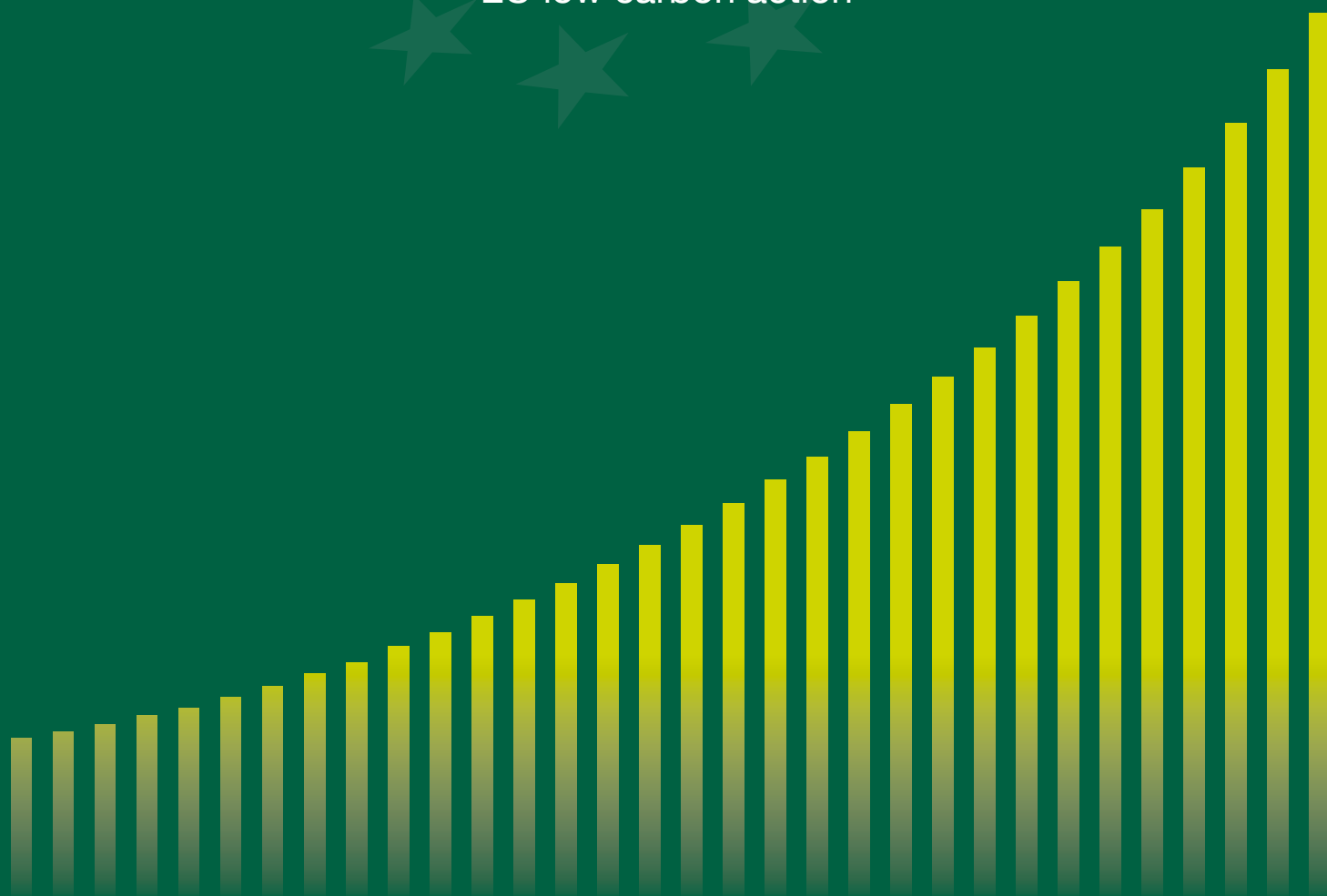


# Going for Green Growth

The case for ambitious and immediate  
EU low carbon action



The Green Growth Group



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EU low carbon action

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# Ministerial Foreword

## A call for ambitious and immediate EU low carbon action

The European Union faces many challenges, but the challenge of how to build a competitive economy while tackling climate change is one of the most pressing. Some would argue that you can't do both at the same time – that one must take priority over the other. We firmly disagree. Economic growth and sustainability are not mutually exclusive. We believe that Europe must see cutting harmful emissions and cost-efficiently and cost-effectively decarbonising our economy as part of the solution to our economic and wider challenges, as well as a moral imperative.

The scientific evidence is clear: climate change is happening. The climate experts looking at this for the UN are more certain than ever before that mankind is the dominant cause. The impacts are assessed as dangerous and costly, and will only get worse without much more ambitious action. An ambitious global climate agreement is essential if we are to keep the 2°C climate goal within reach. Clear EU leadership is needed.

Ambitious EU low carbon action now, at the EU and Member State level, is the best way to avoid the most extreme costs of both climate change and decarbonisation. We fully recognise that decarbonisation does not come without some costs. There will be difficult decisions ahead and we must be vigilant against any genuine risks of carbon leakage and mindful of the needs of the less well off in society.

However, there are many tools at our disposal to ensure our low carbon transition is manageable, cost-efficient and cost-effective, whether through integrating Europe's energy markets, fostering

the diversified deployment of renewables and other safe and sustainable low carbon energy or consuming energy much more efficiently. Unlocking investment in a range of safe and sustainable low carbon technologies and innovation will avoid the burdens of late or inadequate action. Providing clear and early investment signals beyond 2020 is essential and a reformed EU Emissions Trading System must be a key driver to that end.

Moreover, taking ambitious EU action now is the best way to ensure we unlock the full range of immediate economic opportunities and longer-term benefits from decarbonisation: stimulating the massive private sector investments to build safe and sustainable lower carbon energy infrastructure; supporting millions of low carbon sector jobs in this and future decades; developing a new high-tech industrial base and export sector to supply the global low carbon business boom; improving citizens' health and productivity; strengthening our resource efficiency; and reducing our growing and increasingly costly dependence on fossil fuel imports.

This pamphlet makes the over-arching economic and strategic case for early and ambitious EU low carbon action to deliver a cost-efficient and cost-effective EU decarbonisation that delivers maximum economic and wider benefits for Europe. It reviews the recent evidence from respected international bodies, economists, think tanks, business organisations and academics, and makes a number of key policy statements to inform the debate. While there will be many other measures needed in due course, the immediate priority EU actions are clear:

- 1 Agree an ambitious target-based post-2020 policy framework** in line with the EU Low Carbon and Energy Roadmaps and our 2°C climate goal. This will give the private sector the certainty they need to invest now;
- 2 Reform the structure of the EU Emissions Trading System** helping to cut emissions cheaply and further incentivising low carbon investments;
- 3 Ensure the EU uses the opportunity offered by the Ban Ki-Moon Climate Summit in autumn 2014, by being in a position to put an ambitious EU emissions reduction offer on the table**, in order to drive momentum and progress towards the world's first truly global climate deal in 2015.

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**Edward Davey**

Secretary of State for Energy  
& Climate Change  
United Kingdom

**Peter Altmaier**

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# 10 key policy statements

- 1** The scientific evidence on man-made climate change is stronger than ever. The world is on course for dangerous increases in average global temperatures that will incur substantial and growing costs to Europe's and the world's economies.
- 2** Delaying ambitious efforts to cut emissions now will only increase our carbon debt and make it much more expensive to pay off in the future.
- 3** Giving certainty over future EU policy and clear price signals will help unlock the private sector investment we urgently need to build a more modern, safe and sustainable lower carbon energy infrastructure.
- 4** Decarbonisation can be compatible with public deficit reduction, in particular, by leveraging maximum investment from the private sector and through raising public revenues, such as through a reformed EU ETS.
- 5** Risks to EU energy security will grow unless we reverse our growing dependency on fossil fuel imports. Using energy more efficiently and increasing domestic, safe and sustainable lower carbon energy are key.
- 6** From well before the recession, EU GDP has grown while emissions have fallen and we are well placed to benefit from the global low carbon business boom. But we must re-energise our efforts to compete in an increasingly competitive global low carbon market.
- 7** Ambitious decarbonisation will support millions of low carbon sector jobs and spur industrial innovation. We must be vigilant against any genuine risks of low carbon leakage based on sound analysis.
- 8** Ambitious decarbonisation and fostering technology innovation will unlock co-benefits on many wider EU priorities, such as cutting health and industry costs from air pollution, boosting biodiversity and green business and tackling fuel poverty through energy efficiency.
- 9** Deeper integration of the internal energy market will make our decarbonisation cheaper by providing more efficient and effective energy supplies, furthering the integration of renewable and other safe and sustainable low carbon energy and better use of production capacity.
- 10** Building and maintaining a leading position in clean technology will help increase the EU's share of the low carbon market and contribute to an increase in its exports. International carbon trading can further lower mitigation costs.



