based fuels will have to be scaled back over the coming decades. Regionally, the US hydrogen market was estimated at US\$798.1 million in sales in 2005 and is expected to rise to US\$1.6 billion in 2010,<sup>82</sup> an increase of 100% in five years. The European hydrogen market was estimated to be worth about US\$368 million in 2005 and is expected to grow at an average annual growth rate of 15% to US\$740 million by 2010.<sup>83</sup> Globally, the fuel cell and distributed hydrogen market is expected to grow from a US\$1.4 billion industry (primarily from research contracts and demonstration and test units) to US\$15.6 billion over the next decade.<sup>84</sup>

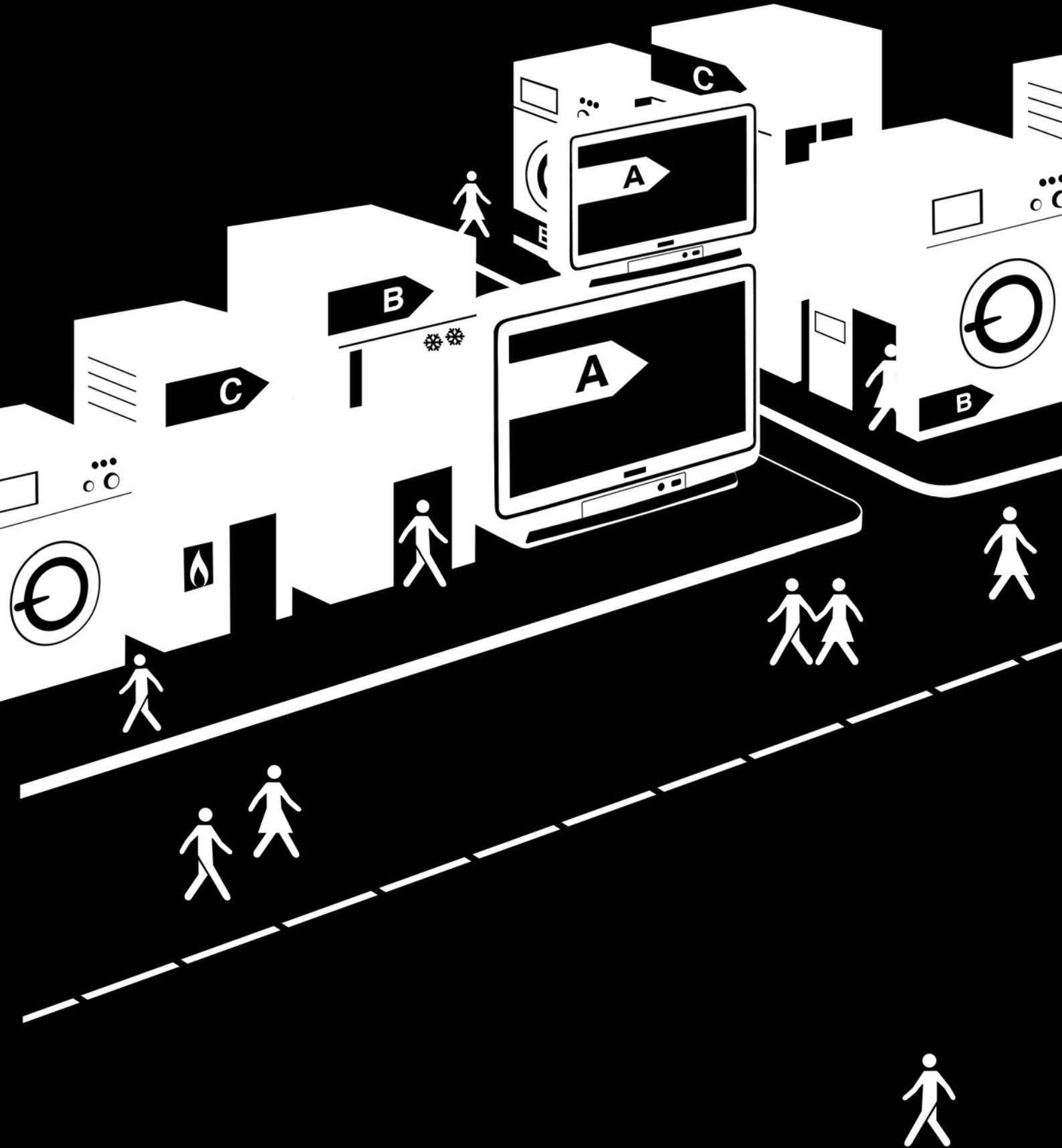
Interest in CCS has also increased significantly over the past few years, as costs have begun to come down. There are a few working examples with oil and gas expro companies re-injecting CO<sub>2</sub> into aquifers to aid oil extraction which, given additional revenues from the extra oil and gas, is already economic. There are now some 12 pilot projects around the world linked to the capture of emissions from industrial or power generation installations, with 20 more in the planning stages. Companies involved in the pilot projects include most major oil companies, alongside a smattering of utilities and oil and gas service companies.

The US National Energy Technology Laboratory, operated by the US Department of Energy, is aiming to demonstrate safe, cost-effective GHG capture, storage and mitigation on a commercial scale by 2012. In one project, in the San Juan basin in northern New Mexico, 75,000 tonnes of CO<sub>2</sub> are to be pumped into an ageing coal-bed methane (CBM) field operated by oil company ConocoPhillips.

## GROWTH PROJECTIONS

Given the potential for CCS to virtually eliminate CO<sub>2</sub> emissions even from traditional fossil power generation, it is possible that this technology will come to be in widespread use for new-build power stations, once it has become more economical. Estimates for the increased costs involved in the use of CCS in electricity production are US\$0.01-0.05 per kWh, depending on the specific technology and location.<sup>85</sup> Early in 2007, the Southern Montana Electric Generation and Transmission Co-operative, developers of a proposed US\$515 million 252MW coal-fired thermal power plant in Montana, announced plans to capture up to 90% of its estimated 2.4 million tonnes of annual CO<sub>2</sub> emissions. The company believes that the additional cost will be offset by reductions in future carbon taxes, and carbon capture is not expected to increase the cost of electricity to more than US\$47 per MWh.

Hydrogen-power generation with CCS technology is at an earlier stage of development. However, in July 2006, GE announced a partnership with BP to build 10-15 hydrogen-fuelled power plants over the next decade, using GE technology. Plans have been announced for two US\$1 billion, 475-500MW hydrogen power plants in Carson, California and Peterhead, Scotland. The California plant is scheduled to be finished in 2011 and the Scottish plant is to be completed by 2010. This latter plant, located at Scottish & Southern Energy's Peterhead power station, will convert natural gas from North Sea fields into hydrogen and CO<sub>2</sub>. The 1.2 million tonnes of CO<sub>2</sub> per year will be sequestered in the BP-operated Miller oil-field more than 4km under the sea bed. BP had been in discussions with the government over potential support incentives (as capital costs will be up to US\$600 million) and was expecting to be able to go ahead with the project in early 2007, but it has now been delayed by at least a year. About 200 construction jobs are expected to be created during construction of the onshore facilities, and 100 permanent jobs at Peterhead Power Station.



## INTRODUCTION

### HIGHLIGHTS

- SPEND ON ENERGY-EFFICIENT PRODUCTS IN THE UK GREW 11% BETWEEN 2004 AND 2005 TO £1.6 BILLION.
- THE LARGEST LIGHTBULB MAKER IN THE WORLD, PHILIPS, HAS SEEN ANNUAL SALES OF ENERGY-EFFICIENT LIGHTBULBS MORE THAN QUADRUPLE SINCE 2001.
- BY 2012, ENERGY-STAR LABELLED PRODUCTS WILL HAVE PROVIDED US CUSTOMERS CUMULATIVE NET SAVINGS OF MORE THAN US\$84 BILLION.
- IN THE UK, RESIDENTIAL ENERGY-EFFICIENCY HAS DOUBLED SINCE THE 1970S, SAVING CONSUMERS £10 BILLION AND REDUCING CARBON DIOXIDE EMISSIONS BY ALMOST AS MUCH AS THE COMBINED EMISSIONS OF THE UK'S COAL POWER STATIONS.
- THE JAPANESE GOVERNMENT PROJECTS THAT ITS NEW ENERGY CODES WILL SAVE THE COUNTRY US\$5.3 BILLION PER YEAR BY 2010 WHILE AVOIDING 34 MILLION METRIC TONNES OF CO<sub>2</sub> EMISSIONS ANNUALLY.
- GERMANY ALREADY HAS THE HIGHEST UPTAKE OF CFLS AMONG THE EU-15, WITH 6.5 PER HOUSEHOLD.

The experts agree: energy-efficiency must be the first priority in tackling climate change. Enormous amounts of energy are wasted by inefficient products, poorly insulated buildings, and a lack of consumer awareness. And – for entrepreneurs, investors and managers – the most compelling thing about energy-efficiency is that many measures quickly pay for themselves in reduced energy bills.

Energy-efficient products and technologies are already playing a key role in cutting power waste, and further rapid market growth is expected. Some companies providing these new technologies are reporting 30-40% annual growth in sales.

Buildings account for about one-third of energy use globally, and electricity demand is expected to rise by about 1.5-2% a year in the OECD countries.<sup>86</sup> The Princeton University analysis includes the potential for reductions of 1GtC through established approaches to improving energy-efficiency in buildings, which translates to a 25% reduction in building emissions by 2050.

Lighting alone accounts for 10-15% of domestic and 25-30% of commercial power use, making the compact fluorescent lightbulb (CFL) an important weapon in the battle to reduce energy use. A total switch-over to CFLs would cut worldwide electricity demand by 18%.<sup>87</sup> The bulbs are typically guaranteed for 8,000 hours and use a quarter of the power of incandescents.

Electric appliances account for 50% of domestic power use and around 10% of household electricity consumption is wasted, through stand-by losses or unused electricity drain. As such, more efficient design in household appliances and electronic goods, including reduced stand-by power consumption, offers substantial power demand reduction potential.

Technologies to improve space and water heating, the major energy use in a building, include more efficient combined heat and power (CHP) systems, or micro-CHP for domestic use. Market demand could be enormous: the total world domestic boiler market is worth around US\$10.9 billion, with 10.46 million units replaced in 2005. Each year, 1.5 million boilers in total are sold in Germany and 1.3 million in the UK.<sup>88</sup> Micro-CHP sales have shown consistent growth over the last five years, most markedly in Germany.<sup>89</sup>

Energy-efficiency also delivers benefits beyond direct cost savings and emission reductions, such as more comfortable homes and offices and quieter motors; stores and schools optimising daylight use can increase retail sales and improve learning; and measurements also show that in efficient buildings, labour productivity typically rises by about 6–16%.<sup>90</sup>

## GROWTH TO DATE

Growing concerns about energy-efficiency within the last 5-10 years are creating substantial market opportunities and economic benefits. Government policy across the four countries covered in this report is moving in the direction of increased energy-efficiency to cut costs – and some companies are beginning to exploit the opportunities created. As well as meeting regulatory energy-efficiency requirements, leading appliance and electronics manufacturers are adopting voluntary standards to reduce electricity use in both operative and stand-by consumption.

Uptake of energy-efficient products has grown given increased availability, consumer awareness and increased electricity costs. These product ranges are therefore creating value for companies tapping into substantial consumer demand.

For example, spend on energy-efficient products in the UK during 2005 was estimated to reach £1.6 billion, up 11% on 2004. In Germany, between 1991 and 2004, the energy-efficiency index for households improved by 9% (a calculation based on eight end-uses including space heating, water heating, cooking and five large appliances).<sup>91</sup> Germany also has the highest uptake of CFLs among the EU-15, with 6.5 per household.

In the US meanwhile, the Environmental Protection Agency estimates that Energy-Star labelled products will have provided cumulative net savings to customers of more than US\$84 billion. Two billion such products have been sold to date.

Japan is aiming for a 30% increase in energy-efficiency on 2006 levels by 2030, through its New National Energy Strategy, launched in 2006, even though it is already considered the most highly efficient country in the world. Japan plans to build a society exploiting next generation energy sources such as solar power, hybrid cars and fuel cell heating. Japan's energy strategy particularly targets the improvement of efficiency in its transportation sector and daily life via tightening efficiency standards in the use of home appliances and fuel-efficient automobiles.

In addition to reducing energy costs and improving energy security, energy-efficiency can contribute to job creation and retention. For example, an improvement in energy-efficiency can divert expenditure from electricity generation – a highly capital-intensive industry – to more labour-intensive industries.

Studies in the US at the regional level, both in energy-producing and energy-importing states, show that improving the efficiency of electricity use of homes and businesses leads to a net increase in jobs, due to the labour required to manufacture, sell and install energy-efficiency products.<sup>92</sup> In 2002, the potential market in the US for heating, ventilation and cooling (HVAC) or energy retrofits was estimated at around US\$180 billion, of which only 2% is realised each year.<sup>93</sup>

In addition, employment has been created by the energy services companies, or 'ESCOs', set up after the oil shocks of the 1970s. These are most common in the US, although they are also well established in the UK and Germany. Such companies typically contract to meet their clients' energy needs for a fixed price, thus providing an incentive for the ESCOs to improve their clients' energy-efficiency.

As of 2000, there were 54 ESCOs in the US (although 75% of the market is concentrated in 13 companies). It has been estimated that the market grew at an average rate of 25% per year during the 1990s, although this slowed down somewhat to 9% per year by 2000. Annual revenues from performance contracting were estimated to be between US\$1.2 and US\$1.8 billion in 2002.<sup>94</sup> ESCO activity outside the US was worth US\$560-620 million,<sup>95</sup> suggesting substantial opportunities for growth. In the UK, ESCOs grew by 15% per year during the 1990s, driven by the increased use of outsourcing in industry, and since 2003, by large increases in gas and electricity prices. In Germany, there were 500-1000 ESCO contracts worth US\$150 million in 2001,<sup>96</sup> and Japan counted 21 ESCOs worth US\$61.7 million in the same year.<sup>97</sup>

## MAJOR PLAYERS

The companies for whom the capacity and incentives to create energy-efficient products for mass take-up are greatest are often the large manufacturers of home appliances, electronics, heating and cooling systems and lighting. Many of these are industrial manufacturers or conglomerates with a wide range of products and large R&D divisions. Below are some who have benefited from meeting new market demands, or indeed, are helping to generate them.

### ENERGY-SMART APPLIANCES:

- Whirlpool is the world's largest home appliance manufacturer, with annual sales of more than US\$14 billion. It has been an Energy Star Partner of the Year every year since 1999. It has always had a strong focus on energy-smart appliances, and has often been a step ahead of consumer awareness and demand for such products.
- Mitsubishi Electrical Corporation is one of the largest Japanese industrial manufacturers, with total sales in fiscal 2005 of JPY3,604 billion (US\$30.8 billion). Eco-products, including energy-efficient air-conditioners, TV and washing machines comprised 74% of FY2005 sales.
- Matsushita Electric Industrial Company is a Japanese electronics giant, with 2006 revenues of JPY8,894 billion (US\$73.9 billion). The company has a goal to improve the GHG efficiency of its products by 50% between 2001 and 2010. By 2003, its efforts had benefited its customers to the tune of JPY18.2 billion in terms of reduced energy costs.<sup>98</sup>

### ENERGY-SMART HEATING/COOLING:

- United Technologies Corporation (UTC) is a large US-based industrial manufacturer with 2005 sales of US\$42.7 billion. Two primary sources of revenue for UTC are air conditioning manufacturer Carrier (29% of total revenue in 2005) and elevator manufacturer Otis (22%). Carrier residential air conditioning systems are 30% more energy-efficient than previous designs and energy savings achieved by Carrier equipment over its lifetime will be equivalent to retiring one million cars. Otis' Gen2 elevator system is 50% more energy-efficient than conventional systems. Gen2 systems are being widely implemented in China, the fastest growing segment of the world elevator market.
- Danfoss is a private company based in Denmark, with a turnover of US\$2.7 billion a year, which manufactures components such as valves, controls, pumps, compressors, drives, and motors for refrigeration, air conditioning and heating systems. New US residential air conditioners regulations, requiring a 30% increase in efficiency, have seen its valves used in one in three new AC systems. Industrial air conditioning units can reap similar efficiencies, by using Danfoss's Turbocor compressors.

These products and others have made the US the fastest growing market for Danfoss. Sales growth for 2006 increased over 30% on 2005.

- Johnson Controls, based in the US, operates in three market segments, including building efficiency involving HVAC and integrated building management systems, and is also the largest provider of facilities management services to the Fortune 500. The buildings efficiency business generated US\$6 billion in revenues in 2005, up 7.4% on 2004.
- Capstone Turbines is the world's leading producer of low-emission microturbine systems and was first to commercialise a viable microturbine energy product in 1998, for use in CHP units. Founded in 1988 in California, and listed in 2000, revenues grew 40% between 2005 and 2006.
- SenerTec is the leading company in Europe for micro-CHP for use in domestic heating. It was set up in Germany in 1996 and is now owned by Baxi Group (a heating and boilers specialist). More than 13,000 of its CHP units are currently installed throughout Europe.

### ENERGY-SMART LIGHTING:

- Philips is the world's largest lightbulb manufacturer, with lighting sales of €4.8 billion (US\$6.4 billion), accounting for 16% of total 2005 revenues. The company is also promoting energy-saving lighting, lobbying European city governments about the benefits of energy-efficient street lighting and promoting CFLs to consumers and architects. Philips expects its sales of CFLs to rise to 325 million units in 2007, up from 65 million in 2001. Sales of environmentally-orientated products rose to €4 billion (US\$5.3 billion) in 2006 – these included several new efficient lighting products, an area in which Philips has invested €400 million in R&D in the past five years.<sup>99</sup>
- GE controls 60% of the market for residential bulbs in the US. Wal-Mart, the world's largest retailer, is partnering with GE to meet its goal of selling 100 million CFLs by the end of 2007, one for every household in the US. This initiative will be a key driver in enabling mass market penetration of CFLs into the US market.
- Siemens is another big global player in the lighting industry, and has offered rebates on energy-saving bulbs through Shaw's Supermarkets, Lowe's and other US retailers. In Germany, Europe's largest lighting market, innovative lighting products generate c. 40% of revenues for Siemens' subsidiary OSRAM.

**FACT:**

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## FUTURE PROJECTIONS

As discussed, cutting energy waste is the cheapest, easiest and fastest way to solve many energy problems, improve the environment and enhance both energy security and economic development. Many corporate energy-efficiency projects – such as retrofits installing, for example, high efficiency lighting, air conditioners, boilers and waste heat recovery systems – quickly pay for themselves. Typical annual returns on investment are 20-40%.

Energy-efficiency uptake is, however, notoriously low, and governments are now very keen to address this. One solution to overcome the perceived effort involved is for electricity utilities to dramatically expand their demand-side management programmes and provide energy-efficiency services to households involving physical upgrades, much in the way that corporate ESCOs operate. Alternatively, as is being discussed currently in Europe and the US, and already committed to in Australia, some inefficient types of products such as incandescent lightbulbs could be banned outright, to enforce uptake of improved technology such as CFLs.

In Europe alone, a 20% reduction in energy consumption by 2020 would deliver:

- A net saving of €60 billion per year, or the present combined energy consumption of Germany and Finland
- Enhanced economic competitiveness
- One million additional jobs, more than those supplied by the entire mining/quarrying sector across Europe.<sup>100</sup>

## COUNTRY-LEVEL OVERVIEWS

### UK

#### BENEFITS FROM EFFICIENCY

In the UK, although absolute energy use has increased, residential energy-efficiency has doubled since the 1970s, saving consumers £10 billion, whilst reducing carbon dioxide emissions by 28Mt CO<sub>2</sub> per annum; almost as much as the combined emissions of the UK's coal power stations. Consumers are now increasingly prepared to invest in solutions to reduce energy use particularly given that, since 2003, the average annual electricity bill has increased by £141 to £383, and the average gas bill has gone up by £300 to £630.<sup>101</sup>

Consumer spending on energy-efficient electrical appliances rose from £1.4 billion in 2004, to £1.5 billion in 2005, a growth of 11%<sup>102</sup> (see table below). Over the same period, UK household expenditure increased by only 1.4%. CFL uptake has increased by 110%, from 10 million unit sales of CFLs in 2001, representing 6.5% market share, to 21 million bulbs in 2005, representing 13% of market share.

#### SUPPORTED BY

- The restriction in sale of inefficient appliances by the 1992 European Council Directive on energy-labelling, A-rated fridge-freezers and washing machines now have 80% market share.
- The UK's Energy Saving Recommended logo used for new home appliances.
- The Energy Star label, adopted for office equipment in European countries, expected to help reduce consumption by about 10TWh/yr by 2015, equivalent to just over 2% of the UK's electricity consumption in 2005.<sup>103</sup>
- Energy-efficiency branding, advertising and retail staff training.
- The 2006 UK Building Regulations which, among other things, specify the need to provide energy-efficient fixed building services.
- A new suite of tax measures announced in October 2006 by the European Commission – covering energy-efficient buildings, appliances, processes and energy systems, and which aims to cut energy use by more than 20% by 2020, reducing the EU's annual fuel bill by €100 billion.

#### LOW CARBON HOUSEHOLD PURCHASING IN THE UK

GREEN PRODUCTS	SPEND IN 2004	SPEND IN 2005	GROWTH
ENERGY-EFFICIENT ELECTRICAL APPLIANCES	£1,361M	£1,511M	11.0%
MICRO-GENERATION	£21M	£26M	23.8%
ENERGY-EFFICIENT LIGHTBULBS	£34M	£35M	2.9%
GREEN CARS	£90M	£138M	53.3%
GREEN ENERGY	£38M	£54M	42.1%

## GERMANY

### BENEFITS FROM EFFICIENCY

Between 1991 and 2004, household energy-efficiency has improved significantly, partly due to improvements in electrical appliances and space heating.<sup>104</sup> Germany has the highest uptake of CFLs in Europe, with 6.5 per household. Micro-CHP systems have also proved popular, with the majority of Europe's 13,000 complement of such systems installed in Germany.