# PART 1

*The economic and wider costs of delayed or unambitious climate action are substantial and rising<sup>1</sup>*

# Climate change risks and costs are growing

The scientific evidence on climate change is **overwhelming**. The scientific community is now 95% certain that the majority of the increase in average global temperatures since 1951 is due to rising levels of man-made greenhouse gas concentrations<sup>2</sup>. The evidence of our changing climate is increasingly evident<sup>3</sup>:

- Each of the last three decades has been successively warmer at the Earth's surface than any preceding decade since 1850<sup>4</sup>.
- Arctic sea ice has shrunk to its smallest summer extent since satellite records began<sup>5</sup>.
- After 2,000 years of little change, global average sea levels have risen throughout the twentieth century and at an accelerating rate in recent years<sup>6</sup>.
- There is growing scientific evidence that climate change is helping to drive more frequent, intense and costly extreme weather events<sup>7</sup>.

To avoid the most dangerous impacts of climate change we need to limit global temperature rises to no more than 2°C above 1850-1900 levels<sup>9</sup>. However, it is increasingly clear that the world is well off course to meeting this climate goal.

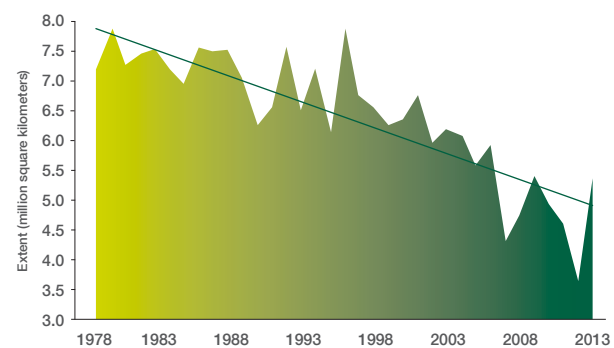
**Without substantial emissions reductions, the world could see average temperature rises of as much as 5°C above pre-industrial levels by the end of this century<sup>10</sup>.**

“The question is not whether we need to act... 97% of scientists, including some who originally disputed the data, have now put that to rest... the question now is whether we will have the courage to act before it's too late.”<sup>8</sup>

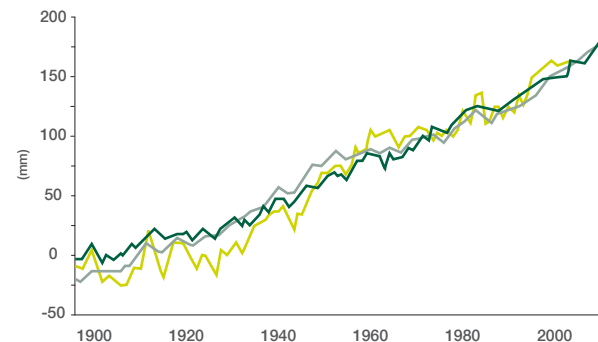
US President Barack Obama, June 2013

**Figure 1**  
Decline in Arctic sea-ice summer minimum 1979-2013. Data from NSIDC

Average monthly arctic sea ice extent September 1979-2013



**Figure 2**  
Global Mean Sea Level Change (relative to 1900-1905 mean, all datasets), IPCC<sup>11</sup>



**The costs of climate change are immense** and could be as high as 14% of average world consumption per person<sup>12</sup>. The global insurance industry estimates the annual insured world economic losses attributable to climate-related disasters has grown from \$5bn in the 1970s to \$60bn today<sup>13</sup>. Climate change is now considered a top threat by many security experts and military chiefs<sup>14</sup>.

**“I got it wrong on climate change – it’s far, far worse.”**

Nicholas Stern, 2013<sup>15</sup>

**Europe is already feeling the economic impact of climate change**, including:

- Falling average rainfall and more intense, frequent and lengthy heat waves and droughts across southern Europe.
- Rising rainfall levels, and greater river and coastal flooding across central and northern Europe.
- Extreme weather events increasingly linked to climate change<sup>16</sup>.

**“If we do nothing, the temperature of our planet will have increased by 3 to 4 degrees by the end of the century. We know the consequences: flooding in some places, drought in others, direct threats to peace around the world.”**

François Hollande, President of France, September 2012<sup>17</sup>

Putting aside the projected damage to world economic growth and stability, the European Environment Agency (EEA) projects that the direct costs of climate change to the EU are substantial and will materialise in different ways across the EU as shown in figure 3<sup>18</sup>.

Europe must use the opportunity offered by the Ban Ki-Moon Climate Summit in Autumn 2014 to generate further high-level momentum, and help steer the world towards agreeing a global climate deal at the UNFCCC meeting in 2015, which should take place in Paris.

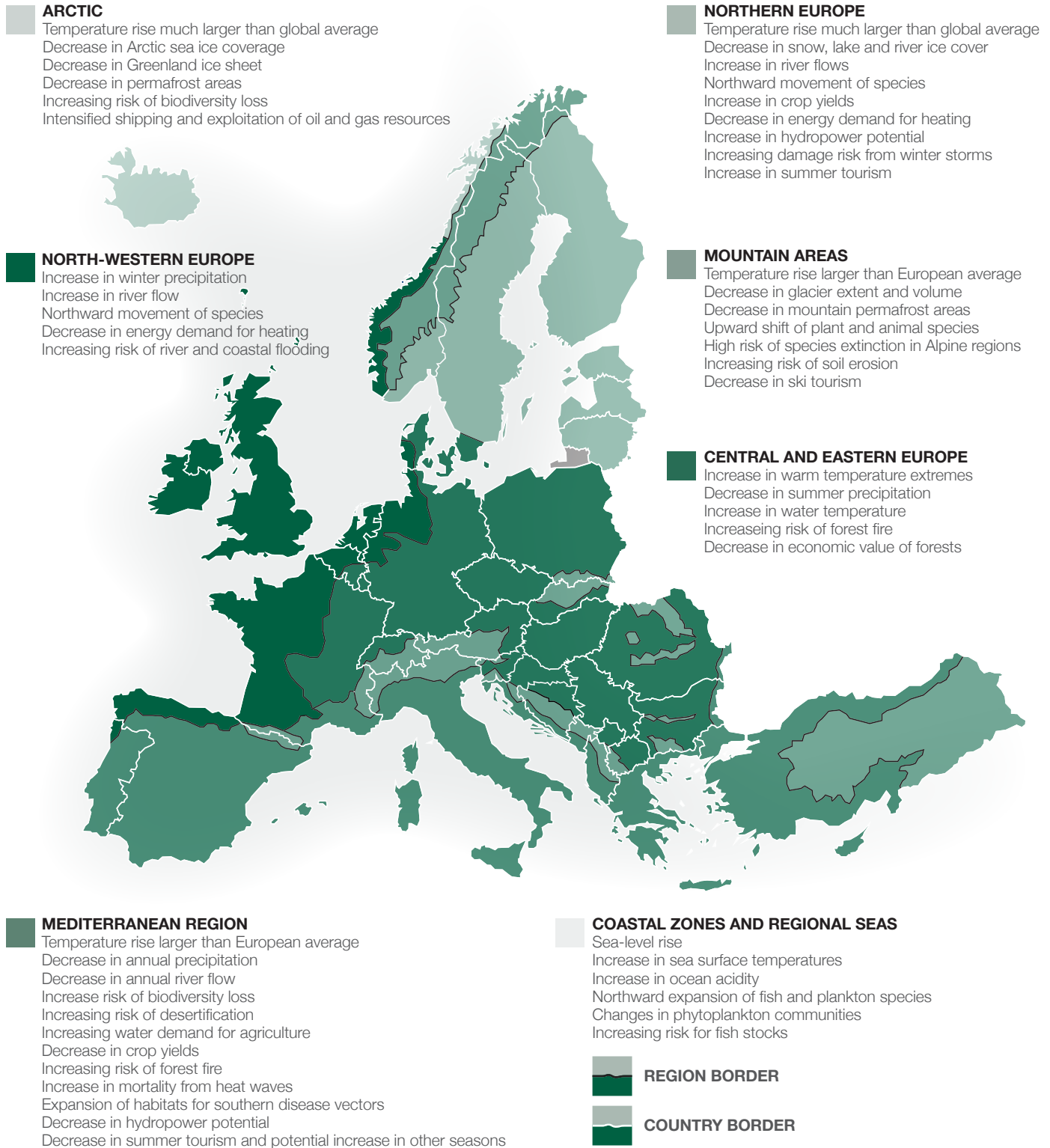
**“The world needs an EU that keeps its leadership... That leads the fight against climate change.”**

Commission President Barroso, State of the Union Speech 2012<sup>19</sup>

**“I invite all of you to a Climate Summit meeting one year from now... I challenge you to bring to the Summit bold pledges... that will close the emissions gap and put us on track for an ambitious legal agreement through the UNFCCC process.”**

Ban Ki-Moon, UN Secretary-General, Address to the UN General Assembly, September 2013<sup>20</sup>

**Figure 3**  
**Projections of Climate Change Impacts across Europe, EEA (2012)**



# Policy uncertainty is deterring urgently needed energy investments

**There is an urgent need to reverse the decline in private sector investments in order to build a modern, low carbon and competitive EU energy infrastructure:**

- To keep the lights on and stay on a cost-effective decarbonisation path, Europe must replace a fleet of old power stations with cleaner energy, and substantially upgrade its infrastructure.
- It is estimated that this will require Europe-wide investments of €1 trillion by 2020<sup>21</sup>, €2.5 trillion by 2025<sup>22</sup> and up to €7 trillion by 2050<sup>23</sup>. This means energy investments must increase by 30% for gas and 70% for electricity this decade<sup>24</sup>.
- With public budgets constrained, much of this investment must come from the private sector and long-term institutional investors<sup>25</sup>.

**But post-2020 EU policy uncertainty and the slump in the EU carbon price risk delaying EU-wide lower carbon energy investments<sup>26</sup>.**

- **Future Policy Uncertainty:** The EU's low carbon policy framework runs to 2020. However, energy investments have a lifespan of several decades. Businesses and Investors tell us that this is creating an 'EU 2020 policy cliff-edge' that is damaging the confidence required to make billions in energy investment.

“We are concerned that we are unlikely to have certainty about the post-2020 framework until 2015 or beyond. This is 'yesterday' from an infrastructure investment perspective... if this uncertainty continues, the cost of capital for Europe's energy sector will be higher and major investment decisions will be deferred... if uncertainty is too great, the sector may simply become un-investable.”

Institutional Investors Group on Climate Change, 2013, who hold EU-wide assets of €7.5 trillion, over 50% of EU GDP<sup>27</sup>.

- **Slump in the EU Carbon Price:** Emissions Trading allows the most cost effective emissions reductions by allowing abatement to take place where it is cheapest. However, driven in part by the recession, a huge surplus of allowances has built up in the EU Emissions Trading System (ETS) leading to a dramatic slump in the EU carbon price<sup>28</sup>. This is damaging investor confidence. It also risks steering investments towards high carbon technology and away from low carbon solutions, risking locking Europe in to a new generation of high emission energy production for decades.

“The uncertainty surrounding the future of existing carbon markets in recent years has prevented valuable resources from being channelled to low-carbon investments, particularly from the private sector.”

World Bank, Mapping Carbon Price Initiatives, 2013<sup>29</sup>

- **Alternative Investment Drivers?** Without clear EU-level low carbon investment drivers, national governments may choose to opt for fragmented national approaches to promote lower carbon energy investments. This could add costs to industry and businesses, confuse the regulatory landscape and undermine the EU's internal market in the process<sup>30</sup>.

“Until the current conflicting and contradictory signals are resolved, investors will avoid the European electricity market... the delay while we wait for a policy signal poses a serious threat to security of supply and to the feasibility of meeting climate targets. Crucially it puts at risk the goal of affordable energy.”<sup>31</sup>

Eurelectric, Power Choices Reloaded, 2013

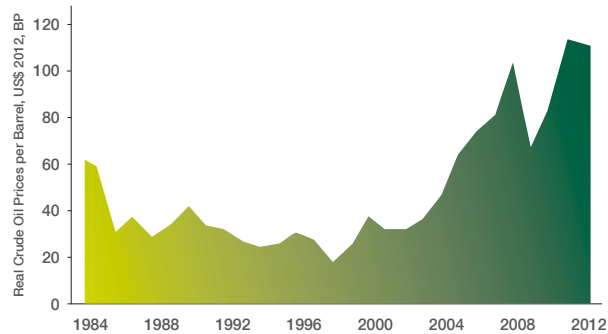
# Europe's energy security is at risk and fossil fuel import bills are rising

## Europe's energy security is increasingly at risk and our fossil fuel import bill is rising.

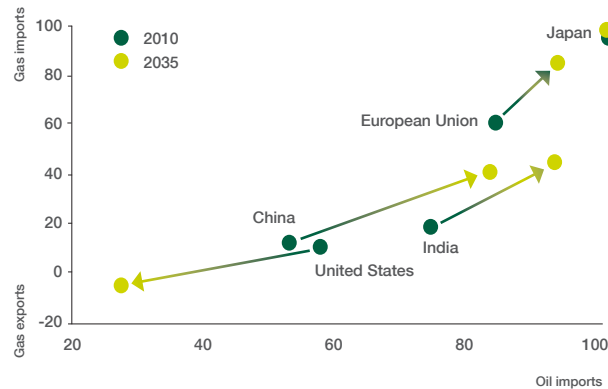
IEA forecasts show that unless we change our course, the EU will become even more dependent on fossil fuel imports over the next 25 years, further increasing our exposure to rising and increasingly volatile fossil fuel prices, risking price spikes and supply shocks.

- The EU already imports over 80% of its oil and over 60% of its gas needs. The International Energy Agency (IEA) estimates that by 2035, this will rise to over 90% for oil and over 80% for gas<sup>32</sup>. Europe's oil and gas supplies are increasingly sourced from potentially risky or unstable parts of the world<sup>33</sup>.
- Since 1998, real crude oil and gas prices have risen substantially<sup>34</sup>. Global primary energy demand is expected to rise by 47% and global electricity demand by 89% over the next 25 years<sup>35</sup>. The IEA projects continued rises in fossil fuel prices and price volatility<sup>36</sup>.
- According to the IEA, the EU is on course for its annual fossil fuel import bill to rise to over \$615 billion by 2035<sup>37</sup>. By 2050, the Commission estimates the EU's oil and gas import bill could double, costing an extra €400 billion per year by 2050 or 3% of today's GDP<sup>38</sup>.

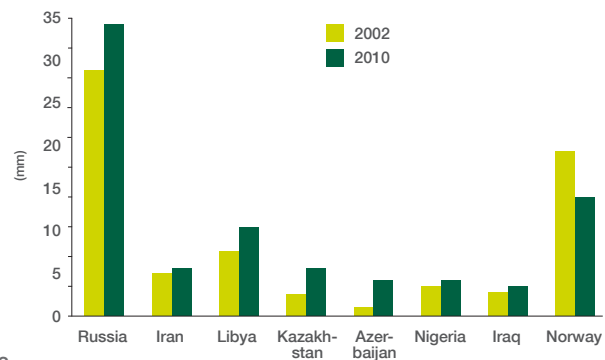
**Figure 4**  
Real Crude Oil Prices per Barrel, US\$ 2012, BP (2013)<sup>39</sup>



**Figure 5**  
Current IEA Predictions of Oil and Gas import dependence<sup>40</sup>  
Net oil and gas import dependence by region (%)



**Figure 6**  
Share of EU Oil imports from certain countries of origin, 2002 vs. 2010, Eurostat



# Indecision today risks locking in higher costs tomorrow

One of the lessons from the economic crisis is that building up evermore private and public debt today only makes it that much more painful and difficult to pay off later. The same is true of climate change. **Releasing greenhouse gas emissions is like racking up a huge carbon credit card bill: one day, we will have to pay for it, either gradually starting today, or we allow it to grow and have to face higher and more painful costs tomorrow.**

“Waiting is not an option... if we do nothing at this stage, everything will simply become much more expensive.”

Chancellor Angela Merkel, Petersberg Climate Dialogue, May 2013<sup>41</sup>

- In Europe in the last twenty years economic growth has been decoupled from increasing carbon emissions<sup>42</sup>.
- However, without urgent action beyond 2020 to trigger lower carbon investments now, we will have to cut emissions harder, faster later.
- Without decisive policy action to 2030, Europe risks being locked into high carbon energy sources. There are already 69 new high carbon emitting coal plants being planned across Europe with a capacity of over 65 gigawatts<sup>43</sup>, over 150% of the total capacity of all new EU power installations in 2011<sup>44</sup>.

The IEA's recent **World Energy Outlook Reports<sup>45</sup>** highlight how economically counter-productive it is to avoid taking early and ambitious low carbon action:

- Every year of delayed mitigation action adds \$500 billion to the global low carbon energy investment bill between 2010 and 2030.
- Every \$1 of low carbon investment avoided today means \$4.30 of low carbon investments needed after 2020 to meet the 2°C goal.

- Delaying further action until after 2020 could require an extra \$5 trillion of global investments between 2020-2035 in order to meet the 2°C target.

“Delaying action on climate change is a false economy”<sup>46</sup>

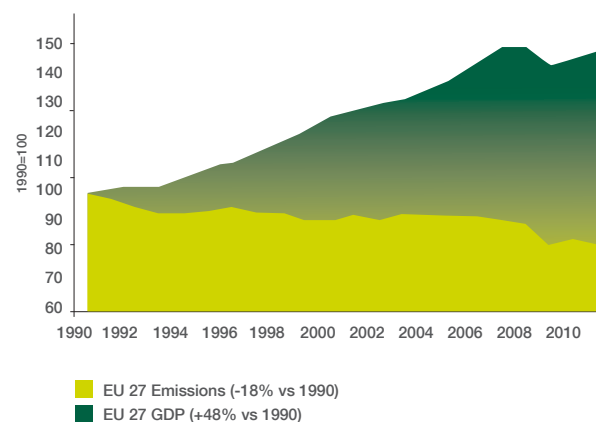
International Energy Agency, 2013

In the power sector alone, decarbonisation could lead to a dramatic dash to catch up later on, causing bottlenecks in equipment supply, price rises due to overheated demand and stranded assets because of over-investment in redundant capacity.