In 2004, the energy-efficiency index for the industrial sectors (by unit of output) improved by up to 23% compared to 1991. This is considerably above the EU average of 12%.<sup>105</sup>

However, there is much potential still to be exploited. The Federal Environmental Agency reports that, in 2004, stand-by consumption alone – reaching 14.7TWh – was equivalent to half the output of all the wind turbines in Germany that year, and 3% of total electricity production. Preventing stand-by losses through improved technology could save German offices and households €3.5 billion annually.

### SUPPORTED BY

- The Energy Savings Ordinance, in force since February 2002 and aiming to reduce the energy requirements of new residential and non-residential buildings by 25-30%. A new Energy Savings Ordinance is planned for 2007.
- A joint nationwide information campaign on efficient electricity use by electricity sector trade associations and the German Energy Agency (Dena), started in autumn 2002.
- The restriction in sale of inefficient appliances by the 1992 European Council Directive on energy-labelling.
- The adoption of various other eco-labels, include Energy Star, for office equipment in European countries.
- Energy certificates introduced under the 2007 Energy Conservation Regulations to kick-start energy-efficiency improvements in the building stock.
- The 2006 European Commission tax proposals covering energy-efficient buildings, appliances, processes and energy systems.

## US

### BENEFITS FROM EFFICIENCY

The 1992 Energy Policy Act (EPACT) standards are expected to save consumers US\$186 billion by 2030. More than 1,400 manufacturers now use the Energy Star logo across a total of 32,000 individual product models, and the logo is now recognised by over 60% of consumers.<sup>106</sup>

The EPA estimates that two billion products with the high-efficiency Energy Star logo were sold from 2002 to 2006. In 2005 alone, the US saved US\$12 billion in reduced energy costs from the use of these products, and prevented the release of GHG emissions equivalent to 23 million cars. By 2012, the EPA estimates that Energy Star will have delivered cumulative net savings of more than US\$84 billion. Currently, the annual energy bill for the US is US\$1 trillion. Without earlier national energy-efficiency efforts, it would be US\$1.5 trillion.<sup>107</sup>

Forward-looking retailers such as Wal-Mart stand to benefit from this new trend. Overall sales of CFLs rose 22% between 2004 and 2005.<sup>108</sup> Krystal Planet Corporation announced that six months into the launch of its green technology product catalogue in 2005, sales were growing by an average 52% per month (624% annualised). Furthermore, policies to promote energy-efficiency within individual businesses can significantly boost productivity. Case studies demonstrate benefits such as increased product output, shorter process cycle times, increased reliability in production, improved product quality, improved working environments, and better morale among workers.<sup>109</sup> The reduced operating expenses associated with energy-efficiency may also help businesses remain competitive, in turn securing jobs. One study also estimated that policies to promote energy-efficient technologies in the US could create 773,000 jobs by 2010.<sup>110</sup>

Reduced power demand resulting from increased energy-efficiency also lowers the risk of brownouts and blackouts at times of peak demand. Two days of rolling blackouts during the California energy crisis in 2001 cost California businesses an estimated US\$1.7 billion in lost productivity.<sup>111</sup>

### SUPPORTED BY

- Energy Star labelling has been key to raising consumer awareness of the more energy-efficient products.
- EPACT energy standards for appliances – these will, by 2020, save the equivalent of the annual energy use of 23 million average US households. For example, between 1990 and 2001, the average energy consumption of a 140-litre refrigerator dropped by 29%.
- Upgrades to standards – the standards for washing machines have been raised by 35% in 2007, expected to result in savings of approximately 100TWh per year by 2020. The 2004 update to the residential air-conditioner standards represents a 23-30% improvement and is expected to result in a reduction of peak demand for electric power by 41,500 MW by 2020.

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**FACT: BY 2010,  
JAPAN'S  
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ANNUALLY**

## JAPAN

### BENEFITS FROM EFFICIENCY

The Japanese government's Kyoto implementation plan projects that its energy codes for households and office buildings will save US\$5.3 billion per year while avoiding 34 million metric tonnes of CO<sub>2</sub> emissions annually by 2010. CFLs, for example, already account for 10% of lightbulb sales in Japan, a proportion that has been increasing year-on-year, partly due to government campaigns.

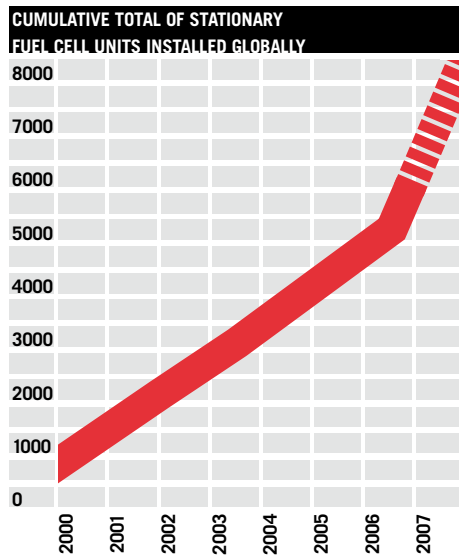
Energy-efficiency can also lead to improved economic productivity, and related job creation and retention. Some of the most electricity-intensive industries in Japan, such as the paper and iron industries, spend an average of 5-7% of their total costs on electricity. If these companies were to optimise energy-efficiency, the reduced operating expenses associated would help businesses maintain competitive prices and retain jobs in Japan.

In summer 2005, Prime Minister Junichiro Koizumi launched the 'cool biz' campaign, encouraging workers to stop wearing ties to work and to set office air-conditioners at 28°C or higher. In Tokyo alone, the campaign is reported to have saved 70 million kW in demand for power over the summer enough to power a city of a quarter of a million people for one month, according to Tokyo Electric Power Company.

The government has also introduced its 'Top Runner' standard, which requires over time all products to reach the same specifications of market-leading 'top runners'. The Japanese government expects this to have resulted in energy savings of up to 59% for video recorders, 63% for air-conditioning systems and 83% for computers by 2010.

### SUPPORTED BY

- Japan's strong energy-efficiency tradition – In 2001, Japan consumed around half of the energy per person of the US.<sup>112</sup>
- A goal to increase energy-efficiency by 30% from 2006 levels by 2030.
- The Top Runner Standard for energy-efficiency.
- The Voluntary Energy Saving Labelling Programme, which covers 13 products.<sup>113</sup>
- The Japanese government's Kyoto implementation plan – including energy-efficiency of machinery and equipment (45% of goal), energy-efficiency in housing and office buildings (43% of goal) and home and building energy management systems (12% of goal).
- The Japanese government's national campaign in 2005 to dramatically boost energy-efficiency in its economy – encouraging the public to replace older, inefficient appliances and to buy hybrid cars.
- Recent goals for boosting appliance efficiency even further, cutting the energy use of television sets by 17%, personal computers by 30%, air-conditioners by 36%, and refrigerators by 72%.



## FUEL CELLS FOR STATIONARY POWER GENERATION

Fuel cells are one of the great hopes for reducing greenhouse gas emissions – if their fuel, hydrogen, is made using renewable energy. A fuel cell is essentially an energy storage device. It produces electricity through an electrochemical process that combines hydrogen and oxygen in the presence of a catalyst, with water and heat the only by-products.

While many hoped that fuel cells would soon replace the internal combustion engine in cars, it is likely that the first wide-scale commercialisation of the technology will be in stationary power generation where, in addition to their emissions-reduction potential, they provide ultra-high reliability power with limited heat output and no noise.

### GROWTH TO DATE

The 2007 PwC Fuel Cell Survey covered 181 respondents, with reported sales up from US\$331 million in 2005 to US\$353 million in 2006. Almost half of all sales (48%) took place in the US, while Japan and Germany accounted for 14% and 12% respectively. R&D expenditure increased by 11% to US\$796 million – mostly in the US and Canada. In the US, forty-seven states and the District of Columbia have some sort of fuel cell or hydrogen legislation, demonstration or activity taking place today,<sup>114</sup> and employment is also up to 7,074 FTEs.<sup>115</sup>

There are currently about 100MW of stationary fuel cell capacity installed globally.<sup>116</sup> To put this in context, total global electricity generating capacity stands at 3,800GW, of which renewables (including large hydro) makes up 930GW. Over three-quarters of stationary fuel cells are used in Japan, with around 12% in the US, 5% in Europe, and the remainder in other Asian countries. The number of stationary fuel cell units globally has risen from 1,000 in 2002 to more than 5,000 by 2006 (see graph). More than 50% of stationary fuel cells are manufactured in Japan, about one-third in the US and around 10% in Europe,<sup>117</sup> and US and Japanese companies dominate in terms of market share.

Japan is still leading the way in the residential sector, with new houses in some areas sold with fuel cells installed. A 1kW fuel cell unit presents an alternative to a standard water heater, providing 100% of hot water needs and the first kW of electricity. However, uptake has typically been within niche markets such as these, as the technology is not currently economic in most applications. The flip-side of this is that percentage growth rates have been rapid, exciting investor interest.

### SUPPORTED BY

Growth has been driven mainly by government R&D support and incentives:

- The Fuel Cell Commercialisation Conference of Japan (FCCJ) coordinates the efforts of government and industry towards the implementation of fuel cell technology.<sup>118</sup> Subsidies for the industry in 2004 totalled JPY32.9 billion (US\$270 million), up from JPY30.7 billion in 2003. The Japanese government further announced

an increase in its investment by 7% in March 2005, bringing total investment to US\$350 million.<sup>119</sup>

- The Japanese national cogeneration fuel cell project.
- The Bush Administration's 2003 Hydrogen-Fuel Initiative, funded to the tune of US\$1.7 billion over five years and the US Department of Energy's award of US\$100 million to fuel cell R&D in October 2006 to fund 25 projects.<sup>120</sup>
- Connecticut's Project 100, aiming to develop 100MW of renewable energy generation by 2008, including large-scale (1MW+) fuel cell plants.<sup>121</sup>
- The Renewable Portfolio Standard initiatives in California, e.g., the Self Generation Incentive Program, which provides incentives for base load capacity provided by fuel cells.
- The 2003 International Partnership for the Hydrogen Economy (IPHE), launched initially between the US and the EU, and now including 16 countries and the European Commission.<sup>122</sup> The IPHE enables the countries and regions involved to coordinate on R,D&D work related to hydrogen and fuel cell technologies. It also provides a forum for developing common technical standards, and keeps stakeholders and the public informed.

### MAJOR PLAYERS

#### US

FuelCell Energy is a manufacturer of various sized 'molten carbonate' fuel cell power plants. Sales increased to 9MW in 2006 from 6MW in both the past two years. However, to become profitable, FuelCell Energy needs to lower its cost per kW for its stationary power fuel cell from about US\$9,000 (as of 2005) to US\$1,500.

Ballard Power Systems and Plug Power are both major North American fuel cell companies providing fuel cells for stationary applications, focusing on domestic cogeneration and industrial on-site energy generation respectively. Ballard's 2006 revenues reached US\$49.8 million, up from US\$42.2 million in 2005.<sup>123</sup> Currently Ballard's system costs are c. US\$45,000, but this is hoped to come down to US\$11-30,000 by 2008 and then to US\$6-13,000 by 2011.<sup>124</sup>

UTC Fuel Cells is the largest supplier of 'phosphoric acid' fuel cell units in the world. Its product, PureCell 200 (200kW/925,000 Btu/hr Combined Heat and Power unit), has been installed in more than 275 sites worldwide. One high profile project that UTC is involved with is the Verizon call-switching centre in Garden City, New York. This location is home to 1.4MW (7 x 200kW units) PAFC power – the largest such fuel cell project in the world.

Distributed Energy System Corp. is the hydrogen electrolysis products leader in fuelling demonstration programmes, with about 10 of these currently running.

Quantum Fuel Systems Technologies Worldwide, Inc. designs, manufactures and supplies integrated fuel systems to OEMs for use in various fuel cell applications.

## EU

Siemens and Energie Baden-Württemberg have announced plans for the first ever 1MW fuel cell power plant capable of producing electricity at 70% efficiency. The groundwork for the planned fuel cell hybrid plant is to be completed in 2008, with the plant running at full capacity by 2012.<sup>125</sup>

European Fuel Cells, owned by the UK's Baxi Group, is developing and testing a 'Fuel Cell Heating Unit' to provide 75% of heating needs for a typical European household.

Ceres Power is working with British Gas and the UK's Department of Trade and Industry on residential CHP for the UK market. Ceres expects to commission a full-size manufacturing facility for the units during 2008.

## JAPAN

Matsushita Electric Industrial Co. is a leader in the Japanese fuel cell market and is actively marketing houses with fuel cell CHP units installed. The company aims to reduce the production cost of the fuel cell CHP units to JPY1.2 million (US\$10,000) by 2008.

Fuji Electric is developing larger 100kW units for small industrial or large building use and has to date released two models, the first of which appeared in 1998. By the end of 2006, Fuji Electric will have delivered a total of 18 units, 16 of which are running off synthetic gas and two off digester gas. Fuji has set a commercialisation date of 2008 for its units and is targeting annual sales of 5–10,000 units, priced at JPY1.5–2 million (US\$12–16,000). By 2015 it is aiming for a reduction in price to JPY300,000–500,000 (US\$2,500–4,000).

Fuji is also developing a small household-size 1kW fuel cell power unit, running on city gas (85% LNG, 5% natural gas and 10% LPG).

Toshiba Fuel Cell Power Systems is a new subsidiary formed by Toshiba to commercialise its 1kW residential fuel cells, by 2008. Its 'Dash to 2008' aims to put a unit on the market costing less than JPY1.2 million (approximately US\$9,500).

Kyocera is developing 1kW 'solid oxide' fuel cells for residential use, and larger units for businesses. The 1kW unit is in collaboration with Osaka Gas, whilst the large unit is with Tokyo Gas and is anticipated to be commercialised in the spring of 2007.

## GROWTH PROJECTIONS

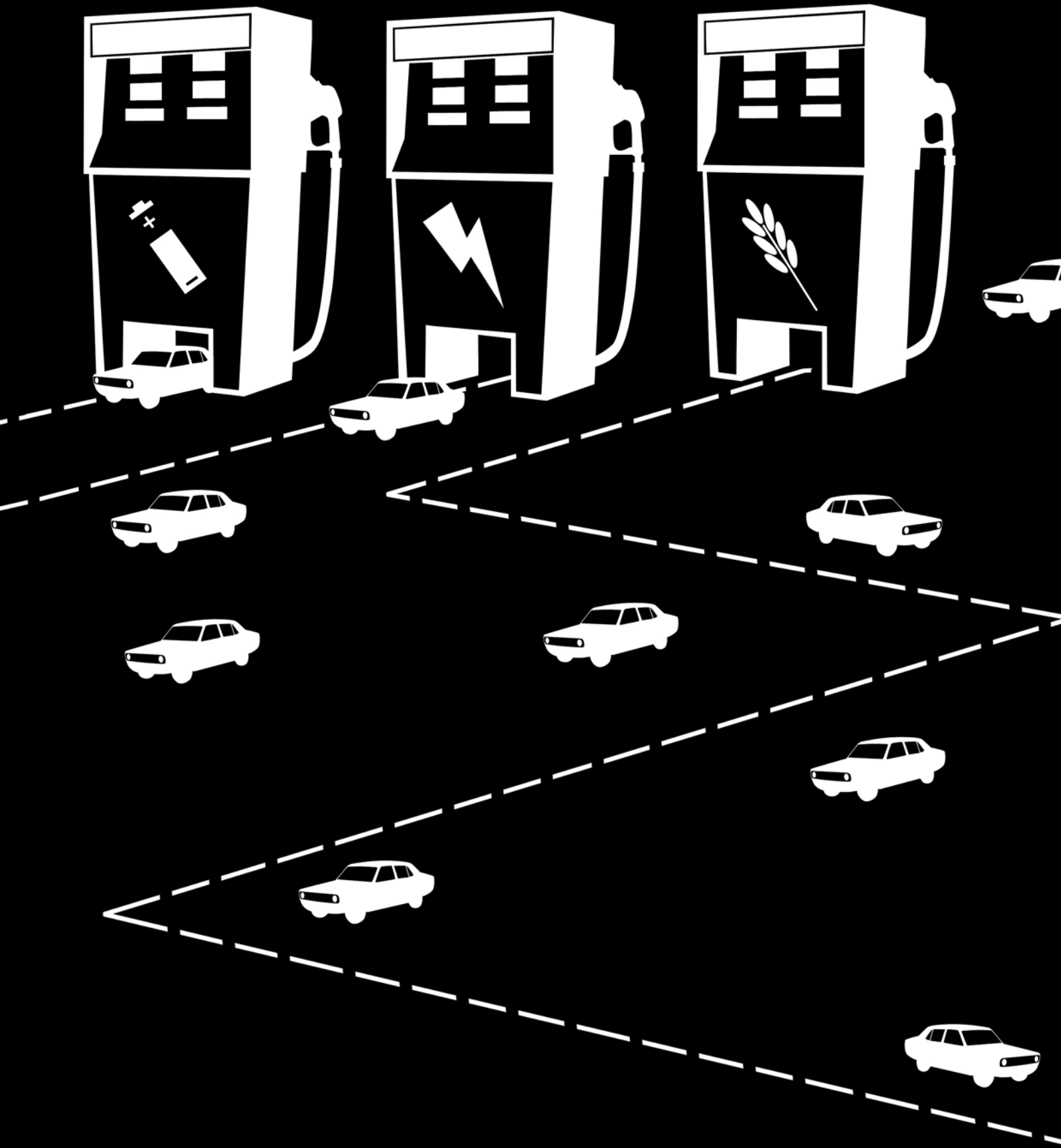
Hydrogen fuel cells based on natural gas are expected, on current trends, to start to become economically attractive in small-scale power generation applications after 2020, producing 1% of total electricity output globally by 2030.<sup>126</sup> It is likely that a combination of recent advances in fuel cell technology and larger customer orders will help drive down manufacturing costs and improve the economic incentives for this technology fairly rapidly.

In terms of market value, the global fuel cell and distributed hydrogen market is expected to grow from US\$1.2 billion in 2005 (primarily for research contracts and demonstration and test units) to US\$15.1 billion by 2015.<sup>127</sup>

Currently, Japan is the major market for fuel cells, although units for stationary applications are installed mainly for trial use. However, Ballard Power Systems certainly sees residential cogeneration in Japan as a near-term commercial opportunity, by around 2009/10. The Japanese national cogeneration fuel cell project provided subsidies of US\$26 million in 2005 and US\$32 million in 2006 for the deployment of 1kW units providing electricity and hot water, and there is a request for US\$32.7 million in the 2007 budget. The market value is estimated to be over US\$9 billion in annual systems sales (1.8 million single family detached households).

By 2010, Japan's Ministry of Economy, Trade and Industry (METI) has set a target for 1.2 million fuel cell cogeneration units to be installed in Japanese households – making up a total of 1.2GW of distributed generating power. That represents around 2% of the country's 47 million households; however, the Japanese government expects that, by 2030, fuel cells will be used in at least 6% of households.<sup>128</sup>

Government policy is backed by oil and gas companies buying into cogeneration, with commitments to launch products that they hope will enable them to compete with Japan's electricity companies.<sup>129</sup>



## HIGHLIGHTS

- PRODUCTION OF BIOFUELS GLOBALLY HAS GROWN 95% BETWEEN 2000 AND 2005, AND IS EXPECTED TO REACH 54-73 MILLION TONNES BY 2015.<sup>130</sup>
- ACCOUNTING FOR ABOUT 5% OF TRANSPORT FUELS.
- INVESTMENT IN NEW BIOFUELS PRODUCTION CAPACITY WORLDWIDE EXCEEDED US\$1 BILLION IN 2005 AND DOUBLED TO REACH US\$2 BILLION IN 2006.
- THE VALUE OF THE MARKET FOR PRODUCTION AND PROCESSING OF BIOFUELS HIT US\$15.7 BILLION GLOBALLY IN 2005, UP MORE THAN 15% FROM THE PREVIOUS YEAR, AND COULD REACH US\$52.5 BILLION BY 2015.<sup>131</sup>
- MORE THAN 200,000 US JOBS IN ETHANOL PRODUCTION AND CAPACITY CONSTRUCTION ARE EXPECTED TO BE CREATED BY 2015.
- BIOFUELS ARE EXPECTED TO CREATE IN TOTAL AN ADDITIONAL US\$200 BILLION IN US GDP FROM 2005-2012 AND NEW INVESTMENT OF US\$6 BILLION IN RENEWABLE FUEL PRODUCTION FACILITIES.<sup>132</sup>
- IN GERMANY, MORE THAN 57,000 PEOPLE WERE EMPLOYED IN THE BIOFUELS INDUSTRY IN 2005.<sup>133</sup>
- THERE WERE SIX MILLION FLEX-FUEL CARS ON US ROADS AS OF MID-2006, AND PRODUCTION IS FORECAST TO DOUBLE TO 2 MILLION CARS AND TRUCKS ANNUALLY BY 2010.
- IN THE US, HYBRID CAR SALES HAVE GROWN BY 2,200% SINCE 2000, AND HYBRIDS ARE EXPECTED TO REACH 1 MILLION IN UNIT SALES GLOBALLY BY 2010 AND MORE THAN 7.5 MILLION BY 2020.
- IN THE UK, GREEN CAR SALES INCREASED MORE THAN 53.3% FROM £90 MILLION TO £138 MILLION BETWEEN 2004 AND 2005.
- THE NEWEST TECHNOLOGY, CARS USING ZERO-EMISSIONS FUEL CELLS, IS EXPECTED BY MANUFACTURERS TO BE IN MASS COMMERCIAL PRODUCTION BY 2015-2020.