“If there is a lack of confidence that climate change policies will persist, then businesses may not factor a carbon price into their decision-making. The result may be overinvestment in long-lived, high-carbon infrastructure which will make emissions cuts later on much more expensive and difficult.”<sup>47</sup>

Nicholas Stern, 2006

**Figure 7**  
EU GDP growth vs. GHG Emissions 1990–2010, EEA Eurostat  
EU GDP and Emissions have decoupled



## PART 2

*The economic opportunities and wider benefits of ambitious and immediate low carbon action are substantial*



# Let's unlock energy investments to build a modern and competitive low carbon energy infrastructure

Providing clear EU low carbon price signals and post-2020 policy certainty will help unlock the huge private sector investment in lower carbon energy we urgently need. This will lay the foundations of a more competitive EU economy, and could help support Europe's economic recovery in the process:

- Modern energy assets and infrastructure built today could provide decades of economic benefits to the EU<sup>48</sup>. Energy investments represent one of the most productive forms of infrastructure investment available<sup>49</sup>.
- Unlocking the huge energy investments needed in Europe may also help support Europe's economic recovery by generating fiscal multipliers<sup>50</sup>. Many of Europe's energy projects needing investment are ready to be built without undue delay, delivering potential positive benefits quickly<sup>51</sup>.
- Energy investment can be compatible with public deficit reduction: it is largely private sector-led and long-term<sup>52</sup>, especially suited to institutional investors who collectively hold €13.8 trillion in assets, equivalent to 100% of EU GDP<sup>53</sup>.
- With borrowing costs low and private capital underemployed, now is an ideal time to trigger investments<sup>54</sup>. European Investment Bank, Connecting Europe Facility and EU Project Bond financing can further help leverage greater private sector investments<sup>55</sup>.
- Europe's major competitors have invested over 15% of their post-crisis stimulus packages in low carbon energy projects, totalling some \$380bn<sup>56</sup>.

“Energy infrastructure is essential for economic growth. Since before the industrial revolution transformations in how energy is generated, transported and consumed have underpinned technological progress... Longer term certainty for private investors drives down costs for taxpayers and consumers, releases efficiency savings from long-term planning and consistency and gives the supply chain greater clarity.”<sup>58</sup>

Her Majesty's Treasury, UK Government, 2013

Figure 8  
EU Energy, Transport and Broadband Investment Needs by 2020,  
European Commission<sup>57</sup>

## EU 2020 Investment Needs



# Let's win the global low carbon business race

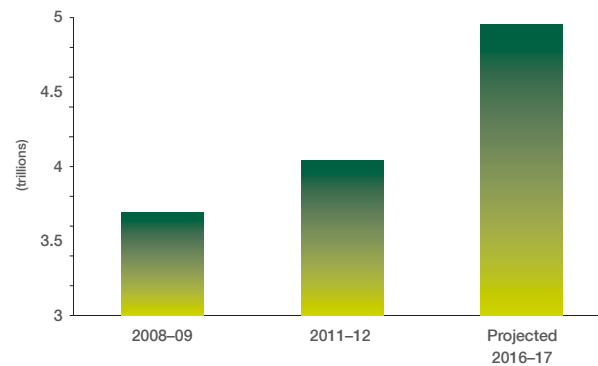
As an existing low carbon market leader, Europe is well-placed to build a major export manufacturing and services industry to supply the rapidly growing global demand for low carbon goods and services.

- The global low carbon and environmental business market is worth around €4 trillion a year and is expected to grow at over 4% a year to nearly €5 trillion by 2016<sup>59</sup>. Since 2004, global clean energy investments alone have increased by 669% to \$269bn a year<sup>60</sup>.
- The EU has carved out a 22% share of the global low carbon and environmental business market worth over €900 billion a year, compared with a 19% share for the US, 13% for China and 6% for both India and Japan<sup>61</sup>.
- Over the last four years Europe's low carbon market has grown by over 10%, over €85bn<sup>62</sup>. It has been estimated that if the EU can build and maintain a leading position in clean technology, increased exports could contribute €25 billion a year to GDP this decade<sup>63</sup>.
- Low carbon business is becoming increasingly mainstreamed throughout the economy, along the value chain and across the EU. Some of the most dynamic low carbon markets are now among Visegrad and South East Member States with average market growth of over 6% a year<sup>64</sup>.
- Europe is a major hub for low carbon innovation filing around 35% of all global low carbon patents today<sup>65</sup>.
- According to the IEA, the role of renewable sources in the global power mix continue to increase. On a percentage basis, renewables continue to be the fastest-growing global power sources and are set to become the world's second most important electricity source by 2016, after coal<sup>66</sup>.

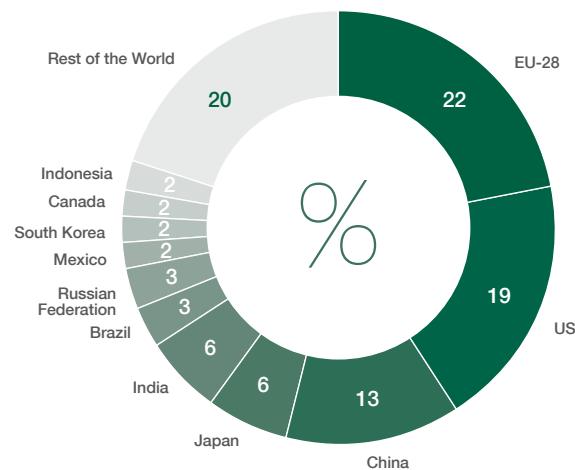
“Action on climate change is one of the great economic opportunities of the 21st century.”<sup>67</sup>

US President Barack Obama, June 2013

**Figure 9**  
Global Growth in the low carbon and environmental business market, BIS LCEGS Data  
Global Low Carbon & Environment Business Market Size (€ trillions)



**Figure 10**  
Share of Global Sales (%) – Global Low Carbon and Environmental Goods and Services Sector



**Global competition for low carbon business is already fierce, and is only set to intensify.**

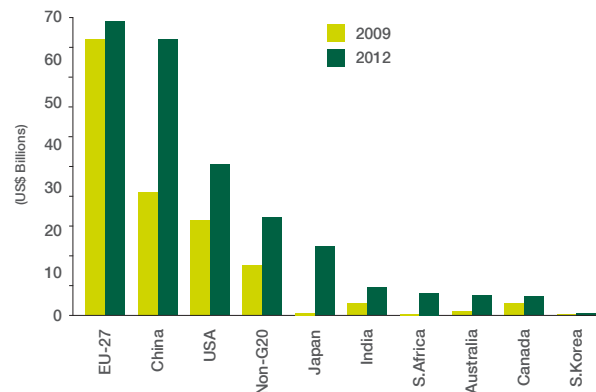
China and the US are aggressively targeting low carbon commerce, and new and ambitious low carbon competitors are emerging. Europe needs to re-energise its commitment to decarbonisation to turn potential low carbon business opportunities into a commercial reality, and to compete in this marketplace.

- While global clean energy investments have grown sixfold since 2004 to nearly \$270bn<sup>68</sup>, the EU share is down from 40% in 2009 to just 25% in 2012<sup>69</sup>.
- Chinese clean energy investments are now on a par with the EU at £65bn per year<sup>70</sup> (24% of the global total) and rising rapidly. China will invest up to \$1.28 trillion in its green economy between 2011 and 2015<sup>71</sup>.
- The US global low carbon business market is almost on a par with the EU, worth over \$800bn<sup>72</sup>. The US is investing record sums in clean energy<sup>73</sup> and has recently become the world's largest investor in low carbon energy RD&D<sup>74</sup>.
- Though still high, the EU's share of global low carbon patents filed is on the decline having fallen to just around a third from almost a half share in 1999<sup>75</sup>.
- Ambitious low carbon competitors are rapidly emerging, especially in Japan, South Korea and India, while non-G-20 country clean energy investments increased by over 50% last year alone<sup>76</sup>.

**“We are in a global race and the countries that succeed in that race, the economies in Europe which prosper, will be those that are the greenest and most energy efficient,”**

Rt Hon David Cameron MP, UK Prime Minister, Feb. 2013<sup>77</sup>

**Figure 11**  
Clean Energy Investments (US\$ Billions) in 2009 and 2012, Bloomberg New Energy Finance



**See the Annex for an overview of Climate Commitments, Actions and Low Carbon Business activity across Europe's major global low carbon competitors.**

# Let's strengthen Europe's energy security and reduce our growing fossil fuel import dependency

Decarbonisation, especially through low carbon energy and energy efficiency, has helped enhance energy security.

- Yearly average oil prices have risen by over 200% since 2003 alone<sup>78</sup> while EU oil import dependency has risen to 85%<sup>79</sup>. Without major energy efficiency improvements and growing domestic low carbon energy capacity, the economic costs of recent fossil fuel price rises would have been even higher.
- The EU's energy intensity has fallen consistently and substantially over the last 20 years: today, Europe uses one-third less energy for every €1,000 of GDP added to the EU economy. IEA statistics show the EU is one of, if not the, most energy efficient major economy in the world<sup>80</sup>.
- European-built cars are among the most fuel efficient in the world and are set to outstrip their competitors further<sup>81</sup>. For example, EU energy efficiency labelling for tyres alone could cumulatively deliver savings equivalent to 15m tonnes of oil by 2020 (equal to Denmark's annual final energy consumption) and lower emissions equivalent to removing 1.3m cars from Europe's roads every year<sup>82</sup>.
- The Commission estimates that the EU Energy Performance of Buildings Directive could support 450,000 new jobs in the construction sector, Energy End-Use rules could save equivalent to 120m tonnes of oil by 2016 alone (more than the annual EU aviation industry's energy consumption), and Eco-design standards could save equivalent to 70m tonnes of oil by 2020 (half UK annual final energy consumption)<sup>83</sup>.

Figure 12  
EU-27 Energy Intensity 1990–2010, Eurostat

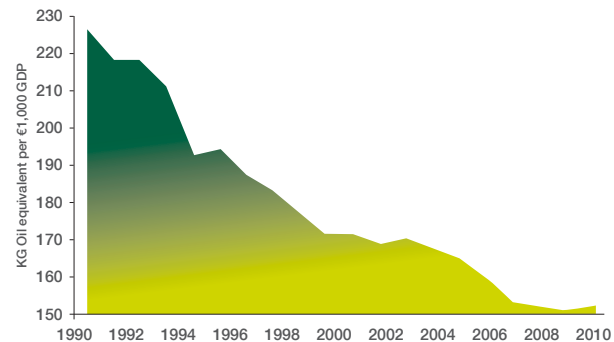
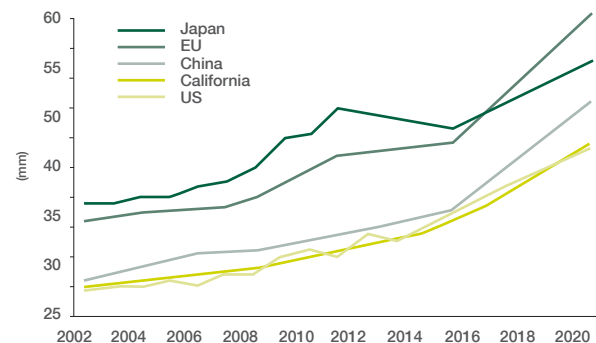


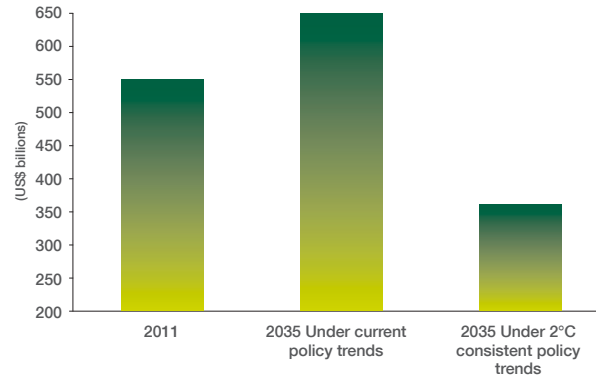
Figure 13  
International comparison of vehicle fuel economy standards (miles per gallon), ICCT 2013<sup>84</sup>



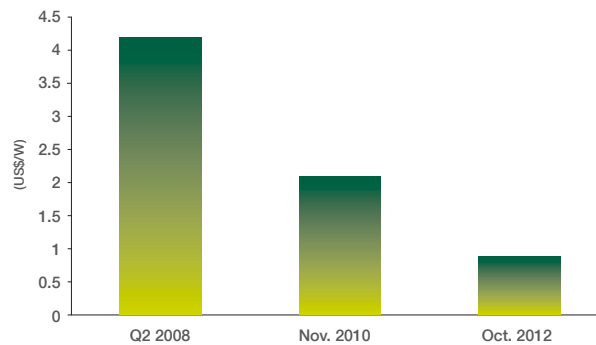
**Looking ahead, renewed ambitious decarbonisation can offer much greater and wider welfare, competitiveness and energy security benefits in the future.**

- The Commission estimates that reaching our 20% energy saving target by 2020 could reduce EU oil imports by the equivalent of 2.6bn barrels a year and potentially saving up to €200bn a year (the size of the Finnish economy<sup>85</sup>)<sup>86</sup>.
- Cost-effective energy efficiency measures can pay back within 2 years, making much energy efficiency investment a clear net positive even in the short term and often the quickest and most cost-effective way to decarbonise<sup>87</sup>.
- By 2035, the IEA estimates that 2°C consistent policies could cut the EU’s annual fossil fuel import bill by 46% or €275bn (1% of EU GDP), lower oil imports by over 7.3bn barrels a year and gas imports by 190bn cubic metres a year<sup>88</sup>. The Commission estimates that by 2050, a 2°C pathway could reduce EU fuel costs by up to €320bn per year by 2050<sup>89</sup>, the savings equivalent of 2.5% of 2008 EU GDP every year<sup>90</sup>.
- A recent Fraunhofer Institute study<sup>81</sup> found that maximising Europe’s energy efficiency potential could cut EU energy demand in half by 2050 compared with projections, saving energy equal to 11 times Poland’s 2008 final energy demand and 118% of EU energy imports in 2008, deliver financial savings of €500bn annually by 2050 and emission cuts of by 79% on 1990 levels.
- The costs of scaling up our domestic low carbon energy are coming down all the time. For example, wind turbine prices the world over are down by 30% in the last 4 years<sup>92</sup> and solar PV installation costs are down 50% in the last 5 years alone<sup>93</sup>.
- The cumulative global installed solar PV capacity grew by around 70% in 2011 resulting in significant price declines in recent years. With continuing cost degression, some renewable technologies could soon reach grid parity with some residential electricity tariffs and certain conventional power generation. For certain technologies, in certain locations, this is already the case.

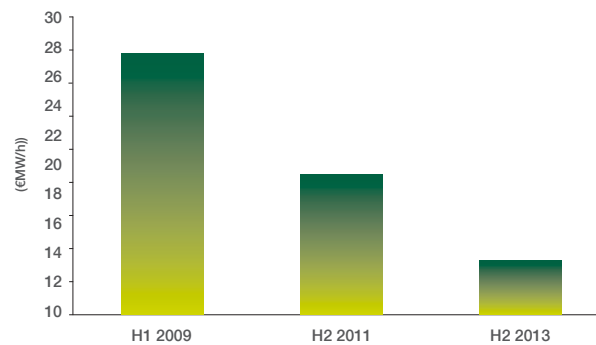
**Figure 14**  
Projected EU Fossil Fuel Import Bill in 2035 under Current Trends and 2°C Consistent Policies, IEA



**Figure 15**  
Solar PV Price Drop, Bloomberg New Energy Finance & CleanTech  
Declining cost of solar PVs (Crystalline silicon module prices in \$/W) Bloomberg New Energy Finance and quarterly filings of Chinese publicly quoted goods



**Figure 16**  
Wind Turbine Price Index by date of delivery, cost per MWh of expected production (€MWh), Bloomberg New Energy Finance



# Let's support millions of new low carbon sector jobs and develop a modern and innovative industrial base

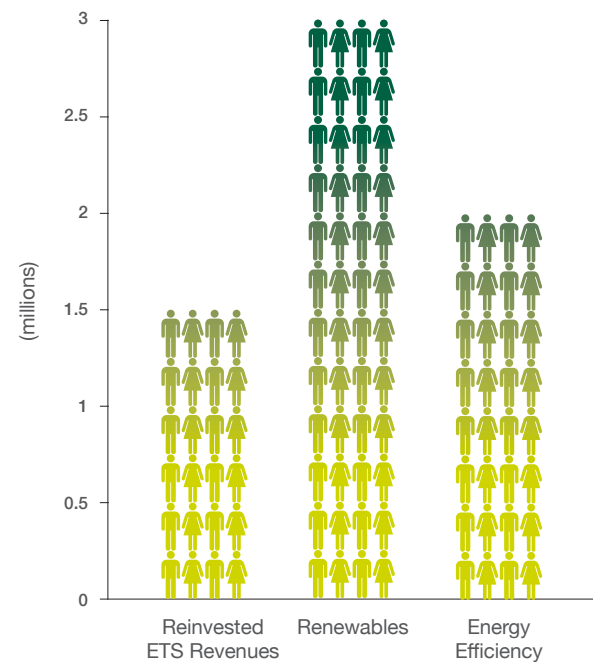
**Ambitious decarbonisation will help support millions of low carbon sector jobs across Europe.**

- In 2011, an estimated 7.8 million Europeans were employed in the EU's low carbon and environmental business sector<sup>94</sup>.
- The Commission estimates that up to 6.5 million jobs could be created or retained by 2020 in renewables, energy efficiency and from reinvested ETS revenues alone<sup>95</sup>.
- Given the knock-on supply chain benefits, and the much wider range of low carbon business activities, the overall low carbon sector employment potential is likely to be much greater, even in the short term<sup>96</sup>.
- Across Europe, low carbon sector jobs have grown significantly, even in those countries experiencing severe recessions<sup>97</sup>.