Vehicles are responsible for around 25% of man-made greenhouse gas emissions annually – and, worryingly, their emissions are increasing rapidly. Worldwide, more than one billion vehicles are predicted to be on the road by 2025.<sup>134</sup>

As such, vehicle emissions represent a major challenge in addressing climate change. And efforts to address climate change will also help address energy security and costs related to fossil fuels. In the US, net imports account for 58% of total petroleum consumption, mainly from Middle Eastern countries, and the EU buys 82% of its oil from third-party states such as Russia, which is increasingly flexing its muscles where energy is concerned.

But a range of technologies exist to help decarbonise car-travel. Two of the 1GtC emissions reductions ‘wedges’ could stem from these solutions.

Biofuels perhaps provide the first step towards reducing vehicle greenhouse gas emissions. If biofuels are sustainably grown and processed, their use will release only a small net amount of carbon dioxide (CO<sub>2</sub>). If, by 2050, we managed to replace 34 million barrels per day of petrol with ethanol (a production rate 50 times greater than today), we would save 1Gt of carbon every year.

There is enormous investor interest in the sector and plenty of capacity for growth. However, there are hurdles to be overcome, such as concerns over loss of rainforest cover, or land needed for food production, and greater emissions of other GHGs during biofuels cultivation, such as N<sub>2</sub>O from fertilisers.

Energy-smart solutions such as improved fuel economy, e.g., through the use of hybrid-engines or by improving engine efficiency, or using fully-electric systems, offer another approach.

Hybrid car engines use a mix of petrol or diesel and battery-power. The most efficient emit between 42-47% of the emissions of a conventional car engine.

Plug-in hybrids are a mid-step between hybrids and electric cars, allowing owners to recharge at wall outlets, and as the technology and driveability improve, sales of the purely electric Smart and GeeWhiz cars in Europe are growing, and ZAP (Zero Air Pollution) has recently rolled out its first electric ‘XEBRA’ city car in several states across the US.

To save another 1Gt in annual carbon emissions by 2050 would require all two billion cars expected on the roads by 2050 to have doubled their fuel economy, from 30 to 60 miles per gallon.

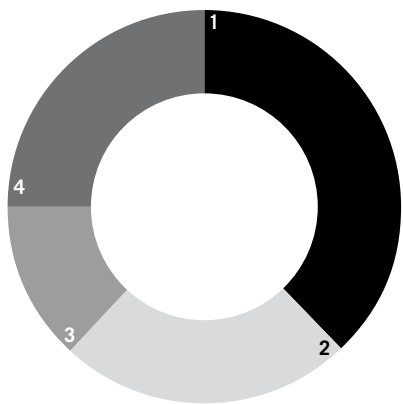
The future might also see the introduction of novel zero-carbon propulsion systems, for example, using hydrogen as an energy carrier alone, or within fuel cells, as discussed at the end of this chapter.

Emission reductions are in the end likely to be delivered by a portfolio of approaches involving all of the above technologies.



TOP FIVE CAR MARKETS IN 2005	
COUNTRY	UNIT SALES
1 US	17M
2 JAPAN	5.6M
3 CHINA	5M
4 GERMANY	3.6M
5 UK	3.5M
6 OTHERS	29.3M
GLOBAL TOTAL	64M

**FACT: THE VALUE OF THE MARKET FOR PRODUCTION AND PROCESSING OF BIOFUELS HIT US\$15.7 BILLION GLOBALLY IN 2005, UP MORE THAN 15% FROM THE PREVIOUS YEAR AND COULD REACH US\$52.5 MILLION BY 2015.**<sup>135</sup>



GLOBAL PRODUCTION OF ETHANOL IN 2005	
1 BRAZIL	38%
2 US	24%
3 EU COUNTRIES INCLUDING SPAIN, UK	13%
4 OTHERS	25%

## GROWTH TO DATE

Globally, government incentives in place to stimulate the growth of new transport technologies include significant tax credits, the waiving of various charges and road regulations applicable to conventional vehicles, government R&D programmes and reduced fuel duty on biofuels.

## BIOFUELS

Such support has helped drive dramatic production growth: from 2000-2005, production of biofuels globally grew 95% from 8.8 to 17.07 million tonnes of oil equivalent (Mtoe).<sup>136</sup>

Biofuel options include:

- Bioethanol (often E85 – 85% ethanol/15% petrol) is made from the fermentation of corn, sugar cane or other such crops and is in widespread use in Brazil, and commonly available in the US.
- ‘Cellulosic’ or second-generation bioethanol can be derived from a much wider range of feedstock, including agricultural waste, using enzymes to extract the sugar. However, the extraction technology isn’t currently commercial. Shell has invested in this sector.
- Biodiesel – often made from soy beans, palm oil or wastes – is used in Europe in particular.
- Biobutanol – a more advanced biofuel, using the same feedstocks, but with superior properties making it more compatible with existing engines and supply infrastructure – is under development by BP and DuPont.

At low blending levels, biofuels can be used in virtually all vehicles, and in fact petrol quite often will have a small amount of ethanol blended in without drivers realising. The growth of the biofuel industry therefore is not necessarily dependent on auto manufacturers producing specifically adapted flex-fuel vehicles (FFVs), although for eventual mass scale-up of this fuel, such a development would be necessary. A market is furthermore emerging for FFVs which, for a small additional cost – less than US\$150 – can be manufactured to accept higher blends of biofuels, particularly required for bioethanol.

Brazil, with its large sugar crop, and vulnerability to rising oil prices, pioneered the development of FFVs and a domestic ethanol market in the 1970s, although the US – driven by government policy and regulation – is following suit. There, the most common fuel used is E85, and there are roughly six million FFVs on US roads. The cars have been popular with both customers and with auto makers, who can earn credits for producing highly fuel efficient FFVs that can be offset against other less efficient traditional cars.

In Europe, biodiesel is much more widely used than ethanol, as about half the cars in use have diesel engines. In the UK, cars and light trucks used twice as much biofuel in 2005 as in 2004, at over 250 million litres (220,000 tonnes) of mostly biodiesel. However, in Europe, there is currently only one model able to run on E85 – the Saab BioPower – available in a few countries. But in Sweden, it has taken 30% of new car sales since its launch there in July 2005. The first Saab BioPower cars have been recently introduced in Germany and the UK, where the first E85 blend petrol pumps have been installed by Morrisons supermarket chain.

Japan’s FFV market is currently very small, as virtually all biofuel has to be imported. However, this is likely to change rapidly, as a government initiative launched in June 2006 aims for 40% of cars to be able to run on biofuels within five years, such as a biofuel blend called gasohol, and there is likely to be financial support for the growth of a domestic biofuel production industry.

In 2005, 2% of the world’s gasoline market and 0.2% of the world’s diesel market were supplied by biofuels.<sup>137</sup> This is expected to rise to 5% by 2010 and almost 10% by 2020. And investors are piling in: investment in new biofuels production capacity worldwide exceeded US\$1 billion in 2005 and reached US\$2 billion in 2006.<sup>138</sup>

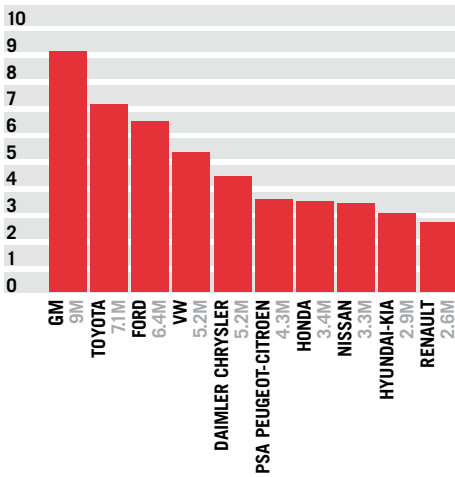
## HYBRIDS

In terms of energy-smart cars, hybrid cars have become increasingly popular with consumers in the US, Europe and Japan since the launch of the first Honda vehicle in 1999-2000, and markets have grown rapidly. Worldwide, hybrids are forecast to reach one million in annual unit sales by 2010.

The US is the largest hybrid market, and Toyota is the clear leader there (and worldwide), mainly via its Prius models, but it is also building sales of its up-market Lexus brand. Its worldwide hybrid sales reached 750,946 units by August 2006, just over half sold in the US, where the company has nearly three-quarters of the hybrid market. Although hybrids currently represent a small percentage of total cars sold – only 2% of Toyota’s 2005 European sales, 3% in Japan and 6% in the US – the company expects hybrids to comprise 20% of all US sales by 2012.

Germany and the UK are the largest car markets in Europe, although neither have yet generated the same level of hybrid sales as the US, and only three or four models are currently available. However, this looks to be changing. In the UK, there are government measures to help support the introduction of hybrids such as low Vehicle Excise Duty and a congestion charge exemption in London. Toyota’s hybrid sales in Europe reached 36,470 units in 2006, an increase of 56% over 2005’s 23,368 hybrid sales. By 2011, at this same rate of increase, sales would reach 336,945 units in Europe.

**NUMBER OF VEHICLES MADE BY TOP 10 CAR MAKERS IN 2005**



**CUMULATIVE NUMBER OF FFV MODELS LAUNCHED TO DATE AND PLANNED**

Company	1999/2000	2001	2002	2003	2004	2005	2006	2007
GM	2	8				9	11	17
DC	1			5	6	7	9	12
TOYOTA								
HONDA	1							
FORD	3	4	7		8		12	
PEUGEOT								
VW								
NISSAN						1		2
HYUNDAI-KIA								
RENAULT								
MAZDA	1							

**CUMULATIVE NUMBER OF HYBRID MODELS LAUNCHED TO DATE AND PLANNED**

Company	1999/2000	2001	2002	2003	2004	2005	2006	2007/2008
GM							2	10
DC								1
TOYOTA	1			2		5	6	10
HONDA	1		3			4		
FORD					1			3
PEUGEOT								
VW								1
NISSAN								1
HYUNDAI-KIA								
RENAULT				1				
MAZDA								1

**MAJOR PLAYERS (AUTO INDUSTRY AND BIOFUEL PRODUCTION INDUSTRY)**

Recent developments in the global auto industry show how vulnerable companies can be to changing customer preferences, driven by resource constraints and environmental concerns. The big US automakers – GM, Ford and Daimler Chrysler – have been hit hard by an over-reliance on gas-guzzling SUVs (comprising 60% of their sales), at a time when more American drivers are switching to smaller, more economical cars due mainly to higher fuel prices.

In 2005, the price of gasoline in the US reached a record US\$3 per gallon in most states. As a result, the craze for SUVs appears to have peaked in 2004-05, at just over four million in unit sales in the US, and to now be on a downward trajectory, falling quickly to near 3.5 million in 2006. Ford has plans to close 16 factories in North America and cut 45,000 jobs. GM has already closed 12 plants and cut more than 34,000 jobs, trying to cut US\$9 billion from 2006 operating costs after a US\$10.6 billion net loss in 2005. Chrysler is cutting 9,000 jobs in the US and 4,000 in Canada.

As SUV sales have dropped, the sale of smaller vehicles has risen. And the beneficiaries have been Japanese firms Honda and Toyota, with their ranges of smaller, more fuel-efficient models. By 2005, Japanese-owned plants in the US were producing four million cars per year, 25% of the whole US output. Toyota is now rolling out its hybrid electric-petrol engine across its entire range. The company is now the world's ninth most valuable – worth more than double the combined value of GM, Ford and DaimlerChrysler (also dubbed 'The Big Three').

The 'Big Three' are being forced to revise their former strategies, and are seeking to emulate Toyota and Honda's success. GM is still the leader in terms of number of models of flex-fuel vehicles and, in 2006, produced 400,000. Moreover, GM, Ford and DaimlerChrysler have announced combined plans to double the annual production of vehicles capable of running on E85 ethanol or biodiesel to two million cars and trucks by 2010.<sup>139</sup>

In Germany, diesel-fuelled cars – which are more efficient than petrol models – dominate the market. VW, the largest car maker in Europe, has to date, therefore, steered clear of launching a hybrid model in Germany, but will introduce one into the US market for 2008. GM, on the other hand, is likely to launch a hybrid diesel within the next few years specifically for the European market.

GM is also attempting to catch up with Toyota's hybrid success by improving on the technology. It has recently announced plans to introduce a production version of a 'plug-in' hybrid. Start-ups such as EnergyCS in California and Hymotion in Canada have already started converting hybrids into plug-ins. Ford also recently unveiled its Airstream Concept vehicle, a plug-in hybrid electric vehicle that utilises a hydrogen fuel cell to recharge the lithium-ion battery while the car is on the road. The vehicle's 'HySeries Drive' powertrain features a Ballard fuel cell.

Employment figures directly linked to hybrid technology are difficult to disentangle from auto manufacturing employment as a whole, but what is clear is that increasing sales of fuel-efficient and hybrid cars made by Japanese car manufacturers both in Japan and in the US are supporting the major Japanese auto manufacture and export industry, and the opening of new manufacturing plants in the US; hence employment creation. For example, the four Japanese-owned US plants opened or planned from 2006-08, will create 4,680 jobs in total, and automobile-related employment in Japan totals 4.86 million and rising.

The success of the hybrid has also driven demand for auto parts and batteries. Some providers benefiting include Johnson Controls, whose battery business saw 29% growth in sales in 2004; Sanyo, which provides nickel-metal hydride batteries for the Honda Accord and Ford Escape hybrids; Denso, which supplies parts for Honda and Toyota; and Eaton Corporation, which provides hybrid power trains in its truck segment, which grew 27% between 2004 and 2005.

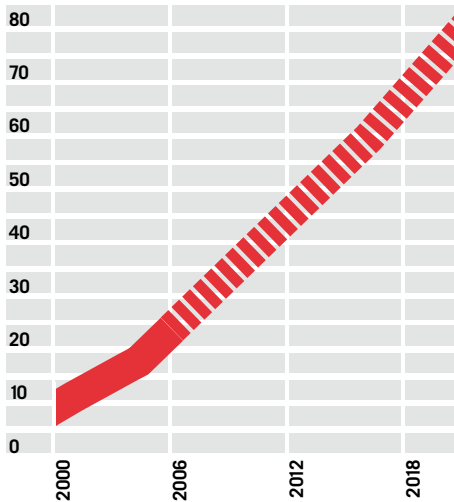
**FACT: ONE MILLION HYBRID CARS WILL BE SOLD GLOBALLY BY 2010, 3.9 MILLION BY 2015 AND OVER 7.5 MILLION BY 2020.<sup>140</sup>**

### GROWTH PROJECTIONS

It is expected that biofuels will account for 5% of transport fuels by 2015 globally.<sup>144</sup> There is substantial potential to reduce the costs of biofuel production processes, and realise ambitions for cellulosic ethanol and possibly biobutanol, a third form of biofuel. Biofuels production and use is currently

dominated by ethanol,<sup>145</sup> however, by 2030, biodiesel is expected to account for approximately one-third globally and about 15% of total biofuels use in both the US and Brazil. Europe will continue to be the main market for biodiesel in the world with announced capacity to reach c.12 million tonnes of production per year by 2010.

**PRODUCTION OF BIOFUELS GLOBALLY<sup>141, 142, 143</sup>**  
(MILLION TONNES)



**MAIN BIODIESEL PRODUCERS IN THE EU – PROJECTED CAPACITY GROWTH**

PRODUCER	COUNTRY	2005	2008	GROWTH IN CAPACITY*	
		PRODUCTION CAPACITY (TONNES)	PLANNED CAPACITY (TONNES)		
1	DIESTER INDUSTRIE	FRANCE	500,500	960,000	92%
2	ADM	US/GERMANY	270,000	545,000	102%
3	EOP BIODIESEL	GERMANY	132,500	332,500	144%
4	NOVAOL (BUNGE)	ITALY	250,000	N/A	N/A
5	MUW/SAUTER GROUP	GERMANY	180,000	330,000	83%
6	FOX PETROLI	ITALY	150,000	N/A	N/A
7	CAMPA BIODIESEL	GERMANY	120,000	480,000	300%
8	BIO-OLWERK MAGDEBURG	GERMANY	100,000	N/A	N/A
9	BIOPETROL INDUSTRIES	SWITZERLAND/GERMANY	300,000	500,000	67%
10	CARGILL DEUTSCHLAND	GERMANY	200,000	650,000	225%
11	NECKERMANN	GERMANY	300,000	580,000	93%
12	OTHERS	VARIOUS	631,000	N/A	N/A

\*Correction to percentage values from 2007 print edition

**MAIN BIOETHANOL PRODUCERS IN THE US – PROJECTED CAPACITY GROWTH**

PRODUCER	2005	TOTAL	2006	GROWTH IN CAPACITY	
	PRODUCTION CAPACITY (GALLONS)	CAPACITY	CAPACITY UNDER CONSTRUCTION		
1	ADM	1,070M	25%	N/A	N/A
2	VERASUN	230M	5%	N/A	N/A
3	AVENTINE RENEWABLE ENERGY	150M	3.5%	57M	38%
4	HAWKEYE RENEWABLES	50M	1%	150M	300%
5	AS ALLIANCES BIOFUELS	N/A	N/A	200M	N/A
6	ABENGOA	110M	2.5%	88M	80%
7	MIDWEST GRAIN PROCESSORS	50M	1%	102M	200%
8	US BIOENERGY CORP	N/A	N/A	145M	N/A
9	CARGILL	120M	2.8%	N/A	N/A
10	NEW ENERGY CORP	102M	2.4%	N/A	N/A
11	ADVANCED BIOENERGY	N/A	N/A	100M	N/A
<b>TOTAL CAPACITY</b>		<b>1,882M</b>	<b>43%</b>	<b>842M</b>	<b>45%</b>
<b>TOTAL US CAPACITY*</b>		<b>4,336.4M</b>	<b>100%</b>	<b>1,981M</b>	<b>46%</b>

\*THE REMAINDER OF THE CAPACITY IS PROVIDED BY ABOUT 70 SINGLE REFINERIES, 70% FARMER-OWNED.

## COUNTRY-LEVEL OVERVIEWS

### UK AND GERMANY

#### SOLUTIONS TAKE-UP

European markets for hybrids are beginning to take off, with a cumulative total of 50,000 in unit sales by Toyota/Lexus between 2000 and June 2006. New fuel-efficiency regulations are likely to support significant further market development for hybrids.

German biofuel use has already reached millions of cars in the country in a low-blend produced under national blending requirements. In the UK, just 0.3% of cars are knowingly using biofuel, mainly because the distribution network is thus far very limited although, as in Germany, there is often an element of unnoticed blending. However, the UK Renewable Transport Fuels Obligation, requiring suppliers to source a rising percentage of renewable fuels, could create in the UK one of the largest biodiesel markets in Europe over the next 5-10 years.

EU biofuels production overall reached 3.9 million tonnes in 2005, up 65.8% from 2004, of which 80% was biodiesel.<sup>146</sup> Production of ethanol in the EU, however, grew 70.5% between 2004 and 2005. Production of biodiesel was expected to reach six million tonnes by the end of 2006 – see table below.

#### DRIVEN BY

- EU fuel efficiency regulations – the European Commission has proposed a mandatory 25% reduction in fleet average CO<sub>2</sub> emissions by 2012, to 130g/km, replacing a voluntary target that the industry failed to meet.
- The EU's Biofuels Directive sets a non-binding target of 5.75% of transport fuels to be biofuels by 2010 (on an energy basis).
- As of February 2007, the EU has set a new target for 2020 of 10% biofuels in the transport fuels mix, but there is an ongoing debate over whether this should be mandatory.
- A combination of tax breaks and blending requirements, subsidies for energy crops and R&D programmes.
- Greater potential for the meeting of air quality targets, given biodiesel's reduced particulate matter burden.

- The UK's Renewable Transport Fuel Obligation, which requires fuel suppliers to source 5% of their fuel from renewable sources by 2010 – this has encouraged investment in some of the largest plants in Europe.
- The UK's £10 reduction in Vehicle Excise Duty for cars running on biofuels, a 20p per litre tax reduction on biofuels, and new biodiesel incentive programmes in 2007 and 2008.
- Germany's Renewable Energy Sources Act (2000 and 2004), which provides tax relief, including a 100% fuel-tax exemption for Biodiesel B100 and pro-rata tax exemption where biofuels are added to fuels.

#### CREATING DOMESTIC VALUE

Investor enthusiasm for biofuels has seen a number of listings, with biofuels producer BioDiesel International raising US\$59m in September 2006 on the Frankfurt Stock Exchange, and Verbio raising US\$236m in October of the same year.

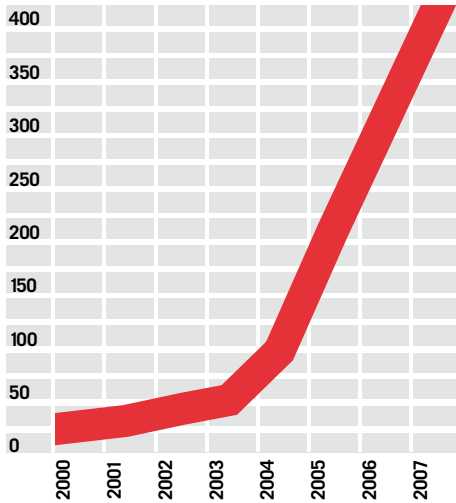
There are employment benefits also. It has been estimated that one job is created for every 70 tonnes per annum of biodiesel production. In Germany, more than 57,000 people were employed in the biofuels industry in 2005, virtually all in biodiesel.<sup>148</sup>

In its Communication on 'Alternative Fuels for Road Transportation' of November 2001, the European Commission expects the rural employment potential from the development of biofuels EU-wide as being 45,000-75,000 new jobs per 1% inclusion level of biofuels. This figure has been based on studies in Germany and Spain.<sup>149</sup> In the UK, 2003 data shows that job creation for biomass as a whole, including biofuels, has so far accounted for 600 jobs, although research from the East of England Development Agency showed that one 100,000 tonne biofuels plant would create 60-80 direct jobs and 550 agricultural jobs<sup>150</sup> and, in this part of the country, agriculture is a more important contributor to the regional economy than the national average.<sup>151</sup> Extrapolating the Commission's work in Europe to the UK, and assuming a 5% bioethanol inclusion level, some 20-30,000 jobs could be created from the development of a 1.2 million tonne British bioethanol industry.