**We must support our industry to prosper in a low carbon future.** This means:

- Working with industry to build an innovative and export-led low carbon industrial base, building on our comparative advantages and converting low carbon Research, Development and Deployment (RD&D) into commercial successes.
- Supporting the modernisation of Europe's industries to adopt cutting edge energy efficient equipment.
- Where needed and justified, continuing to provide targeted help to industries to transition towards a modern low carbon future, and ensure low carbon growth delivers maximum benefits along the supply chain, especially for Energy Intensive Industries (EIIs).

**Figure 17**  
EU low carbon sector job creation and retention in potential in 3 low carbon sectors, European Commission<sup>98</sup>



**Energy Intensive Industries (EII) are crucial for our low carbon economic future, for example<sup>99</sup>:**

- The IEA estimates that, compared to current policy trends, many EII particularly benefit from energy price falls under 2°C-consistent policies, allowing spending to be redirected towards capital and labour and leading to increased activity through to 2020<sup>100</sup>.
- Chemicals: Essential to produce insulation, double glazing, wind turbines, light weight plane and vehicle materials and low temperature detergents. The materials save double the CO<sub>2</sub> produced in their manufacture<sup>101</sup>.
- Cement, Metals, Plastics: Up to 150t of cement and steel are needed to build a megawatt of low carbon energy<sup>102</sup>. Increasing quantities of strong, lightweight steel, aluminium and plastics are needed to increase vehicle fuel efficiency.
- Ceramics: Ceramic refractory materials are needed for efficient metal and glass manufacturing. Energy efficient building retrofits require up to 100kg of tiles and brick for every square metre of retrofitted housing space<sup>103</sup>.
- Glass: Energy efficient building retrofits requires up to 3kg of glass for every square metre of retrofitted housing space<sup>104</sup>.

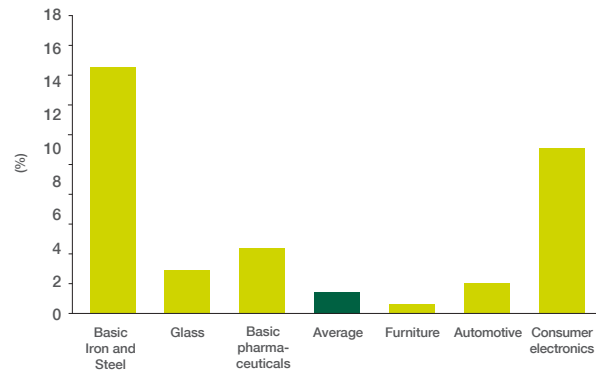
**Some industries will need focused support to adapt to a decarbonising Europe:**

- While there is growing evidence that only a few sectors are likely to be at high risk of carbon leakage<sup>105</sup>, some energy intensive sectors will need help to transition to a low carbon future. We should continue to provide sufficient and targeted support to these industries, based on sound analysis of carbon leakage risks.
- Direct energy costs represent a small fraction of most industries' overall costs. For example, energy costs represent just 3% of total production costs for German<sup>106</sup> and UK manufacturers on average<sup>107</sup>.
- There are great many factors that make up the overall costs of energy bills of which climate and energy policies are just one. Others include wholesale energy costs, network and operational costs and profit margins<sup>108</sup>.



The EU ETS is designed to help cut emissions cheaply and further incentivise low carbon investments. In the case of a reduction in the volume of allowances auctioned, the reduction could be more than offset by the increase in the price of allowances generating significant extra revenue for national treasuries. These direct national revenues could be used by national governments as they wished, such as helping the decarbonisation process or supporting public deficit reduction.

**Figure 18**  
**Energy share of production costs – German Industrial Sectors in 2010, European Commission<sup>109</sup>**  
 Share of Energy as % of production costs – Selected German Industrial Sectors (2010)



**Figure 19**  
**Drivers of UK Household Energy Bill Increases 2010–2012, DECC<sup>110</sup>**  
 Estimated breakdown of average UK dual fuel household energy bill 2013, DECC

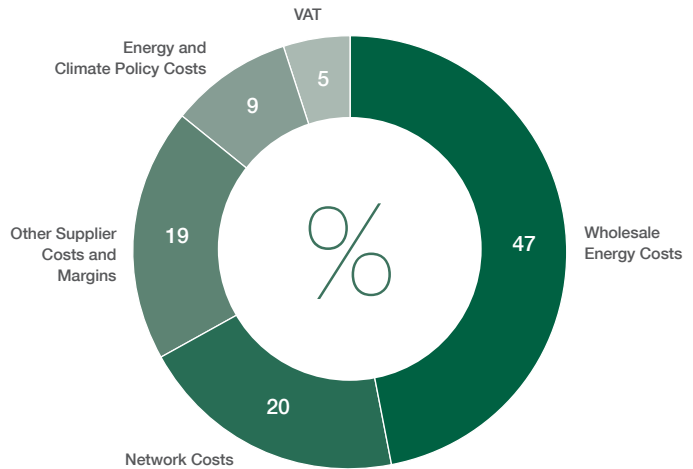


Figure 20  
 Estimated Change in Total National EU ETS Auction Revenues over 2013–2020  
 (in € per capita) from a Retirement of 900Mt and 1700 Mt of EUAs<sup>11</sup>



\* The change in Estonian public revenues from permanently retiring 1700Mt of allowances equates to an estimated €1,299 per capita

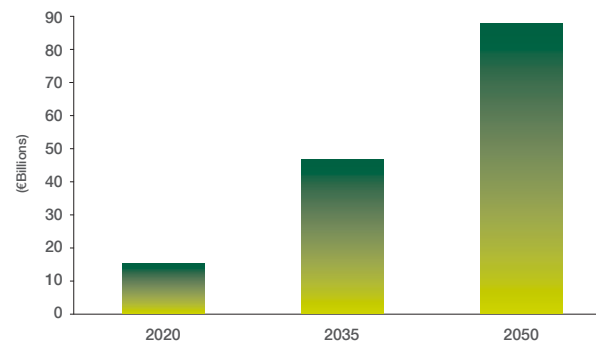
# Let's unlock the full range of co-benefits from low carbon ambition

The study of the wider co-benefits and policy synergies from ambitious decarbonisation is at an early stage. But it is already clear that the potential benefits are substantial. For example:

- **Health & Air Pollution:** Some 500,000 premature deaths occur in Europe each year due to the concentration of air pollutants<sup>112</sup> costing Europe around €537bn every year<sup>113</sup>. Ambitious decarbonisation can cut healthcare and air pollution control costs substantially by lowering air pollution from power and transportation. The Commission estimates that achieving a 30% emissions target by 2020 could bring health benefits of €8 billion a year<sup>114</sup>, and 2°C consistent policies will reduce mortality rates with benefits of up to €17 billion a year in 2030, and €38 billion a year in 2050. With 2°C consistent policies, the EU could cut air pollution control costs by \$8 billion a year by 2020 and \$30 billion a year by 2035 according to the IEA<sup>115</sup>, and by €50bn a year by 2050 according to the Commission<sup>116</sup>.
- **Fuel Poverty & Energy Efficiency:** An energy efficiency drive as part of our decarbonisation can help lower fuel bills, combatting fuel poverty among the poorest in society while driving down energy costs for European households and consumers across the board. The European Commission estimates, for instance, that meeting our 20% energy saving target could lower average household energy bills by as much as €1,000 a year<sup>117</sup>. EU fuel efficiency standards for vehicles are substantially driving down fuel costs for drivers and EU energy efficient tyre labelling could cut drivers' fuel bills by up to 10% by 2020<sup>118</sup>.

- **Nature Conservation & Biodiversity:** Carbon mitigation requires protecting and promoting natural environments that absorb carbon dioxide emissions. In the process, this can help boost economically critical biodiversity and reduce the need for mitigating emissions through other more expensive means. According to The Economics of Ecosystems and Biodiversity (TEEB) global initiative, the global business opportunities from investing in biodiversity could be worth around US\$ 2-6 trillion by 2050<sup>119</sup> and conserving global forests will avoid greenhouse gas emissions worth \$3.7 trillion<sup>120</sup>.

**Figure 21**  
**Projected Annual Health Benefits & Air Pollution Control Cost Savings with 2°C Consistent Low Carbon Policies (€bn), European Commission & IEA**  
Estimated Annual EU Health Benefits & Air Pollution Control Savings in selected years with 2°C Consistent Policies (€bn)



# Let's further lower decarbonisation costs by integrating energy markets and promoting international carbon pricing

Europe has other key tools at its disposal to ensure we decarbonise in the most cost-effective way. Most importantly, a modern, deeply integrated and interconnected EU internal energy market will be vital to securing a least cost energy decarbonisation pathway.