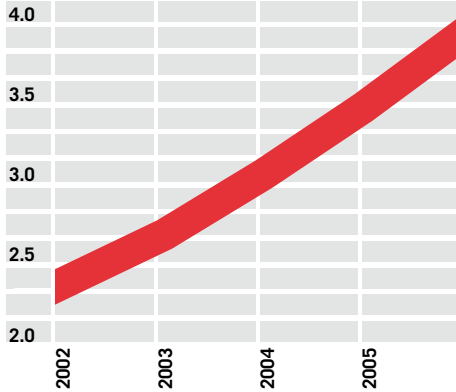
#### GROWTH IN EU BIODIESEL PRODUCTION (TONNES)<sup>147</sup>

COUNTRY	2004	2005	GROWTH	2005	2006
	PRODUCTION	PRODUCTION		PRODUCTION	ESTIMATED CAPACITY
GERMANY	1,035,000	1,669,000	+ 61.3%	52.4%	2,681,000
FRANCE	348,000	492,000	+ 41.4%	15.5%	775,000
ITALY	320,000	396,000	+ 23.8%	12.4%	857,000
CZECH REPUBLIC	60,000	133,000	+ 121.7%	4.2%	203,000
POLAND	0	100,000	N/A	3.1%	150,000
AUSTRIA	57,000	85,000	+ 49.1%	2.7%	134,000
SLOVAKIA	15,000	78,000	+ 420%	2.4%	89,000
SPAIN	13,000	73,000	+ 461.5%	2.3%	224,000
DENMARK	70,000	71,000	+ 1.4%	2.2%	81,000
UK	9,000	51,000	+ 466.7%	1.6%	445,000
OTHERS (10 COUNTRIES)	6,400	36,000	+ 463%	1.1%	430,000
TOTAL	1,933,400	3,184,000	+ 64.7%	100%	6,069,000

**TOTAL HYBRID ELECTRIC PASSENGER VEHICLE SALES IN THE US (IN THOUSANDS) 2000-2007<sup>152, 153</sup>**



**GROWTH IN US BIOFUEL PRODUCTION (IN BILLION GALLONS)**



**CASE STUDY: PROVIDER**

Greenery Fuels supplies nearly 50% of the UK biofuels market. It was founded in 1992 and is one of the UK's fastest growing companies. Turnover for FY 2006 was £775 million and profits reached £8.7 million. It introduced the first crops for fuels contract to the UK farming community in 2003, led the introduction of bioethanol blended petrols and created the next generation of premium quality biofuels blends with the launch of Tesco 99 Octane in 2005.

Greenery's first biodiesel production plant, located at Immingham on the Humber, is currently operating with an annual production capacity of 100,000 tonnes, sourcing feedstock from UK farmers. The second phase of construction, to double production capacity to 200,000 tonnes, will be completed by the end of 2007. Greenery has created a 'Carbon Declaration', reporting on emissions savings. For 2006, it announced that it had delivered over 242,000 tonnes of carbon dioxide emission savings through its biofuels sales.

**CASE STUDY: END-USER**

Retailer Tesco announced in December 2006 that it would run three-quarters of its distribution fleet on biodiesel from January 2007. Its fleet comprises 2,000 lorries responsible for transporting goods to 754 stores and 716 smaller Express outlets. Tesco estimated that by using the B50 blend – 50% ordinary diesel mixed with biodiesel – it would cut its greenhouse gas emissions by more than 70,000 tonnes a year. It already stocks biofuel blends on some petrol forecourts, resulting in the reduction of a similar level of carbon dioxide emissions to the distribution initiative. Tesco fuels are supplied by Greenery. Tesco has also partnered with Greenery in the construction of its new biodiesel plant at Immingham.

**US**

**SOLUTIONS TAKE-UP**

The US is by far the largest market for hybrids in terms of both absolute numbers of vehicles and the percentage of new car sales. The technology was first introduced in 2000, when only 9,367 hybrid cars were sold. Since then, however, the segment has grown massively – 2,200% by 2005. In that year, hybrid vehicle sales reached 1.3% of total car sales in the US (205,000 cars sold for a total of US\$373.2 million), and sales are expected to increase by nearly 120% over the next six years, with revenues reaching US\$851.9 million in 2012.<sup>154</sup> This compares very favourably with overall car sales in the US, which rose by only 0.5% in 2005 compared to 2004.

With regard to biofuels, the US is much more focused on bioethanol than biodiesel. The ethanol industry produced four billion gallons in 2005, with a growth rate of 20% per year since 2002.<sup>155</sup> Once serving just niche markets in the Midwest where it is mainly produced, ethanol is now sold throughout the country, and blended in 30% of the petrol. (US biodiesel production in 2005 was only 75 million gallons/250,000 tonnes, albeit tripled from 2004 levels).<sup>156</sup>

**DRIVEN BY**

- A major focus on the use of biofuels to replace an increasing percentage of gasoline, given President George Bush's recent well-publicised concern over the nation's 'addiction to oil'. The aim is to cut petrol use by 20% by 2017.
- The 2005 Energy Policy Act requires that 7.5 billion gallons of biofuels are used by 2010,<sup>157</sup> and a new target of 10-12 billion gallons by 2012 is under discussion. That target includes a goal of 250 million gallons of 'next generation' cellulosic ethanol from 2013.
- An R&D programme worth US\$550 million for advanced biofuels technologies.
- Federal tax credits of US\$0.51 and US\$1.00 per gallon for ethanol and biodiesel, respectively.<sup>158</sup>
- 40 separate state-level incentives for ethanol production or use.<sup>159</sup>
- Recognition of the positive impact on meeting air quality regulations, and the replacement of the banned MTBE with ETBE in many states, an ethanol-derived petrol additive.
- The boost to the agricultural markets.
- Fuel efficiency regulations in California to reduce greenhouse gas emissions from new vehicles by 22% for the 2012 model year and 30% by model year 2016.
- Fleet fuel efficiency standards in New York, from 2009, tightening up to 2016. Connecticut, Massachusetts, Oregon and Washington are considering similar regulations.
- Federal income tax credits of up to US\$3,400 for hybrid cars placed in service from 2006.

### CREATING DOMESTIC VALUE

Increasing sales of hybrid cars made by Japanese car manufacturers are helping to support the opening of new manufacturing plants in the US, and hence employment creation. In 2006, members of the Japan Automobile Manufacturers Association (JAMA) opened three new auto and auto parts manufacturing plants, with a fourth plant opening in 2008, at a total investment of US\$1.73 billion. By 2008, Japanese corporate investment in US auto and auto parts manufacturing plants will have grown to a projected total of US\$30.09 billion. New job creation is estimated at 4,680 in just those four plants. Total employment stands at 431,738 in 25 plants, 36 research facilities, and distributors. JAMA members' US plants produced nearly 3.5 million cars and trucks in 2005, an increase of 10% over 2004. US-based parts purchases were US\$48.44 billion in 2005, reflecting growth of 7% over 2004.

The value of biofuels production plants either under construction or announced up to 2008 exceeds US\$2.5 billion.<sup>160</sup> At the end of 2005, 29 ethanol refineries and nine expansions were under construction with a combined annual capacity of nearly two billion gallons. Forecasts are for biofuels to reach 4% of transportation fuel in 2010 and 10% in 2020.<sup>161</sup>

The ethanol industry created almost 154,000 US jobs in 2005 alone, boosting household income by US\$5.7 billion. It also contributed about US\$3.5 billion in tax revenues at the local, state, and federal levels.<sup>162</sup> US job creation from ethanol production and capacity construction is expected to reach 203,879 jobs in all sectors of the economy by 2015.<sup>163</sup> As of 2006, the much smaller biodiesel sector employed 6,338, but by 2015, the total is expected to be 26,382.<sup>164</sup> Biofuels are expected to create in total an additional US\$200 billion in GDP from 2005-12 and new investment of US\$6 billion in renewable fuel production facilities.<sup>165</sup>

### JAPAN

#### SOLUTIONS TAKE-UP

In terms of decarbonising passenger transport, Japan's focus has been on energy-efficiency in engine design, and the hybrid car has been very successful in Toyota's and Honda's domestic markets. Toyota sold 58,000 hybrid cars in Japan in 2005 alone. Cumulative sales of hybrids from all manufacturers had reached 196,800 in 2004, up from 132,500 in 2003.

These car companies have been highly successful globally, with their efforts on energy-efficiency and hybrid technology a major contributor to their overall profitability – Toyota's net profits rose by 17% for the year to 31 March 2006, and Honda's by 23%.

#### DRIVEN BY

- The introduction of fuel-efficiency regulations in 1999, which mandated automakers to improve mileage by 23% by 2010 compared to 1995 levels.
- New regulatory proposals made in December 2006 by the Ministry of Economy, Trade and Industry and the Ministry of Transport to increase fuel efficiency standards by a further 23.5% on average by 2015 (current emissions rates stand at 138g/km).
- A new policy target for 40% of cars to be able to be run on biofuels such as a biofuel blend called gasohol by 2020 – a stretch target, given the current low level of provision and take-up of this fuel.

### CREATING DOMESTIC VALUE

Domestic companies Toyota and Honda have capitalised worldwide on their hybrid-technology development. For example, although hybrids make up only 3% of Toyota's overall world sales, the buzz resulting from their success has added to Toyota's public image as a trend leader. Toyota believes that, 10 years from now, most new cars will run on a version of a hybrid-engine.

The automotive industry is a core industrial sector for Japan. In 2004, auto manufacturing shipments accounted for 16.1% of total manufacturing, reaching JPY45 trillion (US\$40 billion) in value. Automobile-related employment in Japan totals 4.86 million, with 7.7% of Japan's working population employed directly or indirectly in the car industry. In 2005, motor vehicle production increased for the fourth year running, reaching 10.8 million units, up 2.7% on the previous year. Automotive exports rose 8.3% in 2005.<sup>166</sup>

Biofuels employment, on the other hand, is currently negligible, with fewer than 100 jobs in this area. Japan currently has very little domestic biofuel manufacturing capacity, and therefore has to import its ethanol from Brazil. However, the government aims to subsidise investment in biofuels plants to kick-start its domestic industry.<sup>167</sup>

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**FACT: MAJOR  
AUTO MAKERS  
ALL PLAN FOR  
COMMERCIAL  
FUEL CELL CARS  
BY 2015–2020**

**FACT: THE MARKET FOR FUEL CELLS AND HYDROGEN – US\$1.2 BILLION IN 2005 (PRIMARILY FOR RESEARCH CONTRACTS AND DEMONSTRATION AND TEST UNITS) – IS SET TO RISE TO US\$15.1 BILLION BY 2015.<sup>168</sup>**

**FACT: REGIONALLY, THE US HYDROGEN MARKET WAS ESTIMATED AT US\$798.1 MILLION IN 2005 AND IS EXPECTED TO RISE TO US\$1.6 BILLION IN 2010,<sup>169</sup> AN INCREASE OF 100% IN FIVE YEARS. THE EUROPEAN HYDROGEN MARKET IS ESTIMATED TO BE ABOUT US\$368 MILLION IN 2005 AND IS EXPECTED TO GROW AT AN AVERAGE ANNUAL GROWTH RATE OF 15% TO US\$740 MILLION IN 2010.<sup>170</sup>**

### FUEL CELL AND HYDROGEN-POWERED VEHICLES

Looking beyond hybrids, fuel cells potentially represent the next stage in zero-carbon power for mobile applications. A fuel cell creates electricity through an electrochemical process that combines hydrogen and oxygen in the presence of a catalyst, with water and heat the only by-products. Hydrogen can be formed from a fossil-based fuel, such as natural gas or gasified coal, methanol derived from biomass or – in the environmentally best-case scenario – from the electrolysis of water using renewable energy.

### GROWTH TO DATE

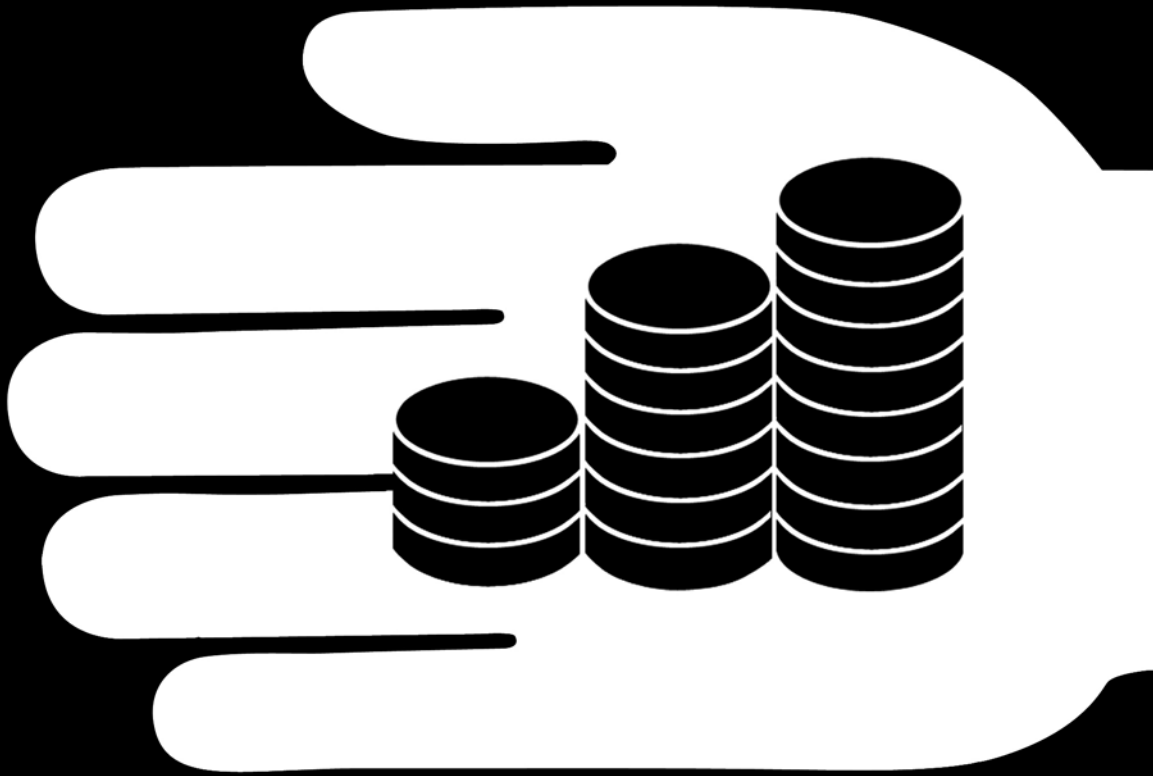
The commercial market for fuel cell or hydrogen-fuelled cars is still at an early stage, given the technologies' current economics. The total number of fuel cell cars globally was projected to reach just over 600 by 2006.<sup>171</sup> Although the largest market for fuel cells overall in 2005 was the mobile market, this was supported almost exclusively by government and corporate funding and military contracts. Ballard Power is the biggest maker of fuel cells for vehicles (DaimlerChrysler and Ford have invested US\$100 million into the company in a joint venture) but, in common with most companies in the sector, is still not profitable.

### GROWTH PROJECTIONS

Among the top ten car manufacturers, GM, Toyota, Ford, DaimlerChrysler and Honda all plan for commercially viable fuel cell cars to be available by 2015, and DaimlerChrysler, Honda and GM believe there will be a mass market by 2020-25. Although Toyota was the first to introduce a fuel cell vehicle, Honda appears to be one step ahead of the industry here. It introduced its second generation model, the FCX, in 2005. This uses a Honda-designed fuel cell stack (rather than one from Plug Power as used in the first model). The company plans to begin leasing an expensive new hydrogen-powered fuel cell car in Japan and the United States in 2008, and to have 50,000 cars on US roads by 2020. Furthermore, Honda is the industry leader in terms of developing home refuelling units. President and CEO Takeo Fukui believes that there will be a sizeable market for a Honda fuel cell car, even with a JPY10 million (c.US\$80,000) price-tag. However, before production can be scaled-up, Fukui said there are still some technological challenges to overcome.<sup>172</sup>

The scale-up of purely fuel cell cars will take decades (given current annual new car sales of 64 million). However, replacing the internal combustion engine with a fuel cell in mass produced plug-in hybrid cars is one feasible solution that might be more rapidly achieved, if a hydrogen distribution infrastructure is developed. The cost of a large-scale hydrogen refuelling infrastructure in the US is estimated at US\$100 billion – meaning that a partnership between government and industry will be necessary. There are currently about 140 hydrogen fuel stations globally, with 59% in the United States (50% of these in California alone), and 7% in both Germany and Japan. As of November 2006 there were 59 hydrogen fuel stations planned, 29 of them in the United States (16 in California alone).<sup>173</sup>

In terms of market value, the global and regional fuel cell and distributed hydrogen markets are expected to grow significantly over the next 10 years, as shown by the bold text on the left of the page.



Many of the market solutions to support the low carbon economy stem from the well-established financial services industry, which generates approximately 8% of GDP across the OECD countries. The industry has woken up in a big way to the potential for renewable energy and clean technology, and finance is now pouring into these areas. This is enabling much more rapid development of the clean energy and transport technologies than was thought possible only two years ago; as illustrated by the growth figures presented in the previous three chapters. This is of mutual benefit to both sides of the equation, as when low carbon solutions can be made more widely available, take-up increases, and investment returns rise.

In particular, the emerging global carbon market has caught the imagination of the industry, and is undergoing an incredible period of growth, from pretty much a standing start in January 2005 to reach US\$30 billion in traded volumes by the end of 2006. It is expected that a scheme similar to the EU emissions trading scheme, so far the major market, will be set up in the US before long. It has, moreover, been predicted that over the next few years, carbon trading will reach the same levels as trading in global commodities, currently a US\$100 billion per year market.

Both these sources of finance and investment into clean technologies and carbon mitigation processes have been vital in ensuring that carbon is increasingly correctly priced and they are providing the fuel to drive the global economy towards the brighter future of the low carbon world.

Described in the following pages, are the exciting trends in growth and value creation that smart investors and traders are supporting, from both the worlds of finance and carbon markets.

### HIGHLIGHTS

- IN 2005, 10% OF ALL ENERGY SECTOR INVESTMENT (ESTIMATED TO TOTAL BETWEEN US\$500-600 BILLION) WENT INTO RENEWABLES AND CLEAN ENERGY TECHNOLOGIES.<sup>174</sup>
- IN 2006, INVESTMENTS IN RENEWABLE POWER REACHED US\$71 BILLION, UP BY 43% ON THE PREVIOUS YEAR.<sup>175</sup>
- CLEAN TECHNOLOGY, PARTICULARLY ENERGY-RELATED, HAS BECOME THE FASTEST-GROWING SECTOR IN VENTURE CAPITAL (VC) AND PRIVATE EQUITY (PE), AND IS NOW THE FIFTH-LARGEST SECTOR FOR VC IN THE US.<sup>176</sup>
- CLEANTECH HAD REACHED 9.4% OF US VC INVESTING ACTIVITY AS OF END 2006 (FROM A TOTAL OF US\$25.5 BILLION), UP FROM 4.2% IN 2005 – A TENFOLD INCREASE WITHIN EIGHT YEARS.<sup>177</sup>
- FOR EVERY US\$100 MILLION INVESTED INTO VENTURE-BACKED COMPANIES, 2,700 NEW JOBS ARE CREATED AND THE OVERALL ECONOMY SEES FIVE TIMES THE IMPACT IN RELATED ECONOMIC GROWTH.<sup>178</sup>
- THE VALUE OF GLOBAL CLEANTECH INITIAL PUBLIC OFFERINGS (IPOS) AND SECONDARY TRANSACTIONS HAS GROWN MORE THAN TWENTYFOLD IN JUST THREE YEARS – FROM US\$416 MILLION IN 2003 TO SOME US\$10 BILLION IN 2006.<sup>179</sup>
- GLOBAL RENEWABLES PROJECT FINANCE HIT US\$27.9 BILLION IN 2006, INCLUDING FURTHER DEVELOPMENT OF THE LARGEST WIND FARM IN THE US, HORSE HOLLOW IN TEXAS, FUNDED BY MIZUHO, FORTIS AND BAYERN LB TO THE TUNE OF US\$600 MILLION.

In the past two years, investment in forms of sustainable energy has grown more rapidly than investment in any other sector. Many alternative investment vehicles have emerged that target sustainable energy financing, and major institutions have now jumped into the fray.

Investors are responding to clear political signals – President Bush’s 2006 State of the Union address, strong European support for action on climate change, and the publication of the Stern Review and the US mid-term elections in late 2006.

In addition, government support for renewable energy in the US and Europe combined was in the order of US\$10 billion in 2004. In the US, Canada, Asia and Europe, governments provide R&D funding, tax subsidies, direct and indirect financial support, and the use of market mechanisms.