“A single energy market is Europe's best asset to promote the shift to low carbon, resource efficient growth... and reap the benefits of the expected growth in eco-industries.”<sup>121</sup>

Mario Monti, Former European Commissioner and Italian PM, 2010

- An integrated, interconnected and competitive electricity market could enable low carbon energy to be built in the most cost-efficient locations across Europe, with power traded across the EU to where it is in high demand<sup>122</sup>.
- The total net gains from integrating Europe's electricity markets are estimated to be up to €40bn a year by 2030, a net saving of €80 per person per year<sup>123</sup>.
- Increased demand management through smart grid technologies could help reduce peak demand, potentially saving up to €5bn a year by 2030<sup>124</sup>.
- This will help in balancing intermittent renewable supplies which could, according to some estimates, deliver operational savings of up to €3bn a year, while potentially reducing back-up power needs significantly<sup>125</sup>.

- Regional approaches could accelerate the realisation of these benefits, enabling a diverse regional portfolio of low carbon energy to balance, trade and improve the security of power supplies. For example, a Commons Inquiry found that a North Sea supergrid could cut renewable deployment costs by 25%, while delivering more balanced and efficient electricity<sup>126</sup>. Cost-effective regional energy market integration opportunities exist right across the EU.

**The recent difficulties with the EU ETS have masked the accelerating growth in carbon markets and emission trading schemes in many other parts of the world. Moving to greater international carbon pricing could bring major efficiency gains that can further cut decarbonisation costs:**

- The World Bank credits the growth in carbon markets in operation or under development around the world to the demonstrative power of the EU ETS<sup>127</sup>. Carbon trading has grown to cover 10 billion tCO<sub>2</sub>e in transactions every year worth over €130 billion annually<sup>128</sup>.

“Today, countries with carbon pricing mechanisms implemented and scheduled emit equivalent to 21% of the 50 GtCO<sub>2</sub>e emitted globally. If China, Brazil, Chile, and the other emerging economies eyeing these mechanisms are included, carbon pricing mechanisms could reach countries emitting almost half of the total global emissions.”

World Bank, 2013<sup>129</sup>

- The growth in carbon trading is extremely promising. The EU can use its carbon market leadership to further export carbon trading, and pave the way for linking cap-and-trade schemes towards a global carbon price. This could deliver multiple economic and climate benefits:
  - Enable emission reductions to take place wherever they are cheapest on a global scale<sup>130</sup>, lowering the costs of mitigation at home and abroad<sup>131</sup>.
  - Increase carbon market liquidity and help stabilise the price for investors<sup>132</sup>.
  - Accelerate the expansion of global low carbon business opportunities and drive greater global climate cooperation in the process<sup>133</sup>.

“The next 10 to 20 years will be a period of transition, from a world where carbon-pricing schemes are in their infancy, to one where carbon pricing is universal and is automatically factored into decision making.”<sup>134</sup>

Nicholas Stern, 2006

# Let's open up new low carbon markets through the single market and EU free trade deals

The single market and EU free trade policy can help accelerate the uptake of new low carbon technologies and services, lower costs for consumers, open new trade opportunities and create global low carbon business champions<sup>135</sup>.

- The EU's single market, worth over €12 trillion a year in economic activity, is the largest in the world. If EU single market policy can keep pace with low carbon economy developments, businesses and innovators can benefit from an EU-wide market of 500m consumers from the outset, and offer low carbon goods and services to citizens more cheaply<sup>136</sup>.
- Europe can use its collective weight in free trade negotiations to unlock new low carbon trade access, set international low carbon standards and ensure developing countries can access the most cost-effective low carbon technologies and providers<sup>137</sup>.
- The EU-South Korea FTA will remove almost all tariffs for environmental technologies within 3 years, giving EU companies full access to South Korea's green market worth over €70bn annually<sup>138</sup>.
- The EU-US trade deal (TTIP) could provide EU businesses with full access to a low carbon and environmental market<sup>139</sup> worth nearly €800bn a year<sup>140</sup>, while the EU-Japan FTA could open up free trade with a Japanese green business market<sup>141</sup> worth nearly €250bn annually<sup>142</sup>.
- The World Bank found that removing trade barriers in 18 high-emitting developing countries in efficient lighting, solar and wind technology could increase trade volume gains by over 60%<sup>143</sup>.

# Ambitious and immediate action is critical for delivering cost-effective decarbonisation and the full range of low carbon benefits

This pamphlet has illustrated that Europe has enormous potential to work together to ensure that our decarbonisation is manageable, cost-effective and unlocks the full range of immediate low carbon economic opportunities and longer-term benefits.

This will require sustained, comprehensive and ambitious low carbon action over many decades, at all levels of governance, and across all parts of society, especially the private sector.

**However, the decisions the EU makes today will be critical to delivering cost-effective decarbonisation and to maximise the economic benefits. The EU's urgent low carbon priority actions are clear:**

- **Give investors and businesses ambitious long-term policy certainty:** We must give post-2020 EU policy certainty that investors and businesses need today. This means agreeing an ambitious target-based post-2020 EU Energy and Climate policy framework soon.
- **Repair the EU ETS:** We must reform the EU ETS so that it remains our central EU level climate tool, providing a more stable carbon price to drive cost-effective mitigation and low carbon investment.
- **Help drive ambition and progress at the UN:** We must help to secure a UN global climate deal at the UNFCCC meeting in 2015, that steers the world back towards our 2°C goal. This requires the EU to be in a position to put an ambitious EU emissions reduction offer on the table at the Ban Ki-Moon Global Climate Summit in autumn 2014, and to drive high-level momentum towards a global climate deal through to 2015.

# Annex 1

## Snapshot of what the rest of the world is doing

Emissions Commitment/Pledges	% of Global GHGs (2010)	Examples of Recent Action	Examples of Low Carbon Economy Progress
<b>CHINA</b>			
Cut carbon intensity by 40–45% on 2005 levels by 2020.	22%	<ul style="list-style-type: none"> <li>Plan to increase low carbon energy to 15% of primary energy mix by 2020, and renewables (excl. hydro) to 34% by 2050.</li> <li>Clean energy, energy efficiency and clean vehicles are 3 of the 7 'magic growth sectors' in the latest Five Year Plan.</li> <li>Piloting 7 city/ regional Emissions Trading Schemes.</li> <li>Forest coverage and stock increase targets in place.</li> <li>Possible new Climate Law with a 'peak emissions year'</li> </ul>	<ul style="list-style-type: none"> <li>\$1.28 trillion to the green economy from 2011 to 2015.</li> <li>In 2012, China had the second largest share of the global low carbon and environmental market by country at 13% worth over €500bn.</li> <li>In 2012, China was the biggest single country investor in clean energy with \$65.1bn (a 20% increase on 2011), adding 16 GW of wind and 3.2 GW of solar generating capacity that year.</li> <li>152 GW of clean energy capacity overall, 23% of the world total.</li> <li>Reduced its energy intensity by 21.2% from 2001 to 2010.</li> </ul>
<b>USA</b>			
Cut emissions by 17% on 2005 levels by 2020 and by 80% by 2050.	13%	<ul style="list-style-type: none"> <li>EPA directed to bring forward first Federal GHG emission standards for new and existing power plants.</li> <li>Tightening fuel efficiency/ emissions standards for vehicles and energy efficiency standards for buildings.</li> <li>Aim to double the renewables capacity from 2013 to 2020, with renewable tax credits and a biofuels target.</li> <li>Several states have emissions trading schemes and GHG goals – e.g. Californian ETS and goal to reduce GHG levels to 1990 levels by 2020, and by 80% below this by 2050.</li> </ul>	<ul style="list-style-type: none"> <li>In 2012, the US had the largest share of the global low carbon and environmental market by country at over 19% worth nearly €800bn.</li> <li>US stimulus plan allocated \$94bn to green technologies.</li> <li>Record US clean energy investments in 2011 of \$45.5bn, largest of any single country in the world (up 46% on previous year).</li> <li>Largest emission cut of any country since 2006.</li> <li>49% of all new energy capacity built in 2012 was renewable.</li> <li>Reduced its energy intensity by over 15% between 2000 and 2010.</li> </ul>
<b>INDIA</b>			
Pledged to cut carbon intensity by 20–25% by 2020 on 2005 levels.	5.4%	<ul style="list-style-type: none"> <li>Renewables taxed at half the rate of conventional energy.</li> <li>Set a goal of deploying 20GW of solar energy by 2020.</li> <li>Recent levy on coal power used to fund clean energy investments.</li> <li>Variety of energy efficiency schemes and standards.</li> <li>National Expert Group recently established to set out pathway for low carbon growth in India.</li> </ul>	<ul style="list-style-type: none"> <li>2nd fastest global clean energy investment growth in 2011 to \$10.2 billion, installing 2.8GW of extra wind capacity in one year.</li> <li>Reduced its energy intensity by over 26% between 2000 and 2010, more than almost any other country.</li> <li>In 2012, India had the 4th largest share of the global low carbon and environmental market by country and worth over €250bn annually.</li> </ul>