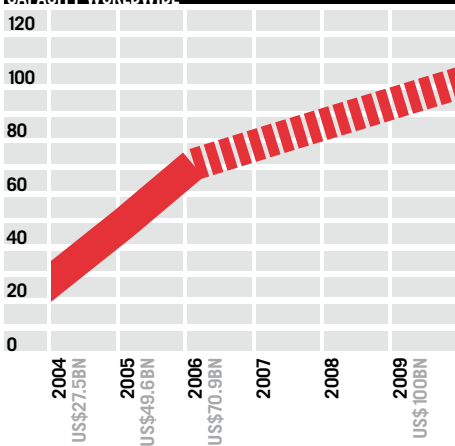
But ultimately, investors are betting on a long-term shift towards a low carbon economy. Some of the most respected names on Wall Street have been making substantial investments in renewable energy and carbon trading – despite the current administration’s opposition to mandatory controls on carbon. A key element of the largest leveraged buy-out in history – of Texas utility TXU – was a commitment by the private equity buyers to dramatically scale back plans for new coal-fired capacity, instead pledging renewable energy investment and a major demand-side management programme.

It should come as little surprise that fleet-footed venture capitalists are backing technology companies that could win big from efforts to cut energy consumption and greenhouse gas emissions. But when private equity houses and the investment banking community – neither of which are known for their radicalism – follow, it’s clear that a tipping point has been reached.

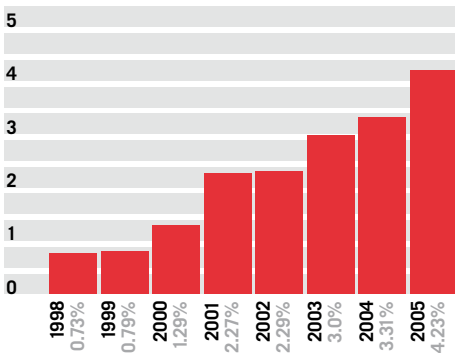
It is now to be expected that there will be an increasing drive over the next decade from all segments of the industry, particularly those providing project finance and advisory work, to shift funding from a carbon-heavy portfolio to cleaner forms of energy and transport.

# MARKET GROWTH AND VALUE CREATION

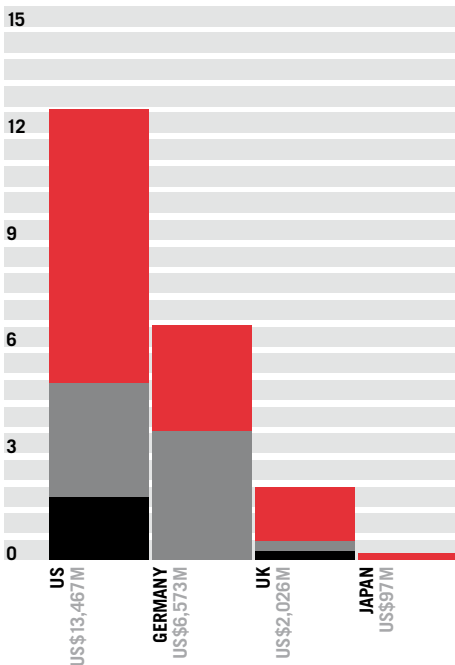
## INVESTMENT IN NEW RENEWABLE ENERGY CAPACITY WORLDWIDE<sup>180</sup>



## ENERGY-TECH INVESTMENTS AS A PERCENTAGE OF TOTAL US VENTURE CAPITAL



## TOTAL INVESTMENT INTO CLEAN ENERGY BY COUNTRY AND ASSET CLASS 2006



## VENTURE CAPITAL / PRIVATE EQUITY PUBLIC MARKETS ASSET-FINANCINGS

### GROWTH TO DATE

By 2005, 10% of investment in the energy industry worldwide (estimated to total between US\$500-600 billion) was accounted for by renewables and clean energy technologies.<sup>181</sup> Total investment in each of our four countries is illustrated in the third graph on the left.

**QUOTE: "WHEN I STARTED NEW ENERGY FINANCE, IN 2004, WE SAW US\$27 BILLION BEING INVESTED IN CLEAN ENERGY WORLDWIDE. I THOUGHT IT WOULD TAKE UNTIL 2014 FOR US TO SEE US\$100 BILLION PER YEAR BEING INVESTED. IN 2006, JUST THREE YEARS LATER, WE TRACKED US\$71 BILLION. WE NOW EXPECT TO HIT US\$100 BILLION BY 2009. INVESTMENT ACTIVITY HAS DEVELOPED FASTER THAN WE EVER THOUGHT POSSIBLE. THE BIG CHALLENGE FOR THE INDUSTRY IS NO LONGER HOW TO SPUR DEMAND, BECAUSE THERE IS DEMAND OUT THERE IN SPADES – IT IS HOW TO DEVELOP THE SUPPLY CHAIN. THE NEX GLOBAL INDEX OF OVER 80 QUOTED CLEAN ENERGY COMPANIES HAS GONE UP BY 30% PER YEAR COMPOUND FOR THE PAST FOUR YEARS. US\$11 BILLION OF PRIVATE EQUITY MONEY WENT INTO THE SECTOR LAST YEAR, AND US\$10 BILLION WAS RAISED ON THE PUBLIC MARKETS. THIS IS BIG BUSINESS, THE FINANCIAL PLAYERS HAVE WOKEN UP AND THEY ARE MAKING MONEY."**

**MICHAEL LIEBREICH, CEO,  
NEW ENERGY FINANCE**

### FINANCING STAGES AND MAJOR PLAYERS

For each stage in the life of a new renewable energy or clean-tech company, a different form of financing will be most useful: firstly, venture capital/private equity (VC/PE) investment at the company start-up stage, followed by public equity investment via stock markets, usually to provide expansion capital and thirdly, in some cases, project finance from commercial banks.

### VENTURE CAPITAL INVESTMENT

A large number of venture capitalists and financial companies have been benefiting from the fast-rising requirements and returns from renewable energy and clean technology finance.

In 2005, out of total US VC investment of US\$21.7 billion, investors put US\$917 million – an increase of more than 25% from 2004 – into more than 80 private clean-tech companies.<sup>182</sup> In 2006, this had risen to US\$2.4 billion.<sup>183</sup>

In 2006, clean energy technology VC and PE investment globally exceeded US\$7 billion, a 167% increase from 2005.<sup>184</sup>

The US is the new clear leader in terms of clean-tech VC. In 2005, from the global total of VC/PE investments, 118 US companies received funds (totalling US\$1.56 billion for the 93 for which data was disclosed). This had risen to 127 companies in 2006 (totalling US\$3.63 billion for the 102 for which data was disclosed).<sup>185</sup>

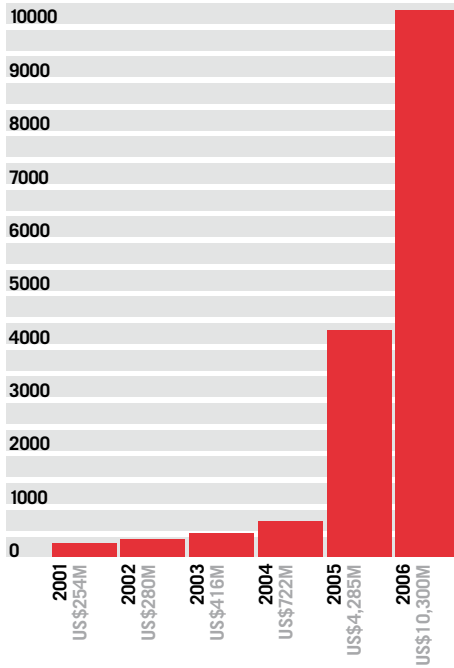
The table below shows the top ten US clean-tech VC/PE investors during 2006. Interesting to note is the inclusion of three major US investment banks; the previous year only Goldman Sachs appeared in the top ten.

### TOP 10 US-BASED VC/PE INVESTORS - TOTAL INVESTED IN 2006

ENERGY CAPITAL PARTNERS	US\$1,340M
KHOSLA VENTURES	US\$105.16M
GOLDMAN SACHS GROUP INC	US\$79.70M
VANTAGE POINT VENTURE PARTNERS	US\$76.58M
CITIGROUP	US\$62.74M
BIRCH HILL EQUITY PARTNERS MGMT INC	US\$62.40M
WESTERN MILLING LLC	US\$60M
KLEINER PERKINS CAUFIELD AND BYERS	US\$57.70M
BAIN CAPITAL	US\$50M
MORGAN STANLEY	US\$50M

Biofuels and solar have been the hot sectors for VC clean-tech investors. Recently Goldman Sachs joined Royal Dutch Shell as a minority investor in Iogen Corporation, investing US\$30 million in the Canadian company, which converts agricultural materials such as straw, corn stalks and switchgrass to ethanol. In 2005, Citigroup's Sustainable Development Investment Program invested in Balrampur Chini Mills, one of the largest sugar producers in India, a company that intends to expand its ethanol manufacturing capacity.

**GLOBAL PUBLIC MARKET IPO AND SECONDARY TRANSACTIONS 2001-06**



In the UK, at least US\$169.5 million worth of VC/PE investment flowed into 29 UK-based clean technology companies during 2006. Venture financing in Japan, however, is at a much lower level. In 2006, US\$3.6 million was raised for one company. The amount invested by Japanese VC/PE entities was also low, at US\$15.49 million in total during 2005, (mainly due to the historically credit-based financial system in the country, rather than a capital-based system more suitable for VC) although this increased to US\$63.51 million in 2006.

Globally, there are an estimated 100 PE funds focused on clean-tech, up 30-40% from 2005.<sup>186</sup> In 2005 alone, five clean-tech fund-of-funds were launched or closed – an unprecedented number.<sup>187</sup> Furthermore, in October 2006, the UK-based Low Carbon Accelerator Fund became the first listed private equity fund to invest solely in private firms in the green energy sector.

And the pioneers have, thus far, been rewarded. As of 2005, 19 venture capitalists investing in 57 clean technology firms in Europe had made an average annual return of 86.7% on their investments since 1999 – the sample represents 30% of all clean-tech companies in Europe which have received VC funding.<sup>188</sup> Illustrating the extra benefits from VC in clean-tech, in Europe (as of the end of 2003), the average rate of return for a 10-year VC investment across all sectors was only 8.3% (although the US market showed returns of 25.4%, probably as US venture capital funds benefited more than their European counterparts from the high asset prices during the technology investment boom).<sup>189</sup>

Venture investing also creates jobs, as well as profits. Research has shown that for every US\$100 million invested into VC/PE-backed companies, 2,700 new jobs are created and the overall economy receives five times greater impact in related economic growth.<sup>190</sup>

**IPOS AND PUBLIC EQUITY INVESTMENT**

Evidence of the growth of the clean energy technology sector can be found in the growing numbers of companies going public, tapping into investor appetite by listing on the world's stock exchanges.

In October 2005, the London Stock Exchange hosted its first renewable energy capital markets day. Expectations were for about 30 investors to attend, but instead about 90 came, including some of the biggest institutions in the financial world – such as UBS, Merrill Lynch, Barclays and Goldman Sachs.

In fact, by 2006, virtually all the major global investment banks were involved in clean energy IPOs: Morgan Stanley and Credit Suisse acted for First Solar (listing on NASDAQ); Lehman Brothers and Deutsche Bank for Canadian Solar (also on NASDAQ); Morgan Stanley and Lehman Brothers for VeraSun (listing on New York Stock Exchange); Deutsche Bank and Citigroup for CropEnergies (listing on Frankfurt), and Goldman Sachs for Aventine (listing on NYSE).

By 2005, the total market valuation of renewable energy companies had reached US\$50 billion, double the 2004 estimate, following several high-profile IPOs.<sup>191</sup> The next year, some US\$10.3 billion of new equity was raised by publicly quoted clean energy companies, with Europe's total reaching US\$5.6 billion.<sup>192</sup>

Solar companies raised the most on the public markets, at US\$5.6 billion, more than double the US\$2.1 billion raised in 2005. Biofuels companies were second, raising US\$3.1 billion, more than 10 times the amount raised the previous year, including the IPO of VeraSun (the second largest ethanol producer in the US) in June 2006, raising US\$419.75 million.<sup>193</sup> Wind IPOs raised US\$1.4 billion, compared with US\$1.9 billion in 2005.

In Europe, meanwhile, London's AIM was the venue of 36 IPOs and secondary fundraisings in 2006, totalling more than US\$1.4 billion – an increase of 46% on the 2005 total of US\$984.1 million.

By the end of 2006, the total market capitalisation of the 50 clean energy companies on AIM had reached US\$7.8 billion. The largest single sector was 'Carbon Markets', with four large constituents totalling US\$1.4 billion in market capitalisation, and delivering an average annualised return of 57.7%. Solar companies totalled less than biofuels, hydrogen/fuel cells and wind power, at US\$1.03 billion, but had the second highest return of all the sectors, at 29.1%.

## COMMERCIAL LENDING AND PROJECT FINANCE

Meanwhile, the world's project finance houses have not been slow to recognise the opportunities in renewables (particularly wind power), and pretty much all the large – and typically conservative – commercial and investment banks, in Europe, the US and Japan are active in underwriting deals.

To place project finance for renewable energy in context, global project financings reached US\$180.6 billion in 2006, a 29.7% increase from 2005. The power sector accounted for US\$57.1 billion in 2006, up from US\$44.4 billion in 2005.<sup>194</sup> And of that, asset finance for renewable energy reached US\$27.9 billion, 15% of total project finance.

The list of top ten banks acting as 'mandated lead arrangers' for renewable (and clean-energy) project finance globally is dominated by European institutions, who arranged a total of US\$10.9 billion. Japanese institutions only accounted for US\$474.28 million in 2006 – roughly split in half between Mitsubishi Corp and Mizuho.

The value attributed to these deals has shown vast growth since the beginning of this decade, as shown in the tables below:

### GROWTH IN PROJECT FINANCE DEALS FOR ALL BANKS 2000-06

YEAR	VALUE OF PROJECT FINANCE DEALS
2000	US\$402.68M
2001	US\$781.34M
2002	US\$1,453.39M
2003	US\$1,541.24M
2004	US\$4,008.43M
2005	US\$13,901.3M
2006	US\$13,937.43M

### GROWTH IN PROJECT FINANCE FOR EU BANKS 2004-06

YEAR	VALUE OF PROJECT FINANCE DEALS
2004	US\$3,191.53M
2005	US\$10,806.32M
2006	US\$10,997.86M

### GROWTH IN PROJECT FINANCE FOR UK BANKS 2004-06

YEAR	VALUE OF PROJECT FINANCE DEALS
2004	US\$139.94M
2005	US\$2,294.89M
2006	US\$2,793.16M

### GROWTH IN PROJECT FINANCE FOR GERMAN BANKS 2004-06

YEAR	VALUE OF PROJECT FINANCE DEALS
2004	US\$1,004.95M
2005	US\$2,120.23M
2006	US\$3,944.34M

SOURCE: NEW ENERGY FINANCE DATABASE

The top 10 banks globally, and specifically in the US, acting as mandated lead arrangers for renewable project finance during 2006 are listed in the tables below.<sup>195</sup>

It is also worth mentioning that, during 2005, Credit Suisse was top of the list of US banking institutions below, with deals worth over US\$1 billion.<sup>196</sup>

### TOP TEN GLOBAL MANDATED LEAD ARRANGERS DURING 2006

GLOBAL BANKING INSTITUTION	TOTAL INDICATIVE VALUE TO THE BANK
ROYAL BANK OF SCOTLAND	US\$2,448.39M
HYPOVEREINSBANK	US\$1,613.63M
HSH NORDBANK	US\$931.68M
GRUPO SANTANDER	US\$597.90M
BANCO ESPIRITO SANTO	US\$550.17M
MILLENNIUM BCP	US\$550.17M
BAYERISCHE LANDESBANK	US\$491.77M
BBVA	US\$406.70M
SOCIETE GENERALE	US\$387.50M
SABADELL BANK GROUP	US\$383.47M

SOURCE: NEW ENERGY FINANCE DATABASE

### TOP TEN US MANDATED LEAD ARRANGERS DURING 2006

US BANKING INSTITUTION	TOTAL INDICATIVE VALUE TO THE BANK
GOLDMAN SACHS GROUP	US\$364.10M
UNION BANK OF CALIFORNIA	US\$361.60M
SCOTIABANK	US\$160M
ROYAL BANK OF CANADA	US\$160M
COBANK	US\$142M
AGSTAR FINANCIAL SERVICES	US\$137.8M
PROSPECT ENERGY	US\$117M
HF FINANCIAL	US\$85.10M
ALLCO FINANCE GROUP	US\$78.35M
GREAT WESTERN BANK	US\$76.50M

SOURCE: NEW ENERGY FINANCE DATABASE

Goldman Sachs has been one of the leaders in North America in this space for a couple of years.<sup>197</sup> The bank has committed to investing US\$1 billion in renewable energy and energy-efficiency projects, devising (and participating in) investment structures for renewable energy, alternative fuels, and other environmentally friendly technologies.<sup>198</sup> It also bought Horizon Wind Energy (formerly Zilkha Renewable Energy) in 2004, a wind-development firm currently developing 4,000MW of wind capacity in the United States. Goldman agreed to re-sell it in March 2007 to Portuguese power provider Energias de Portugal, which valued it at US\$2.15 billion.

Canada's RBC is also active in the sector. It has a C\$50 million alternative energy technology venture fund, and has financed around 30 wind farms in Canada, the US, the UK, Italy and Ireland. Over 2006, RBC has been involved in much advisory and corporate finance work involving raising debt and equity, M&A work, and setting up funds for large-scale renewable energy projects, as well as its own lending.

**QUOTE: "TECHNOLOGY VENTURE INVESTMENT IN CLEAN ENERGY TECHNOLOGY IN THE US (PARTICULARLY FOCUSED ON SOLAR AND BIOFUELS) RUNS THREE TO SEVEN TIMES AS MUCH AS IN EUROPE EVERY SINGLE QUARTER. FURTHERMORE, IN TERMS OF PROJECT FINANCE, THE US IS IN THIRD PLACE NOW FOR WIND CAPACITY AFTER GERMANY AND SPAIN, AND WITH BETTER GROWTH PROSPECTS."**

**MICHAEL LIEBREICH, CEO,  
NEW ENERGY FINANCE**

To illustrate the type and size of individual deals, recent renewables project financings include:

- A 189MW wind farm at Sault Ste. Marie, Ontario, sponsored by Brookfield Power, for which the lead banks for a US\$300 million term loan are Bank of Nova Scotia and RBC Capital Markets. ABN Amro, BMO, Sumitomo Mitsui, Bank of Tokyo Mitsubishi and Fortis Capital were also involved in the deal, which closed in September 2006.
- In October 2006, the 120MW Q7 wind facility off the Dutch coast near Ijmuiden was the first offshore wind park to be project financed. Total financing came to €379 million, arranged by Dexia and Rabobank.
- 'C-Power' is the project vehicle for the Thornton bank offshore wind farm, off the coast of Belgium. Dexia is arranging a €100 million financing package for 30MW, and other finance will be raised later for the remaining 270MW. If approved by the Belgian government, the full 300MW site could become operational in 2010. The total investment is about €500 million.
- AndaSol II is a 50MW solar project based in Guadix, Spain, sponsored by ACS Group. Total financing is €300 million (US\$396 million) via a 15-year term loan, led by WestLB, BNP Paribas and Banco Sabadell, which closed in January 2007. The same sponsor is developing the La Boga wind portfolio at various locations in Spain. The lead banks for this are Natexis and La Caixa for a term loan of €350 million (US\$462 million) and syndication was to take place in the first quarter of 2007.
- Airtricity's 90MW Sand Bluff wind farm in Sterling County, Texas is being led by HVB Bank and syndication was for US\$140 million.
- Lone Star Wind (FPL Energy) is developing a wind farm at Horse Hollow II and III, Red Canyon, in Taylor, Nolen, Borden, Garza and Scurry Counties, Texas. This is being funded by Mizuho, BayernLB and Fortis Capital, for a total of US\$600 million over a 15-year term.

#### **GROWTH PROJECTIONS**

Although US renewables capacity currently stands at less than Europe, US prospects are particularly strong in terms of both VC and the support from lenders for project finance.

In terms of the value raised in IPOs and the value of the listed companies, continued strong growth appears likely. Global project finance for clean energy technology has clearly jumped up a step in 2005 and 2006. Furthermore, the focus on renewable and other forms of clean energy is only set to continue in the US in particular. Pressure on developers and decision-makers to find alternatives to traditional coal-fired plant is growing. As mentioned earlier, the private equity group buying the Texas utility TXU, led by Kohlberg Kravis Roberts & Co. and Texas Pacific Group, agreed to stop plans to build eight new coal-fired power plants, not to propose new coal-fired plants outside Texas and to support mandatory national caps on GHG emissions.<sup>199</sup> Other power companies are looking to increase the efficiency and reduce emissions from coal plant generation, using coal gasification technology and carbon capture and storage.

As the demand for clean energy grows, so too will demand among renewable energy companies and project developers for capital, and for investment advisory services. The large investment and commercial banks particularly, do not dedicate their extremely expensive human capital to business areas without a high degree of confidence that they will be well rewarded – and the commitment of some of the most well-respected names in Europe and North America speaks volumes for the potential of the renewable energy and low carbon sector.

**FACT:**

**US\$71 BILLION  
– THE TOTAL  
INVESTED IN  
RENEWABLE  
ENERGY IN  
2006**

### HIGHLIGHTS

- IN 2006, THE GLOBAL CARBON MARKET REACHED US\$30 BILLION IN VALUE – OVER TRIPLE THE VALUE FOR 2005.
- IN THE FIRST SIX MONTHS OF 2006, IN TOTAL, THE EQUIVALENT OF 684 MT OF CARBON DIOXIDE (CO<sub>2</sub>e) WAS TRANSACTED GLOBALLY, ALREADY 85% OF THE TOTAL VOLUME TRADED IN 2005.
- MORE THAN US\$8.5 BILLION HAS BEEN RAISED INTO AN ENTIRELY NEW INVESTMENT VEHICLE – THE CARBON FUND.

**QUOTE: “THE CARBON MARKETS CONTINUE TO MATURE AT BREATHTAKING SPEED AND THE OVERALL VOLUME OF TRANSACTIONS FOR ALL CARBON INSTRUMENTS HAS INCREASED MORE THAN TENFOLD SINCE 2004. THE COMMON THEME ACROSS ALL SEGMENTS IS RAPIDLY GROWING LIQUIDITY, VOLUMES, AND ANNUAL TRANSACTION VALUES. THE OTHER KEY TREND OVER THE PAST FEW YEARS HAS BEEN THE EMERGENCE OF CREDIBLE MARKET INTERMEDIARIES SUCH AS OFFSET PROVIDERS, BROKERS AND CARBON FUND MANAGERS WHO ARE ABLE TO PROVIDE PARTICIPANTS WITH A HOST OF SERVICES AND PRODUCTS TO MEET BOTH COMPLIANCE AND REPUTATION REQUIREMENTS.”**

**ABYD KARMALI, DIRECTOR OF CLIMATE CHANGE STRATEGIES, ICF CONSULTING**

The global effort to reduce greenhouse gas emissions, by way of the 1997 Kyoto Protocol, has created an entirely new commodity: the emission reduction. The introduction of ‘cap-and-trade’ schemes places a value on a tonne of carbon dioxide (CO<sub>2</sub>) either avoided or stored, incentivising governments, companies and even individuals to reduce emissions, knowing that their reductions have value.

Carbon markets in and of themselves do not reduce emissions. But by putting a price on emissions reductions, they encourage companies to make investments to reduce emissions. At the same time, they provide those with a high cost of emissions abatement a way of meeting reduction targets without going out of business.

Investors, entrepreneurs and market intermediaries have not been slow to recognise the potential of these markets. Companies have sprung up to generate emissions reductions, funds have been launched to invest in reduction projects, and a whole new sub-sector of the financial services industry has been created to analyse, trade and broker this new market. And, as the market grows, more and more established banks and trading houses are bringing their experience to bear.

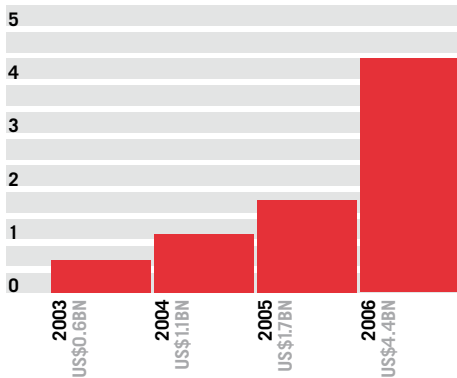
The Kyoto Protocol will establish a global trading scheme for its first ‘commitment period’ (2008-12), and includes two markets for credits from greenhouse gas reduction projects – the Clean Development Mechanism (CDM) and Joint Implementation (JI), which relate to projects in developing countries, and the industrialised world, respectively. However, most trading to date has been in ‘pre-Kyoto’ regional, national and voluntary schemes, such as in the EU.

A further notable area of growth has been the offsetting of carbon emissions through investment in GHG emission reduction projects, often as part of a voluntary emissions reduction commitment. Furthermore, the concept of carbon neutrality – achievement of a net zero-carbon footprint through a combination of direct emissions reductions and offsetting – has been taken up by many companies. As part of an integrated strategy, this can provide an attractive way for organisations to cut internal and supply-chain related emissions and engage with the public. It is expected that the market for the associated low carbon and carbon neutral products will grow significantly in the coming years.

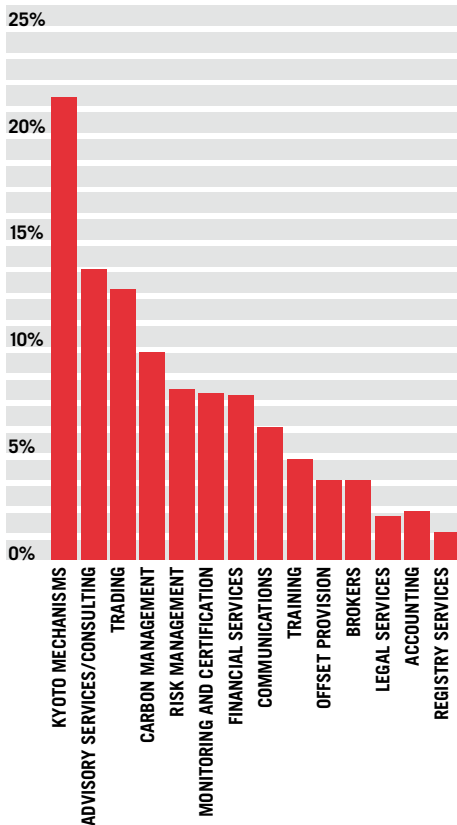
As the voluntary approach has become an increasingly common feature of institutional and individual responses to climate change, there has been a proliferation of companies offering carbon offset and related services.

# MARKET GROWTH AND VALUE CREATION

TOTAL RAISED EACH YEAR INTO CARBON FUNDS<sup>200</sup>



CARBON SERVICE COMPANIES – PRIMARY AREAS OF SPECIALISATION



SOURCE: THE °CLIMATE GROUP/LCCS SURVEY, 2006

## GROWTH TO DATE

### EU ETS

The European Union Emissions Trading Scheme (EU ETS) is by far the largest regional carbon market. Created in January 2005, it accounts for 65% of the total traded volume worldwide.<sup>201</sup> It was worth US\$8.2 billion in 2005 and traded over US\$19 billion during 2006.<sup>202</sup> This compares with trading in the New South Wales emissions trading scheme in 2005 and 2006 of US\$57.2 million (at 2005 currency prices) and US\$217 million respectively.<sup>203</sup> For the Chicago Climate Exchange (CCX), which operates on a semi-voluntary basis, traded values in 2005 rose from US\$2.8 million to US\$36.5 million in 2006.<sup>204</sup>

The first forward trades of EU Allowances (EUAs) under the EU ETS between European companies were contracted in 2003, when less than one million tonnes were traded, followed by about nine million tonnes in 2004. Since then, EU ETS trading volume has grown dramatically – reaching 322 million tonnes in 2005<sup>205</sup> and 817 million tonnes in 2006.<sup>206</sup>

The EU market is now split roughly in half between direct or brokered trading and commodities exchanges. Among the six existing exchange platforms, the European Climate Exchange (ECX) has 70-80% of the market share.

### FLEXIBLE MECHANISM PROJECTS

In addition to the trading schemes, there were about 614 CDM and JI project-based transactions between 1996 and the end of March 2006. JI only accounted for about 4% of these, or about 2% of the entire volume of the carbon markets. However, CDM trade accounts for 27.2% of total carbon market volume.<sup>207</sup> In 2005, 374 million tonnes of CO<sub>2</sub>e were traded, virtually all from CDM projects, at a value of US\$2.7 billion, and the United Nations Framework Convention on Climate Change (UNFCCC) Secretariat – which oversees carbon trading under the Kyoto Protocol – is forecasting that as many as 1.8 billion tonnes of credits may be created by the end of 2012 under the CDM.

### CARBON FUNDS

The first major carbon fund – the Prototype Carbon Fund (PCF) – was set up by the World Bank in January 2000. The Bank has since set up eight other funds. Fifty-seven funds in total were in existence as of March 2007, with a total of €8.5 billion (public €2.6 billion, private €5.9 billion) under management. Two-thirds of private carbon funds are managed in London and New York, and growth opportunities for carbon asset managers in these two cities are significant.

### VOLUNTARY CARBON MARKET

This market is experiencing significant growth as companies not subject to mandatory caps on carbon emissions decide voluntarily to offset some or all of their emissions for reputation-associated reasons or to mitigate risks. Individuals are also now increasingly eager to go down the offset route, particularly for air travel.

The World Bank estimates that, in 2005, the market for voluntary carbon offsets made up less than 10 Mt of CO<sub>2</sub>e, under 1% of global carbon market transactions, and was valued at c. US\$11 million. However, forecasts suggest that global demand could reach around 400 million tonnes of CO<sub>2</sub>e per year by 2010.<sup>208</sup>

### GROWTH OF SERVICE PROVIDERS

To document market growth and economic benefit in all these areas, The °Climate Group undertook a survey with a number of market participants over the months of May, June and July 2006 in association with London Climate Change Services, a membership organisation for companies involved in the carbon markets. The study identified a wide range of activities carried out under the umbrella of carbon services, as can be seen from the graphic opposite: Carbon Service Companies – Primary Areas of Specialisation.

The survey also demonstrated significant value creation linked to the carbon markets. Thirty companies began operating in this market within the 2000-05 period, compared to 14 in the previous decade. In terms of employment, for 41.7% of companies surveyed, carbon/clean energy work makes up 75-100% of their business and 45.7% stated that the percentage of their business from this area has increased significantly over the past five years. Although in all companies surveyed, the number of employees specialising in climate change services remains relatively small (up to 25 maximum), 62.5% of companies stated that their staff numbers had increased significantly over the past five years and 55.1% of companies further predicted that this trend would continue over the next five years. None thought that numbers would decrease.

The average of reported revenues generated from the companies' carbon/clean energy business has shown massive growth, from £189,000 in 2003 to £3.5 million in 2006, as shown in the table below.

AVERAGE REVENUES FROM PROVISION OF CARBON SERVICES		
YEAR	RANGE	AVERAGE
2003	£50,000-£1M	£189,285.71
2004	£125,000-£3M	£395,238.10
2005	£20,000-£5M	£1,361,666.67
2006 Q1	£5,000-£8M	£3,537,500.00

SOURCE: THE °CLIMATE GROUP/LCCS SURVEY, 2006

**QUOTE: "THE OBJECTIVE [IN SETTING UP A CARBON TRADING DESK] WAS TO UNDERSTAND CARBON BETTER, TO COMPLEMENT POWER AND GAS TRADING AND TO PROVIDE A RISK MANAGEMENT SERVICE TO OUR GROWING NETWORK OF ENERGY AND METALS COMMODITY CUSTOMERS THAT WERE INEVITABLY CAPTURED BY THE SCHEME. WE KNEW THAT EMISSIONS TRADING WAS GOING TO TAKE MANY CUSTOMERS INTO UNCHARTED TERRITORY SO IT WAS APPROPRIATE THAT WE STARTED WORKING WITH THEM AHEAD OF THE OFFICIAL START OF THE SCHEME IN JANUARY 2005. WE'VE TRADED MORE THAN 300 MILLION TONNES OF CARBON CREDITS TO DATE, THE MAJORITY AS EUA'S, BUT THE FASTEST GROWING PART OF OUR BUSINESS IS IN CER TRADING (CDM CREDITS). WE'RE A DESK OF FOUR STAFF WITH PLANS TO EXPAND AS AND WHEN THE MARKET TAKES ITS NEXT STEP FORWARD, WHETHER THAT'S THE US, CANADA OR JAPAN."**

**LOUIS REDSHAW, HEAD OF ENVIRONMENTAL MARKETS, BARCLAYS CAPITAL**

#### MAJOR PLAYERS

Major players in the carbon markets can be broken down into four main categories:

- Traders
- Brokers
- Carbon asset managers/CDM project developers
- Carbon offset providers.

#### TRADERS

There are currently around 30-40 regular participants trading 'over-the-counter', mainly European utilities, multinational oil companies and financial institutions, although other countries and sectors (cement, pulp and paper, steel, etc.) are beginning to enter the market. Transactions are typically 10,000-100,000 tonnes of CO<sub>2</sub>e in size, although some can reach up to one million.<sup>209</sup>

There is also substantial trading on the futures markets. Futures trades are carried out on a regulated exchange, via an electronic trading platform. For example, 70 businesses including Barclays, BP, Calyon, E.ON UK, Endesa, Fortis, Goldman Sachs, Morgan Stanley and Shell trade on the European Climate Exchange.

The International Emissions Trading Association (IETA) has a membership of 128 companies worldwide, including London, currently the global centre for trading in emissions allowances. The London-based ICE Futures market lists a total of 106 companies that trade directly or provide financial clearing services to clients. Of these, 64 offer such services to emissions-trading clients.<sup>210</sup>

In addition to those industrial companies covered directly by the EU ETS who already had their own trading desks, as the markets evolved in late 2004 and early 2005, financial institutions began to participate, either trading on their own account or, more commonly, acting for clients without trading capabilities. Barclays Capital (UK), Morgan Stanley (US/UK) and Fortis Bank (Benelux) were the main financial players early on in the evolution of the market.<sup>211</sup> Banks participate in the carbon market primarily by trading carbon as they would any other commodity, but also by providing advisory services and by investing in carbon offsetting projects.

Barclays was the first UK bank to set up a carbon trading desk – employing Louis Redshaw in May 2004 – and is now the biggest banking participant, having traded over 160 million EU Allowances by the end of 2006.

As we have seen in renewables finance, blue-chip investment banks such as Merrill Lynch and Goldman Sachs are moving into the carbon market. In 2005, the London offices of JPMorgan and Morgan Stanley both hired emissions traders and Merrill Lynch began trading allowances in the second quarter of 2005.

By 2006, it was clear that all major financial institutions had been rapidly developing new carbon-focused products and services. Even hedge funds began to be visible in the market.<sup>212</sup> In Europe, HSBC, Barclays, RBS, Lloyds TSB, Standard Chartered, Bank of Ireland, Unicredit Group (which owns the German bank HVB), ING, Fortis, UBS, BNP Paribas, Société Générale, Credit Suisse and Deutsche Bank all have various products to serve the carbon market. US banks with such services include Morgan Stanley, Merrill Lynch, Wachovia, State Street, Wells Fargo, Citigroup, Goldman Sachs and JPMorgan Chase as well as RBC in Canada. Active Japanese banks include Nomura, Mitsubishi UFJ and Mizuho.<sup>213</sup>

#### BROKERS

It is estimated that roughly 40% of trading in the EUA market is undertaken via brokers (the remaining 60% via the electronic exchanges). The project-based carbon market in particular relies heavily on brokerage due to the bespoke nature of many transactions.<sup>214</sup>

There are at least ten brokerages providing GHG credit brokering and carbon mitigation consulting services to companies, and matching sellers and buyers of carbon credits. Major pure emissions players include Evolution Markets, the world's highest volume emissions broker (also covering SO<sub>x</sub> and NO<sub>x</sub>), and the pioneer CO<sub>2</sub>e (now called CantorCO<sub>2</sub>e). Now that the market has showed signs of maturing, large-scale commodity brokers such as Tradition Financial Services have moved aggressively into the field. Overall, the revenues in 2006 for a typical emissions broker increased year-on-year compared to 2005,<sup>215</sup> although over the past two years the commissions they charge have fallen from as much as 7.5% of the value of a transaction to as little as 0.2%, indicating the growing competition in this market.<sup>216</sup>

MANAGEMENT OF PUBLIC MONEY	
US (INCLUDES WORLD BANK CARBON FINANCE UNIT)	45%
IRELAND	8%
GERMANY	4%
OTHER	43%

MANAGEMENT OF PRIVATE MONEY	
UK (INCLUDES MORGAN STANLEY, ECOSECURITIES)	64%
US	9%
CANADA (INCLUDES NATSOURCE)	8%
OTHER	19%

#### CARBON ASSET MANAGERS /CDM DEVELOPERS

The reported global value of carbon funds (or funds investing in carbon credits) reached US\$8.5 billion as of the end of 2006.<sup>217</sup> This money has been raised directly from governments – some of whom have outsourced carbon credit buying to help meet their national Kyoto targets – from industrial companies, who will also need carbon credits, and from investors chasing attractive financial returns. Public and private money is mainly managed from the US and UK respectively – see tables to the left.

The value in the role of a carbon asset manager is in being able to leverage collective funds to achieve more cost-effective emission reductions, in helping to diversify the risks associated with a portfolio of carbon credits, and in reducing the transaction costs of participating in the carbon markets for fund participants. The revenues for carbon asset managers come from a variety of sources including arbitrage between the prices of different carbon instruments, and fund management fees. Given the very private nature of the funds, typically such numbers are not disclosed and are difficult to assess with any precision. The typical fund manager fee varies between 5-15% so, for a fund of €300 million, fund revenue based on fees alone would be around €30 million.

**QUOTE: “THE CARBON FUND SECTOR CONTINUES TO ATTRACT SUBSTANTIAL NEW INVESTMENT WITH MUCH OF THE NEW MONEY COMING FROM PRIVATE INVESTORS. THIS SIGNALS A STRONG BELIEF AMONGST INVESTORS THAT THE CHALLENGES OF CLIMATE CHANGE ARE BECOMING MORE SEVERE AND THAT GOVERNMENTS AND CORPORATIONS ALIKE ARE PREPARED TO TAKE THE STEPS NECESSARY TO ADDRESS THE PROBLEM. THE COMBINATION OF THESE FACTORS IS LEADING TO SIGNIFICANT OPPORTUNITIES FOR BUSINESSES ABLE TO PROVIDE COST-EFFECTIVE SOLUTIONS TO REDUCING GREENHOUSE GAS EMISSIONS.”**  
**GUY TURNER, DIRECTOR, NEW CARBON FINANCE**

The following table lists the top six most significant carbon fund managers currently managing both public and private funds, by descending order of size of funds under management.

FUND MANAGER	APPROX. ASSETS UNDER MANAGEMENT (AS OF 2006) <sup>218</sup>
WORLD BANK	US\$1,900M
CLIMATE CHANGE CAPITAL	US\$1,150M
NATSOURCE ASSET MANAGEMENT	US\$670M
EEA FM (TRADING EMISSIONS)	US\$600M
EBRD	US\$265M
IXIS ENVIRONNEMENT & INFRASTRUCTURES (EUROPEAN CARBON FUND)	US\$190M

- Climate Change Capital is the leading private investment banking group in this area – it set up the largest private sector carbon fund in the world in the third quarter of 2006, which it hoped would top US\$1 billion, and also offers advisory and corporate finance services.
- Natsource Asset Management, formerly operating as a broker, is one of the world’s largest private sector carbon asset management companies.
- Trading Emissions – set up in 2005 and listed on AIM in 2006, the company is an investment fund focused on investing in environmental instruments, but particularly focusing on CDM and JI credits.

Other notable entities include:

- EcoSecurities – a London-listed CDM project developer, with a portfolio of 273 carbon credit projects forecast to deliver more than 146 million carbon credits. It went public in late 2005, raising £54 million, and now has 235 staff.
- Camco – has one of the world’s largest portfolios of tradeable carbon credits, counting more than 100 million tonnes. It is also the market leader in carbon credit origination in China and Russia, two of the largest potential markets for these credits. Camco was listed on London’s AIM at the end of April 2006, with a list value of £83 million.
- RNK Capital – a New York-based international investment firm that invests in assets in environmental and emissions markets worldwide. It invests directly in projects that generate products such as carbon credits and renewable energy credits.

Japanese companies such as Mitsubishi UFJ Securities have been at the forefront of developing and promoting CDM projects, particularly important in Japan for the meeting of its national Kyoto target. The Japan Greenhouse Gas Reduction Fund (JGRF) was set up in 2004 to invest funds in order to buy carbon credits, and now manages a total of US\$145.5 million, over half of which has already been allocated to projects. Mitsubishi UFJ Securities has a ‘Clean Energy Finance Committee’, a consulting unit of 22 specialist staff who work on CDM/JI projects. At a Climate Technology Initiative industry seminar in 2006, the company’s Junji Hatano commented that financing is one of the essential elements for technology transfer – a large number of projects with high profitability are still precluded from implementation due to lack of funding.

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**FACT:**

**US\$30 BILLION  
– THE TOTAL  
VALUE OF THE  
GLOBAL CARBON  
MARKETS BY  
EARLY 2007**

### CARBON OFFSET PROVIDERS

The voluntary market, although smaller than the regulated one, is growing dramatically and a non-exhaustive list of providers already reaches over 100 entities, many based in the UK, continental Europe or the US. Other companies jumping on board include the Bank of New York which, in late 2006, set up a voluntary CO<sub>2</sub> registry, seeing the opportunity for standardisation and simpler transactions. Carbon credits in the system will be verified by third parties.<sup>219</sup> Similar plans include California's Climate Action Registry.

To illustrate the growth, 18 offset companies capitalising on the growing trend for voluntary carbon emissions reductions, were identified in a 2006 paper by Context. Ten of these are based in the UK, five in the US and Canada, two in Europe and one in Australia. Of these 18, five were set up in the 1990s and nine during this decade, and there has been a clear move from a focus on forestry projects, to a much wider range of projects, many of them energy technology-based.

In a consumer's guide to carbon offsets published by the organisation 'Clean Air-Cool Planet', the top-rated providers were named as AgCert/Driving Green (Ireland), atmosfair (Germany), CarbonNeutral Company (UK), Climate Care (UK), Climate Trust (US), co2balance (UK), NativeEnergy (US) and Sustainable Travel/MyClimate (US). The top 10 global companies by volume offset (as of end 2005) are listed in the table below.

### GROWTH PROJECTIONS

A development of note is the desire of some developing countries, particularly Brazil, India and China, to create local exchanges for carbon credits. Overall, the carbon markets are demonstrating that, with credible and stringent policies in place to reduce GHG emissions, the markets will continue to seek out myriad ways to reduce emissions wherever those opportunities may be.

The financial sector has also sent strong signals that it expects the GHG market to grow dramatically in strength and size, given the imminence of the first Kyoto compliance period, political moves in the US towards regulation of carbon emissions and the likelihood of a global cap-and-trade regime. In 2006, Governor Schwarzenegger signed California legislation imposing an emissions cap on utilities, refineries and manufacturing plants, the first in the US, with a goal of cutting greenhouse gases to 1990 levels by 2020. At the end of February 2007, the governors of Arizona, California, New Mexico, Oregon and Washington state signed an agreement to set up a regional cap and trade scheme, the Western Regional Climate Action Initiative.