Emissions Commitment/Pledges	% of Global GHGs (2010)	Examples of Recent Action	Examples of Low Carbon Economy Progress
<b>RUSSIA</b>			
Pledge of 15–25% emissions reduction by 2020 from 1990 levels.	5%	<ul style="list-style-type: none"> <li>Increasingly extensive energy efficiency legislation in place.</li> <li>Legislation with modest targets to increase renewables.</li> <li>Recent legislation to restrict and limit the use of flaring.</li> </ul>	<ul style="list-style-type: none"> <li>Though from a very high baseline, Russia reduced its energy intensity by over 25% between 2000 and 2010.</li> <li>In 2012, Russia's low carbon and environmental goods and services market was worth nearly €100bn annually.</li> </ul>
<b>INDONESIA</b>			
Committed to 26% emission reduction by 2020 against BAU scenario.	3.9%	<ul style="list-style-type: none"> <li>Variety of on-going legislative and financial initiatives to move to more sustainable forestry.</li> <li>Regulatory and financial incentive regime to drive increase in geothermal and biofuels in place.</li> </ul>	<ul style="list-style-type: none"> <li>Rapidly increasing geothermal generation and biofuels. Indonesia has 40% of the world's estimated geothermal capacity.</li> <li>World's fastest growth rate in installed clean energy capacity in 2011 of 520% with over \$1 billion investments.</li> <li>In 2012, Indonesia's low carbon and environmental market was worth €63bn annually and has grown by 17% in the last 4 years.</li> <li>Reduced its energy intensity by over 18% between 2000 and 2010.</li> </ul>
<b>BRAZIL</b>			
Legislated for reductions of 36.1% to 38.9% by 2020 compared to BAU.	3.2%	<ul style="list-style-type: none"> <li>Developed a 'National Climate Plan' aiming to reduce annual deforestation by 80% by 2020, boost energy efficiency and renewable energy.</li> <li>Mainstreamed biofuels in the transportation sector.</li> <li>Aim to source 80% of its energy from renewables by 2030.</li> <li>New measures to boost energy efficiency including a drive to promote smart meters.</li> </ul>	<ul style="list-style-type: none"> <li>Expect to overachieve on its 2020 emission reductions target.</li> <li>Clean energy increased by 10% in 2011 to \$8bn (10th globally).</li> <li>3rd fastest clean energy capacity growth in the last five years.</li> <li>World leader in installed biomass capacity and biodiesel output.</li> <li>In 2012, had the 7th largest share of the global low carbon and environmental market by country worth over €120bn, with growth of nearly 24% over the last four years.</li> </ul>
<b>JAPAN</b>			
Committed to 80% reduction by 2050.	2.8%	<ul style="list-style-type: none"> <li>Introduced a carbon tax in 2012.</li> <li>2012 Energy Strategy seeks to maximise uptake of clean energy to reduce import dependency and cut emissions.</li> <li>New feed-in tariff system in place for renewables.</li> <li>A leading energy efficient economy already but variety of measures in place to drive this further.</li> </ul>	<ul style="list-style-type: none"> <li>2012 Clean energy investment was \$16.3 billion, 5th highest globally.</li> <li>Over 2GW of distributed solar capacity installed in 2012.</li> <li>Working to improve battery performance, advance electric vehicles, and extend charging infrastructure.</li> <li>Reduced its energy intensity by over 7% between 2000 and 2010 and is one of the most energy efficiency economies in the world.</li> <li>In 2012, Japan had the 3rd largest share of the global low carbon and environmental market by country worth €250bn annually.</li> </ul>

Emissions Commitment/Pledges	% of Global GHGs (2010)	Examples of Recent Action	Examples of Low Carbon Economy Progress
<b>MEXICO</b>			
Emissions cut target of 30% by 2030, 50% by 2050 on 1990 levels.	1.3%	<ul style="list-style-type: none"> <li>Recent Climate Change Act passed based on UK model.</li> <li>New forest protection legislation in place.</li> <li>Legislation and funding mechanisms in place to increase renewable energy and energy efficiency.</li> </ul>	<ul style="list-style-type: none"> <li>In 2012, Mexico's low carbon and environmental market was worth over €80bn annually and has grown by over 20% in the last 4 years.</li> <li>548% growth in clean energy investments in 2012 to over \$2 billion with a 50% increase in wind capacity to 700MW.</li> </ul>
<b>SOUTH KOREA</b>			
Pledge to cut emissions by 30% on BAU scenario by 2020.	1.3%	<ul style="list-style-type: none"> <li>Plans to allocate 2% of GDP to cut emissions, improve energy security, and promote new low carbon growth.</li> <li>Target to increase S. Korea's share of global clean technology exports from 2% to 8% by 2012.</li> <li>Legislation in place to launch an ETS in 2015 covering the country's 500 largest emitters.</li> <li>Promotes early climate action benefits to the region.</li> <li>Aims to cut energy intensity by 46% from 2007 to 2030.</li> </ul>	<ul style="list-style-type: none"> <li>In 2012, South Korea's low carbon and environmental market was worth over €70bn annually, having grown by 17% in 4 years.</li> <li>50% increase in clean energy investments in 2012 with significant increases in renewables generation capacity.</li> <li>Reduced its energy intensity by nearly 10% between 2000 and 2010.</li> </ul>
<b>SOUTH AFRICA</b>			
Pledge to meet 34% emissions reduction from BAU scenario by 2020 and 42% by 2025.	0.84%	<ul style="list-style-type: none"> <li>Recent White Paper with a range of mitigation options.</li> <li>Tax incentives for CDM projects, energy efficiency measures and carbon tax on flight passengers in place.</li> <li>Will introduce a carbon tax regime for all sectors and funding mechanisms for energy efficiency and renewables.</li> <li>12% energy efficiency improvement target by 2015, including sub-targets for sectors.</li> </ul>	<ul style="list-style-type: none"> <li>In 2012, South Africa's low carbon and environmental goods and services market was worth nearly €35bn.</li> <li>Clean energy investment in South Africa increased from \$100m in 2011 to \$5.5bn in 2012, taking it 9th position in the global rankings.</li> <li>Reduced its energy intensity by over 12% between 2000 and 2010.</li> </ul>

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# Annex 2

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# Annex 3

## Figures and sources

### Figure 1

Source: National Snow and Ice Data Center

### Figure 2

Source: Climate Change 2013: The Physical Science Basis. Working Group I Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, Figure SPM.3 (d)

### Figure 3

Source: EEA Report (2012) Climate change, impacts and vulnerability in Europe 2012

### Figure 4

Source: BP Statistical Review of World Energy

### Figure 5

Source: World Energy Outlook 2012 © OECD/IEA, 2012

### Figure 6

Source: Eurostat, © European Union , <http://epp.eurostat.ec.europa.eu>, 1995-2013. Responsibility for the adaptation lies entirely with UK Department of Energy & Climate Change

### Figure 7

Source: EEA; Eurostat, © European Union , <http://epp.eurostat.ec.europa.eu>, 1995-2013. Responsibility for the adaptation lies entirely with UK Department of Energy & Climate Change

### Figure 8

Source: European Commission

### Figure 9

Source: Department of Business, Innovation & Skills (2013) Low Carbon and Environmental Goods and Services Report for 2011/12

### Figure 10

Source: Department of Business, Innovation & Skills (2013) Low Carbon and Environmental Goods and Services Report for 2011/12.

### Figure 11

Source: Clean Energy Investment Trends ©Bloomberg New Energy Finance 2012

### Figure 12

Source: EEA; Eurostat, © European Union , <http://epp.eurostat.ec.europa.eu>, 1995-2013. Responsibility for the adaptation lies entirely with UK Department of Energy & Climate Change

### Figure 13

Source: ICCT Global Passenger Vehicle Standards 2013

### Figure 14

Source: World Energy Outlook Special Report: Redrawing the Energy-Climate Map © OECD/IEA, 2013

### Figure 15

Source: Average factory-gate module price, 2000-2013 (\$/W), Solar Insight Service © Bloomberg New Energy Finance 2011

### Figure 16

Source: Wind Research note © Bloomberg Finance L.P. 2013

### Figure 17

Source: European Commission (2012) Exploiting the Employment Potential of Green Growth

### Figure 18

Source: European Commission, Commission President Barroso, Presentation to the June 2013 European Council

### Figure 19

Source: Department of Energy and Climate Change (2013) Estimated Impact of Energy & Climate Policies on Energy Prices and Bills

### Figure 20

Source: Department of Energy and Climate Change Analysis (2012) Impacts of back-loading or permanently retiring EU ETS allowances

### Figure 21

Sources: European Commission (2010) Analysis of options to move beyond 20% greenhouse gas emission reductions and assessing the risk of carbon leakage; European Commission (2011) 2050 Low Carbon Roadmap; World Energy Outlook Special Report: Redrawing the Energy-Climate Map © OECD/IEA, 2013





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