**QUOTE: "IN EUROPE THE EU ALLOWANCE MARKET IS STILL THE MAIN GAME IN TOWN, ALTHOUGH MANY COMPANIES ARE INCREASINGLY DEVELOPING STRATEGIES FOR PROCURING (PROJECT-RELATED) CARBON CREDITS. IN THE US, THE MARKET IS STILL IN ITS INFANCY ALTHOUGH VOLUMES FINALLY APPEAR TO BE PICKING UP IN THE CHICAGO CLIMATE EXCHANGE (CCX). THE ATTENTION IN THE US IS, HOWEVER, RAPIDLY SHIFTING FROM THE VOLUNTARY CCX TO MANDATORY SCHEMES – WE EXPECT EMISSION TRADING ACTIVITY TO TAKE OFF IN THE US IN 2009 AS A RESULT. EUROPEAN MARKET INTERMEDIARIES WILL BE WELL PLACED TO CAPTURE PART OF THIS MARKET THANKS TO THEIR EARLY START."**

**ABYD KARMALI, DIRECTOR OF CLIMATE CHANGE STRATEGIES, ICF CONSULTING**

On 26 October 2006, Morgan Stanley announced that it will earmark US\$3 billion for investment into global carbon markets and low-emissions energy projects over the next few years. In March 2007, Bank of America announced a US\$20 billion environmental programme, including investment in carbon trading.

Goldman Sachs is already a major trader in the EU ETS. It is also set to be a key player in US emissions markets such as the Regional Greenhouse Gas Initiative, which involves several north-eastern US states, and a separate scheme in California, which are both set to launch by the end of the decade. In addition, illustrating the potential growth in the Exchanges, in September 2006 Goldman Sachs took a 10% stake, worth US\$23 million, in Climate Exchange, the UK AIM-listed parent of the ECX and the CCX, increasing this stake to 19% in January 2007.<sup>220</sup>

**TOP TEN GLOBAL COMPANIES IN THE VOLUNTARY CARBON MARKET**

COMPANY	COUNTRY	PROJECT TYPE	VOLUME BY END 2005 (TONNES CO <sub>2</sub> e)
THE CLIMATE TRUST	USA	FOSSIL FUEL USE REDUCTIONS	C.860,000 PER YEAR (C.4 MILLION TOTAL)
CLIMATE CHANGE CONSULTING (3C)	GERMANY	LIVESTOCK/METHANE	300,000 (IN 2005 ALONE)
MY CLIMATE	SWITZERLAND	MIX	200,000 PER YEAR (APPROX)
BONNEVILLE ENV'L FOUNDATION	USA	RECS	700,000 IN TOTAL (APPROX)
THE CARBONNEUTRAL COMPANY	UK	MIX	700,000 IN TOTAL (APPROX)
CARBONFUND.ORG	USA	MIX	100,000 IN TOTAL
CLIMATE CARE	UK	MIX	97,000 TONNES IN TOTAL
PRIMA KLIMA	GERMANY	FORESTRY	31,000 PER YEAR
TERRAPASS	USA	RECS/CCX	10,000 IN TOTAL
SOLAR ELECTRIC LIGHT FUND	USA	OFF-GRID SOLAR ENERGY	6,000 PER YEAR



# Banking on a low carbon future



Barclays is proud to have the opportunity to sponsor this important report on the move towards a low carbon economy. 2006 was a watershed year for the issue of climate change. Thanks to high profile events such as Al Gore's film 'An Inconvenient Truth' and the publication of the Stern Report, there is now more public awareness than ever before and a growing impetus to take action.

Over time, the impacts of climate change will strike at every aspect of our business. This threatens to affect not only the economic stability of our customers but also our own operations around the world. We see climate change as a significant business opportunity to support our customers in the gradual transition towards a lower carbon economy. This is why we are working hard to reduce our own carbon footprint and investing in the development of products and services that can help our customers do the same.

"I find it motivating, and I know that thousands of colleagues across Barclays find it motivating, to know that Barclays is responsible in its approach to the environment and climate change. And it's right that we should be."

**John Varley**  
Group Chief Executive, Barclays Bank PLC.

## Carbon and Commerce

Barclays was the first UK bank to set-up a carbon-trading desk and today we are the most active trader in the EU Emissions Trading Scheme, winning several industry awards including Best Trading Company in the Environmental Finance Awards 2006. We see emissions trading as an important area of business for us and one where we can help our clients manage their emissions risks. We are proud to have been at the forefront of emissions trading since the inception of the EU ETS and to have played a leading role in its continued development.

Barclays also plays an active role in the development of the renewable energy market in the UK and Europe. We have provided long-term finance for over 2,600MW of renewable generating capacity, including onshore wind farms, landfill gas extraction, biomass and bio-diesel conversion plants – enough to generate electricity to power nearly 1.4 million homes each year.

## Shrinking our carbon footprint

Barclays made its UK operations carbon neutral earlier this year, offsetting 223,000 tonnes of CO<sub>2</sub> from our energy use and business travel.

The first and most important step to achieving carbon neutrality is reducing our emissions. In 2006, Barclays cut its UK energy consumption by 5% per employee and over the next five years we aim to further improve our performance through a multi-million pound energy-efficiency investment programme.

Secondly, we are buying more renewable energy. 50% of our UK electricity consumption is now obtained from renewable sources, avoiding up to 125,000 tonnes of CO<sub>2</sub> a year being emitted – the equivalent of the annual CO<sub>2</sub> emitted by 9,000 homes.

For the CO<sub>2</sub> we cannot avoid emitting, we have offset by investing in sustainable energy projects and community-based energy-efficiency schemes in South Africa, India and China.

To help us negotiate some of the obstacles we face, we seek positive engagement with external organisations. One example is our work with the UK Social Investment Forum on a project aimed at accelerating the shift to the low carbon economy by using asset finance, project finance and lending. Barclays works with a number of other companies and organisations including the International Emissions Trading Association, The °Climate Group and Business in the Environment. We aim to make a valuable contribution in identifying the commercial opportunities that the emerging low carbon economy will present and importantly ways to overcome barriers so that everyone in society takes positive action.

[www.barclays.com/climatechange](http://www.barclays.com/climatechange)

Barclays Carbon Trading

## The real futures market...

Looking back from 2106 our great, great grand children will see the establishment of the European Union's Emissions Trading Scheme as a milestone in ensuring sustainable future for the World.

But for now, Barclays Capital continues to establish itself as the leading intermediary in the emissions market, applying the full range of our commodity trading and risk management expertise.

To find out more about emissions trading opportunities contact our team on:

020 777 35142 or  
[emissions@barcap.com](mailto:emissions@barcap.com)

# GLOSSARY OF TERMS

## AC

Air-conditioning.

## AIM

London's Alternative Investment Stock-Market.

## BIOFUELS

Fuels made from processing biomass or metabolic by-products, such as plant oils or animal waste; the liquid versions are used in transport applications.

## CL

Climate Change Levy. A UK tax on fossil fuel use.

## CCS

Carbon Capture and Storage. CCS is an approach to mitigating climate change by capturing carbon dioxide (CO<sub>2</sub>) from large point sources such as power plants and subsequently sequestering it instead of releasing it into the atmosphere, probably in geological aquifers in depleted oil and gas fields. Technology for the capturing of CO<sub>2</sub> is already commercially available for large CO<sub>2</sub> emitters, such as power plants. Storage of CO<sub>2</sub>, on the other hand, is a relatively untried concept.

## CCX

Chicago Climate Exchange. The world's first, and North America's only, voluntary, legally binding, rules-based greenhouse gas emission reduction and trading system.

## CDM

Clean Development Mechanism. Defined in Article 12 of the Kyoto Protocol, the CDM allows industrialised countries with emission reduction targets to invest in emission-reducing projects in developing countries and take credit for any emissions reduced. Such credits are known as Certified Emission Reductions (CERs). CDM projects are also intended to contribute to the sustainable development of the host country.

## CF

Compact Fluorescent Lightbulb.

## CHP

Combined Heat and Power, also known as cogeneration of heat and electricity from the same fuel source.

## COGENERATION

See CHP.

## CO<sub>2</sub>

Carbon Dioxide, the principal greenhouse gas.

## CO<sub>2</sub>e

Carbon dioxide equivalent. A unit, measured in tonnes, that allows emissions of non-CO<sub>2</sub> greenhouse gas emissions to be expressed as if they were CO<sub>2</sub> emissions, using global warming potential coefficients to make the conversion.

## DEFRA

UK Government Department of Environment, Food and Rural Affairs.

## DIGESTER GAS

Produced during the anaerobic treatment of waste sludge and is comprised of methane and carbon dioxide; it has about 60% of the energy value of natural gas.

## E85

An ethanol-based biofuel, comprising 85% ethanol and 15% gasoline.

## ECX

European Climate Exchange.

## EHS

Environment, Health and Safety. Also referred to as Environment, Safety and Health (ESH).

## ENERGY-STAR

This is a joint programme of the US Environmental Protection Agency and the US Department of Energy aiming to promote market growth in energy-efficient products and practices, through an 'Energy-Star' labelling scheme. Energy-Star is also used in countries outside the US.

## EPACT

US Energy Policy Act.

## ESCO

Energy Services Company.

## EUA

EU Allowance. The tradeable commodity created within the EU ETS.

## EU ETS

European Emissions Trading Scheme. The world's largest multi-national greenhouse gas emissions trading scheme commenced on January 1, 2005.

## FUEL CELL

An electrochemical energy conversion device. It produces electricity from external supplies of fuel (on the anode side) and oxidant (on the cathode side). These react in the presence of an electrolyte. Fuel cells can operate virtually continuously as long as the necessary flows of reactants and products are maintained. Fuel cells differ from batteries in that their reactants must be replenished, while batteries store electrical energy chemically in a closed system. Many combinations of fuel and oxidant are possible. A hydrogen cell uses hydrogen as fuel and oxygen as oxidant. Other fuels include hydrocarbons and alcohols.

## GHG

Greenhouse gas.

## GTC

Gigatonne of Carbon (one billion tonnes of carbon).

## GW

Gigawatt of power (one billion watts).

## HVAC

Heating, ventilation, and air conditioning.

## HYBRID VEHICLE

Automotive vehicle with an electric motor and an internal combustion engine powered by a fossil fuel or biofuel.

## ICE FUTURES

The Intercontinental Exchange company operates a leading global, electronic marketplace for trading both futures and OTC energy contracts.

## IGCC

Integrated Gasification Combined Cycle. This is a new type of coal power production plant where coal is turned into gas and can assist in the separation and sequestration of carbon dioxide at a lower cost than conventional coal plants.

## IPCC

Intergovernmental Panel on Climate Change. This is the body established by the World Meteorological Organisation (WMO) and the United Nations Environment Programme (UNEP) in 1988 in order to assess the scientific, technical and socio-economic information relevant to understanding the scientific basis of risk of human-induced climate change, its potential impacts and options for adaptation and mitigation.

## IPO

Initial Public Offering.

## JJ

Joint Implementation.

## KYOTO PROTOCOL

The emissions-reductions agreement created under the UNFCCC and which entered into force in February 2005.

## LED

Light Emitting Diode.

## MANDATED LEAD ARRANGER

A bank in charge of organising a syndicated loan.

## MW

Megawatt.

## MWh

Megawatt hour. A Megawatt corresponds to a billion watts in power capacity, and Megawatt hours describes the amount of power in Megawatts generated over a particular period of time.

## NASDAQ

US-based electronic stock market. The name was originally an acronym for National Association of Securities Dealers Automated Quotations system. It was founded in 1971 by the National Association of Securities Dealers.

## NITROUS OXIDE (N<sub>2</sub>O)

Powerful greenhouse gas emitted through soil cultivation practices, especially the use of commercial and organic fertiliser, fossil-fuel combustion, nitric acid production, and biomass burning. One of the six greenhouse gases to be curbed under the Kyoto Protocol. The global warming potential of N<sub>2</sub>O is 296 times that of CO<sub>2</sub>.

## NYSE

New York Stock Exchange.

## DEM

Original Equipment Manufacturer.

## PAFC

Phosphoric Acid Fuel Cell.

## PE

Private Equity.

## PROJECT FINANCE

Also known as Asset Finance, project finance is the financing of long-term infrastructure and industrial projects where project debt and equity used to finance the project are paid back from the cash flow generated by the project, rather than the general assets or creditworthiness of the project owners. The financing is typically secured by the project assets, including the revenue-producing contracts.

## PV

Photovoltaics.

## R&D

Research and Development.

## R.D.&D

Research, Design and Development.

## REGI

Regional Greenhouse Gas Initiative. Agreement by seven north-eastern US states to establish a GHG emissions trading scheme, due to commence in 2009.

## RPS

Renewable Portfolio Standard.

## SOLAR MODULE

A structure containing c. 40 solar PV cells (capable of generating 1-2 watts of power each).

## TWh

Terawatt hours. A Terawatt corresponds to a trillion watts in power capacity, and Terawatt hours describes the amount of power in Terawatts generated over a particular period of time.

## UNFCCC

The United Nations Framework Convention on Climate Change. Adopted on 9 May 1992 and signed at the 1992 Earth Summit in Rio de Janeiro by more than 150 countries and the European Community. Its ultimate objective is the "stabilisation of greenhouse gas concentration in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system." The Convention entered into force in March 1994.

## US EPA

United States Environmental Protection Agency.

## VC

Venture Capital.

- 1 – S. Pacala and R. Socolow, *Stabilization Wedges: Solving the Climate Problem for the Next 50 Years with Current Technologies*, 2004
- 2 – Per-Anders Enkvist, Tomas Nauclér and Jerker Rosander, 'A cost curve for greenhouse gas reduction', *The McKinsey Quarterly*, No.1, 2007
- 3 – The Chancellor of the Exchequer, the Rt Hon Gordon Brown MP, 'remarks at the launch of the Stern review on the economics of climate change', London, United Kingdom, 30 October 2006
- 4 – Worrell, Laitner, Ruth, Finman, 'Productivity benefits of industrial energy-efficiency measures'. *Energy*, vol. 28, pp.1081-1098, 2003
- 5 – Renewable Energy Policy Network for the 21st Century, *Renewables Global Status Report: 2006 Update*, page 2
- 6 – Renewable Energy Policy Network for the 21st Century, *Global revolution: A status report on renewable energy worldwide – summary 2005*
- 7 – European Commission, employment data, accessed at: [http://ec.europa.eu/employment\\_social/employment\\_analysis/employ\\_2006\\_en.htm](http://ec.europa.eu/employment_social/employment_analysis/employ_2006_en.htm)
- 8 – European Renewable Energy Council, organizational brochure – accessed at: <http://www.erec.org/documents/Technology%20Brochures/Brochure%20EREC%20A4.pdf>
- 9 – International Energy Agency, *World Energy Outlook 2006*
- 10 – International Energy Agency, *World Energy Outlook 2006*
- 11 – Worldwatch Institute, *The Renewable Path to Energy Security*, September 2006
- 12 – Renewable Energy Policy Network for the 21st Century, *Global revolution: A status report on renewable energy worldwide – summary 2005*
- 13 – E. Martinot, *Renewable Energy gains Momentum, 2006* – accessed at: [http://www.martinot.info/Martinot\\_Environment.pdf](http://www.martinot.info/Martinot_Environment.pdf)
- 14 – BTM Consult ApS, Goldman Sachs Research Estimates, *European Renewable Energy – Sun, Wind and Grain p41, 16 October 2006*
- 15 – Renewable Energy Policy Network for the 21st Century, *Renewables Global Status Report: 2006 Update*, page 3
- 16 – Renewable Energy Policy Network for the 21st Century, *Renewables Global Status Report: 2006 Update*, page 5
- 17 – Renewable Energy Policy Network for the 21st Century, *Global revolution: A status report on renewable energy worldwide – summary 2005*
- 18 – Renewable Energy Access website, article – *Global Wind Energy Markets: 2006 Another Record Year*, 7 February 2007, accessed at: <http://www.renewableenergyaccess.com/rea/news/story?id=47361>
- 19 – Global Wind Energy Council
- 20 – Forbes, 'Wind Man', 6 May 2006
- 21 – Global Wind Energy Council press release 02-02-07, accessed at: [http://www.gwec.net/index.php?id=30&no\\_cache=1&tx\\_ttnews\[tt\\_news\]=50&tx\\_ttnews\[backPid\]=4&cHash=7a562a4d4e](http://www.gwec.net/index.php?id=30&no_cache=1&tx_ttnews[tt_news]=50&tx_ttnews[backPid]=4&cHash=7a562a4d4e)
- 22 – BTM Consult ApS, Goldman Sachs Research Estimates, *European Renewable Energy – Sun, Wind and Grain p41, 16 October 2006*
- 23 – Renewable Energy Policy Network for the 21st Century, *Renewables Global Status Report: 2006 Update*, page 3
- 24 – European Photovoltaic Industry Association (EPIA), BTM Consult ApS, Goldman Sachs Research Estimates, *European Renewable Energy – Sun, Wind and Grain p26, 16 October 2006*
- 25 – Citigroup, *Solar Power Industry – let the sun shine in*, page 39, October 2006
- 26 – Datastream, Goldman Sachs Research Estimates, *European Renewable Energy – Sun, Wind and Grain p28, 16 October 2006*
- 27 – Makower, Pernick and Wilder, 'Clean Energy Trends 2006', p4, Clean Edge, March 2006
- 28 – Datastream, Goldman Sachs Research Estimates "European Renewable Energy – Sun, Wind and Grain" 16/10/06 pg. 28
- 29 – Renewable Energy Policy Network for the 21st Century, *Renewables Global Status Report: 2006 Update*, page 2
- 30 – European Photovoltaic Industry Association (EPIA), Goldman Sachs Research Estimates, *European Renewable Energy – Sun, Wind and Grain p26, 16 October 2006*
- 31 – BTM Consult ApS, Goldman Sachs Research Estimates 'European Renewable Energy – Sun, Wind and Grain p45 16 October 2006
- 32 – Renewable Energy Policy Network for the 21st Century, *Renewables Global Status Report: 2006 Update*, page 7
- 33 – Renewable Energy Policy Network for the 21st Century, *Renewables Global Status Report: 2006 Update*, page 7
- 34 – IEA, Goldman Sachs Research Estimates 'European Renewable Energy – Sun, Wind and Grain' p31, 16 October 2006
- 35 – IEA, Goldman Sachs Research Estimates 'European Renewable Energy – Sun, Wind and Grain p31', 16 October 2006
- 36 – Financial Times, 'Renewables gather investment power', 2 January 2007
- 37 – BTM Consult ApS, Goldman Sachs Research Estimates 'European Renewable Energy – Sun, Wind and Grain p41 16 October 2006, Forbes, 'Wind Man', 6 May 2006
- 38 – European Commission, *EU-25 Energy and Transport Outlook to 2030*, accessed at: [http://ec.europa.eu/dgs/energy\\_transport/figures/trends\\_2030/5\\_chap4\\_en.pdf](http://ec.europa.eu/dgs/energy_transport/figures/trends_2030/5_chap4_en.pdf)
- 39 – International Energy Agency, *World Energy Outlook 2006*
- 40 – Renewable Energy Policy Network for the 21st Century, *Renewables Global Status Report: 2006 Update*, page 7
- 41 – Solarbuzz, *Marketbuzz 2006*, accessed at: <http://www.solarbuzz.com/Marketbuzz2006-intro.htm>
- 42 – Photon Consulting, *Solar Annual 2006 Executive Summary*, accessed at: [http://www.photon-consulting.com/executive\\_summary.htm](http://www.photon-consulting.com/executive_summary.htm)
- 43 – Solarbuzz, *Marketbuzz 2006*, accessed at: <http://www.solarbuzz.com/Marketbuzz2006-intro.htm>
- 44 – ALTENER Programme, Directorate General for Energy and Transport, *European Commission, MITRE Overview Report – 'Meeting the Targets and Putting Renewables to Work'*, 2004
- 45 – EurObserver, *Photovoltaic Energy Barometer, 2006*
- 46 – Prof. K. Barnham et al, *Resolving the Energy Crisis, nuclear or photovoltaics?*, *Nature Materials* 5, p161-164, 1 March 2006
- 47 – The Chancellor of the Exchequer, the Rt Hon Gordon Brown MP, 'remarks at the launch of the Stern review on the economics of climate change', London, United Kingdom, 30 October 2006
- 48 – REFOCUS Weekly, 'UK starts consultation on major support program for renewables', 18 October 2006
- 49 – The Chancellor of the Exchequer, the Rt Hon Gordon Brown MP, 'remarks at the launch of the Stern review on the economics of climate change', London, United Kingdom, 30 October 2006
- 50 – Sky News, 'New chance for business', 12 January 2007, accessed at: <http://news.sky.com/skynews/article/0,,30400-13561016,00.html?r=rs>
- 51 – European Commission, employment data, accessed at: [http://ec.europa.eu/employment\\_social/employment\\_analysis/employ\\_2006\\_en.htm](http://ec.europa.eu/employment_social/employment_analysis/employ_2006_en.htm)
- 52 – BBC News, 'UK economic growth tops forecasts', 24 January 2007, accessed at: <http://news.bbc.co.uk/1/hi/business/6293851.stm>
- 53 – The "Climate Group 'California: Low Carbon Leader' report, 2006 & EarthSummit 2002
- 54 – Edie News, 'Wind power to grow at double predicted rate', 27 March 2006, accessed at: [http://www.edie.net/news/news\\_story.asp?id=11247&amp;channel=0](http://www.edie.net/news/news_story.asp?id=11247&amp;channel=0)
- 55 – Scottish Enterprise, 'Scottish Industries – Energy', accessed at: [http://www.scottish-enterprise.com/sedotcom\\_home/services-to-business/improving-performance/economicintelligence/economicintelligence-keyfacts.htm?siblingstoggle=1](http://www.scottish-enterprise.com/sedotcom_home/services-to-business/improving-performance/economicintelligence/economicintelligence-keyfacts.htm?siblingstoggle=1)
- 56 – EWEA
- 57 – Euroserver PV Barometer, 2006 & REFOCUS Weekly, 26 April 2006
- 58 – Renewable Energy Report, 'Study of German exports finds obstacles persist for renewable energy companies', 19 September 2005
- 59 – Ernst & Young, 'Renewable Energy Country Attractiveness Indices' p3, Q3 2006
- 60 – Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, Working Group on Renewable Energies, Ed. Dieter Böhme et al, 'Trends in Renewable Energies in 2005: current situation', March 2006, accessed at: [www.renewable-energien.de](http://www.renewable-energien.de)
- 61 – DENA, *Renewables Made in Germany, the German wind industry*, accessed at: <http://www.renewables-made-in-germany.com/en/wind-energy/>
- 62 – Federal Ministry for the Environment (BMU), *Erneuerbare Energien. Arbeitsplatzeffekte – Wirkungen des Ausbaus erneuerbarer Energien auf den deutschen Arbeitsmarkt*. p.105, 28 Oct 2006, accessed at: [http://www.bmu.de/files/pdfs/allgemein/application/pdf/arbeitsmarkt\\_ee\\_lang.pdf](http://www.bmu.de/files/pdfs/allgemein/application/pdf/arbeitsmarkt_ee_lang.pdf)
- 63 – DENA, *Renewables Made in Germany, the German photovoltaic industry*, accessed at: <http://www.renewables-made-in-germany.com/en/photovoltaics>
- 64 – World Future Council Initiative, 'Policies to change the world', May 2006
- 65 – International Energy Agency, Goldman Sachs Research Estimates 'European Renewable Energy – Sun, Wind and Grain' p31, 16 October 2006

- 66 – Refocus Weekly, 'Solar Company moves into no.3 spot with acquisition of Shell assets', 26 July 2006
- 67 – American Wind Energy Association
- 68 – IEA, Goldman Sachs Research Estimates 'European Renewable Energy – Sun, Wind and Grain' p31, 16 October 2006
- 69 – Ernst & Young, 'Renewable Energy Country Attractiveness Indices Q3 2006'
- 70 – Renewable Energy Access, 'California Formally Adopts Performance-Based Solar Incentives', 29 August 2006, accessed at: <http://www.renewableenergyaccess.com/rea/news/story?id=45831>
- 71 – Union of Concerned Scientists, September 2004
- 72 – University of California, Renewable and Appropriate Energy Laboratory (RAEL), Putting Renewables to Work: How Many Jobs Can the Clean Energy Industry Generate?, April 2004
- 73 – University of California, Renewable and Appropriate Energy Laboratory (RAEL), Putting Renewables to Work: How Many Jobs Can the Clean Energy Industry Generate?, April 2004
- 74 – Worldwatch Institute, The Renewable Path to Energy Security, September 2006
- 75 – Massachusetts Energy Collaborative, accessed 1 February 2007 at: <http://www.mtpc.org/cleanenergy/important/economy.htm>
- 76 – Massachusetts Energy Collaborative, accessed 1 February 2007 at: <http://www.mtpc.org/cleanenergy/important/economy.htm>
- 77 – The 'Climate Group, 'California: Low Carbon Leader' report, p9, 2006
- 78 – Environment California Research and Policy Center, Renewable Energy and Jobs, 2003, accessed at: [http://www.environmentcalifornia.org/uploads/OW/aa/OWaa2RaedlfHwQOWbxKd5w/Renewable\\_Energy\\_and\\_Jobs.pdf](http://www.environmentcalifornia.org/uploads/OW/aa/OWaa2RaedlfHwQOWbxKd5w/Renewable_Energy_and_Jobs.pdf)
- 79 – Renewable Energy Policy Network for the 21st Century, Renewables Global Status Report: 2006 Update p18
- 80 – Renewable Energy Policy Network for the 21st Century, Global revolution: A status report on renewable energy worldwide – summary 2005
- 81 – Sharp, Environmental and Social Report, 2006
- 82 – Research and Markets, '2005 Hydrogen Market, Hydrogen R&D and Commercial Implication in the US and EU', accessed at: <http://www.researchandmarkets.com/reports/c18817/>
- 83 – Research and Markets, '2005 Hydrogen Market, Hydrogen R&D and Commercial Implication in the US and EU', accessed at: <http://www.researchandmarkets.com/reports/c18817/>
- 84 – Clean Edge, Clean Energy Trends 2007, accessed at: <http://www.cleandge.com/reports/Trends2007.pdf>
- 85 – UNFCCC, 2005
- 86 – International Energy Agency, World Energy Outlook, 2006
- 87 – International Energy Agency
- 88 – BSRIA, accessed at: <http://www.bsria.co.uk/press/?press=314>
- 89 – Frost and Sullivan Research Service, accessed 14 December 2006 at: [www.frost.com](http://www.frost.com)
- 90 – Amory Lovins, Rocky Mountain Institute 2004, [http://www.rmi.org/images/other/Energy/E04-02\\_EnergyEffTax.pdf](http://www.rmi.org/images/other/Energy/E04-02_EnergyEffTax.pdf)
- 91 – Odyssee-indicators, Energy-efficiency Profile: Germany, December 2006, accessed at: <http://www.odyssee-indicators.org/Publication/country%20profiles%20PDF/rfa.pdf>
- 92 – Nadel et al. 1997; SWEEP 2002
- 93 – NEMI/FMI 2002
- 94 – Tyndall Centre for Climate Change Research, ESCO Report, November 2005
- 95 – Edward L. Vine. LBNL Berkeley, An International Survey of the Energy Service Company Industry, 23 June, 2003
- 96 – Tyndall Centre for Climate Change Research, ESCO Report, November 2005
- 97 – Japanese Association of ESCOs
- 98 – Hoover's, Matsushita factsheet, accessed at: [http://www.hoovers.com/matsushita--ID\\_41873--/free-co-factsheet.xhtml](http://www.hoovers.com/matsushita--ID_41873--/free-co-factsheet.xhtml)
- 99 – Environmental Finance online news, 'Philips sells €4bn of 'green products', 1 March 2007, accessed at: <http://www.environmental-finance.com/online/news/01marcsr.htm>
- 100 – Bertoldi, European Commission DG JRC, presentation at EEDAL conference 2006 – European Policies for Energy-Efficient Residential Appliances and Lighting, accessed at <http://mail.mtprog.com/eedal.html#H>
- 101 – [www.energywatch.co.uk](http://www.energywatch.co.uk)
- 102 – Co-Operative Bank, Ethical Consumerism Report, 2006
- 103 – DTI, Digest of UK Energy Statistics, accessed at: [http://www.dti.gov.uk/energystats/dukes5\\_2.xls](http://www.dti.gov.uk/energystats/dukes5_2.xls)
- 104 – Odyssee-indicators, Energy-efficiency Profile: Germany, December 2006, accessed at: <http://www.odyssee-indicators.org/Publication/country%20profiles%20PDF/rfa.pdf>
- 105 – Odyssee-indicators, Energy-efficiency Profile: Germany, December 2006, accessed at: <http://www.odyssee-indicators.org/Publication/country%20profiles%20PDF/rfa.pdf>
- 106 – Energy Star, 'The Value of the Energy Star Market', accessed at: [http://www.energystar.gov/ia/partners/manuf\\_res/ENERGYSTAR\\_Value-General.doc](http://www.energystar.gov/ia/partners/manuf_res/ENERGYSTAR_Value-General.doc)
- 107 – Mark Levine, LBNL California, 'Small Steps Save Big in Energy', accessed at: <http://usinfo.state.gov/journals/ites/0706/ijee/levine.htm>
- 108 – Lohas, accessed at: <http://www.lohas.com/journal/trends.htm>, June 2006
- 109 – Worrell, Laitner, Ruth, Finman, 'Productivity benefits of industrial energy-efficiency measures', Energy, vol. 28, pp.1081-1098, 2003
- 110 – Laitner, Barrow and DeCicco, 'Employment and other macroeconomic benefits of an innovation-led climate strategy for the United States', Energy Policy, vol. 26, no. 5, pp.425-432, 1998
- 111 – EPRI, 'The Western States' Electric Power Crisis', 2001, accessed at: <http://www.ee.washington.edu/energy/apr/nsfepri/s1/westcrisis.pdf>
- 112 – EIA, Japan country analysis brief, accessed at: <http://www.eia.doe.gov/emeu/cabs/japanenv.html>
- 113 – The Energy Conservation Centre, Japan, accessed at: [http://www.ecci.or.jp/index\\_e.html](http://www.ecci.or.jp/index_e.html)
- 114 – Hydrogen and Fuel Cell Investor, News page, accessed at: <http://www.h2fc.com/news.html>
- 115 – FuelCell Today, Fuel Cell Seminar 2006 event report, November 2006
- 116 – FuelCell Today, Stationary power applications survey, November 2006
- 117 – FuelCell Today
- 118 – New Energy Foundation, 'Present state of New Energy Introduction', accessed at: <http://www.nef.or.jp/english/new/present.html>
- 119 – Fuel Cell Technology News vol 7. no. 5, 'Japan Increases Fuel Cell Funding', March 2005
- 120 – US DoE, Hydrogen Program, 'DoE awards US\$100 million in fuel cell R&D, 24 October 2006, accessed at: [http://www.hydrogen.energy.gov/news\\_million.html](http://www.hydrogen.energy.gov/news_million.html)
- 121 – Goldman Sachs Research, Americas: Energy: Alternative Energy, October 2006
- 122 – Office of the White House Press Secretary June 25, 2003
- 123 – Ballard Power Systems, 2006 financial results, February 2007, accessed at: [http://www.ballard.com/be\\_informed/about\\_ballard/news/2007/02/21/2006\\_Financial#](http://www.ballard.com/be_informed/about_ballard/news/2007/02/21/2006_Financial#)
- 124 – [www.ballard.com](http://www.ballard.com)
- 125 – Ernst and Young, Renewable Energy Country Attractiveness Indices, Q3 2006
- 126 – International Energy Agency, World Energy Outlook 2006
- 127 – Makower, Pernick and Wilder, Clean Energy Trends 2006, March 2006
- 128 – Institute of Energy Economics Japan, 'Japan Long-Term Energy Outlook' p39, 2006
- 129 – RSC, 'Fuel cells head for mass market', March 2006, accessed at: <http://www.rsc.org/chemistryworld/Issues/2006/March/FuelCells.asp>
- 130 – Renewable Energy Policy Network, Renewables 2005 Global Status Reports, 2005.
- 131 – Clean Edge
- 132 – LECG, LLC, May, 2005
- 133 – Dieter Bockey, 'Union zur Förderung von Oel-und Proteinpflanzen e.V.' (UFOP), 'Biofuels in Germany and in the European Union Technologies, Market Trends and Political Conditions', accessed at: <http://www.rlc.fao.org/prensa/activi/agroenergia/bockey.pdf>
- 134 – JJ Dooley, CA Geffen and JA Edmonds, Joint Global Change Research Institute, Pacific Northwest National Laboratory, 'Global Climate Change and the Unique Challenges Posed by the Transportation Sector', presentation at the 8th Diesel Engine Emissions Reduction Conference San Diego, CA, August 26, 2002, accessed at: <http://www.osti.gov/bridge/servlets/purl/826254-OfGhr8/native/826254.pdf>
- 135 – Clean Edge
- 136 – International Energy Agency, World Energy Outlook, 2006
- 137 – International Energy Agency, Energy Policies of IEA Countries – 2006 Review, accessed at: <http://www.iea.org/Textbase/publications/index.asp>
- 138 – Renewable Energy Network, Renewables Global Status Report: 2006 Update, 2006
- 139 – Automotive business review.com, June 30 2006
- 140 – Freedonia Group, World Hybrid-Electric Vehicles, December 2006

- 141 – International Energy Agency, World Energy Outlook 2006
- 142 – Goldman Sachs, European Renewable Energy – ‘Sun, Wind and Grain’, October 2006
- 143 – Renewable Energy Policy Network, Renewables 2005 Global Status Reports, 2005
- 144 – Renewable Energy Policy Network, Renewables 2005 Global Status Reports, 2005
- 145 – Goldman Sachs, Europe: Energy: Alternative Energy, European Renewable Energy – ‘Sun, Wind and Grain’, October 2006
- 146 – Refocus Weekly, 12 July, 2006
- 147 – Euroserver, Barometer of Biofuels, May 2006
- 148 – Dieter Bockey, Union zur Förderung von Oel-und Proteinpflanzen e.V. (UFOP), Biofuels in Germany and in the European Union Technologies, Market Trends and Political Conditions, accessed at: <http://www.ric.fao.org/prensa/activi/agroenergia/bockey.pdf>
- 149 – House of Commons, Select Committee on Environment, Food and Rural Affairs, Memorandum submitted by British Sugar plc, accessed at: <http://www.publications.parliament.uk/pa/cm200203/cmselect/cmenvfru/929/3070203.htm>
- 150 – London Renewables, Skills and Jobs from Renewable Energy Policies and Targets, September 2004, accessed at: [http://www.london.gov.uk/mayor/environment/energy/docs/renew\\_skills.pdf](http://www.london.gov.uk/mayor/environment/energy/docs/renew_skills.pdf)
- 151 – DEFRA
- 152 – Electric Drive Transportation Association
- 153 – JD Power
- 154 – Frost & Sullivan, Strategic Analysis of Hybrid Automobiles and Impact on the U.S. Motor Markets, accessed at: <http://www.industrialautomation.frost.com>
- 155 – Renewable Energy Policy Network for the 21st Century, ‘Renewables 2005 Global Status Report’, 2005
- 156 – Clean Energy Trends 2006, Makower, Pernick and Wilder, March 2006
- 157 – Ethanol Outlook 2006
- 158 – US DoE, Energy-efficiency and Renewable Energy – Biomass program page, accessed at: [http://www1.eere.energy.gov/biomass/biomass\\_basics\\_faqs.html#incentives](http://www1.eere.energy.gov/biomass/biomass_basics_faqs.html#incentives)
- 159 – Energy Future Coalition
- 160 – Energy Future Coalition
- 161 – US DoE, Energy-Efficiency and Renewable Energy – Biomass program page, accessed at: <http://www1.eere.energy.gov/biomass/ethanol.html>
- 162 – Worldwatch Institute, The Renewable Path to Energy Security, September 2006
- 163 – Renewable Fuels Association – John M Urbanchuk, LECG LLC, ‘Contribution of the Ethanol Industry to the Economy of the United States’, February 21, 2006, accessed at: [http://www.ethanolrfa.org/objects/documents/574/ethanol\\_economic\\_contribution\\_022006\\_r.pdf](http://www.ethanolrfa.org/objects/documents/574/ethanol_economic_contribution_022006_r.pdf)
- 164 – Renewable Fuels Association – John M Urbanchuk, LECG LLC, ‘Contribution of the Biodiesel Industry to the Economy of the United States’ September 30, 2006, accessed at: [http://www.biodiesel.org/resources/reportsdatabase/reports/gen/20060930\\_gen373.pdf](http://www.biodiesel.org/resources/reportsdatabase/reports/gen/20060930_gen373.pdf)
- 165 – LECG, LLC, May, 2005
- 166 – Japan Automotive Manufacturers Association, Brochure 2006, accessed at: <http://www.jama.org/library/pdf/brochures2006MIJReport.pdf>
- 167 – Herald-Sun, ‘Japan kick-starts biofuel transport’, 21 June 2006
- 168 – Makower, Pernick and Wilder, Clean Energy Trends 2006, March 2006
- 169 – Research and Markets, ‘2005 Hydrogen Market, Hydrogen R&D and Commercial Implication in the US and EU’, May 2005 – accessed at: <http://www.researchandmarkets.com/reports/c18817/>
- 170 – Research and Markets, ‘2005 Hydrogen Market, Hydrogen R&D and Commercial Implication in the U.S. and E.U.’, May 2005 – accessed at: <http://www.researchandmarkets.com/reports/c18817/>
- 171 – FuelCell Today, Market Survey of Light Duty Vehicles, 2006
- 172 – WBSCD, ‘Sustainable Mobility News’, 29 December 2006
- 173 – Fuel Cells 2000, ‘Worldwide hydrogen fuelling stations’, accessed at: [www.fuelcells.org](http://www.fuelcells.org)
- 174 – New Energy Finance, ‘Global Clean Energy Investment Overview: Trends and Issues in the Financing of Renewable Energy and Low Carbon Technology’, September 2006
- 175 – New Energy Finance database
- 176 – Los Angeles Times, 1 August, 2006
- 177 – Clean Edge, Clean Energy Trends 2007, accessed at: <http://www.cleantech.com/reports/Trends2007.pdf>
- 178 – Clean-tech Venture Network
- 179 – New Energy Finance database
- 180 – New Energy Finance, personal communication, February 2007 – note that: ‘Calculations of investment levels in renewable energy/clean-tech is made through counting “the value of all the disclosed deals NEF monitors + estimated value of all undisclosed deals (for which value is not public) + estimated value of deals NEF has not yet discovered, based on how recent the period is (NEF assumes some recent deals will be discovered later)’
- 181 – New Energy Finance, ‘Global Clean Energy Investment Overview: Trends and Issues in the Financing of Renewable Energy and Low Carbon Technology’, September 2006
- 182 – Ibid.
- 183 – Clean Edge, Clean Energy Trends 2007, accessed at: <http://www.cleantech.com/reports/Trends2007.pdf>
- 184 – New Energy Finance database
- 185 – New Energy Finance database
- 186 – New York Times, 25 August, 2006
- 187 – Clean-tech Venture Network, Clean-tech Venture Capital Report, 2006
- 188 – New Energy Finance and European Energy Venture Fair, 2006
- 189 – Rosa and Raade, profitability of VC Investment in Europe and the US, March 2006, accessed at: [http://ec.europa.eu/economy\\_finance/publications/economic\\_papers/2006/ecp245en.pdf](http://ec.europa.eu/economy_finance/publications/economic_papers/2006/ecp245en.pdf)
- 190 – Clean-tech Venture Network
- 191 – Renewable Energy Policy Network, Renewables Global Status Report, 2006
- 192 – New Energy Finance database
- 193 – Renewable Energy Monitor, 21 June 2006
- 194 – Thomson Financial, Global Project Finance Review, Fourth Quarter 2006
- 195 – New Energy Finance database
- 196 – New Energy Finance database
- 197 – E. Martinot, ‘Global Revolution’, 2 November 2005, accessed at: <http://www.earthscan.co.uk/news/article/mps/uan/508/v/3/sp>
- 198 – Newsbase, Global Carbon Emissions Monitor Week 2 page 9 – ‘Goldman Sachs Doubles Stake in Climate Exchange’
- 199 – Washington Times, ‘Western Governors hail global-warming pact’, 27 February 2007, accessed at: <http://washingtontimes.com/business/20070226-100042-4985r.htm>
- 200 – New Carbon Finance, personal communication, March 2007
- 201 – World Bank/IETA, State and Trends of the Carbon Market, 2006
- 202 – Point Carbon, Carbon Market Europe, 12-01-07
- 203 – Point Carbon, Carbon 2007, 13 March 2007
- 204 – Point Carbon, Carbon 2007, 13 March 2007
- 205 – World Bank/IETA, State and Trends of the Carbon Market, 2006
- 206 – Point Carbon, Carbon Market Europe, 12-01-07
- 207 – World Bank/IETA, ‘State and Trends of the Carbon Market’, 2006
- 208 – ICF International, Voluntary Carbon Offsets Market: Outlook 2007, December 2006
- 209 – CEAG, Emissions trading and the City of London, September 2006
- 210 – CEAG, Emissions trading and the City of London, September 2006
- 211 – Personal Communication with Shell Trading, November 2006
- 212 – Personal communication with Shell Trading, November 2006
- 213 – Innovest Strategic Value Advisors, Global Banking Report, November 2006
- 214 – Abyd Karmali, ICF Consulting, personal communication, February 2007
- 215 – Abyd Karmali, ICF Consulting, personal communication, February 2007
- 216 – Innovest Strategic Value Advisors, Electric Power Producers N. America Sector Report, 2006
- 217 – New Energy Finance database
- 218 – Environmental Finance Publications, 2006 Carbon Funds Directory, and subsequent Environmental Finance research
- 219 – Renewable Energy Monitor Week 32, 1 November 2006
- 220 – R. Stuebi, ‘What to make of the TXU deal?’, 5 March 2007, accessed at: [www.altenergystocks.com](http://www.altenergystocks.com)

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## ABOUT THE °CLIMATE GROUP

The °Climate Group is an independent, non-profit organisation dedicated to accelerating the international uptake of corporate and government best practice in emissions reductions. We have offices and charitable status in the US, Europe and Australia, and this year will expand into India and China.

Proactive companies, states, regions and cities around the world are demonstrating that the cuts in greenhouse gases required to stop climate change can be achieved while growing the bottom line. Using the work of these leaders as a catalyst, The °Climate Group strives to accelerate international action on climate change with a new strong focus on practical solutions.

Since launching in 2004, we have developed an interlocking programme of leadership groups, research and publications, media engagement, and high-impact events. Our coalition of member companies, cities and sub-national governments has demonstrated that emissions reductions, while essential, can also be profitable. We inspire further action and outreach to implement and support effective strategies and policies that mitigate climate change.

We also promote the development and sharing of expertise on how business and government can lead the way towards a low carbon economy while boosting profitability and competitiveness.



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