



E3G

# The case for EU moving to 30%

**Global low carbon technology race  
and international cooperation**

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## IS THERE A CASE FOR THE EU MOVING BEYOND 20% GHG EMISSIONS REDUCTION TARGET BY 2020?

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## Executive Summary

An unprecedented level of innovation is needed to shift our economies onto a low carbon path and avoid dangerous levels of climate change. New and existing technologies will need to be developed and deployed globally and simultaneously, in order to avoid high carbon lock-in. However, several market failures and barriers to innovation are likely to lead to an underinvestment and therefore a lack of scale and speed in the development and deployment of technologies. A key consideration for governments, therefore, should be creating the right balance of risk and reward in innovation markets to leverage private sector activity, especially in riskier technologies.

Technology policy can act as a key risk management tool for decarbonisation and climate security. The unique public good nature of climate security and low carbon innovation requires a more active public sector role in responding to three key challenges:

1. Robust management of systemic climate risks;
2. Increasing the scale and speed of innovation;
3. Creating integrated global markets.

Around the world governments are already taking action to meet these challenges through a mixture of direct investment, and supportive policy and institutional frameworks. The lessons are mixed and some areas are better explored than others. Nevertheless, trends of research, investment and public policy suggest that low carbon technologies are becoming of strategic importance for major economies. Both developed and major emerging economies are increasingly investing in low carbon technologies in order to secure their competitiveness and prosperity in future global markets. China's energy saving and environmental protection sector is expected to be worth \$715 billion (¥4.5 trillion) by 2015. Europe currently leads in clean energy investment globally, with 44% of the world's financial investment in clean energy in 2009. However, other countries are catching up fast and in 2009 China overtook the US in clean energy finance and investment. All the major economies are betting on a clean energy future with China, US, Japan and South Korea channelling substantial portions of their stimulus packages to low-carbon investment.

The last decade has seen a substantial growth in supportive public policy frameworks for low carbon innovation in both developed and key emerging economies. China's 12<sup>th</sup> five-year development plan (2011-15) is expected to place low carbon and clean energy industries at the heart of China's forward strategy for growth, exports and industrial modernisation. In renewable energy, countries have put a number of different supportive policies in place which have been crucial in 'pushing' technologies and creating market 'pull'. Europe had the highest installed renewable power capacity driven mainly by the introduction of stronger policy incentives, such as feed-in tariffs, and national targets.

So far, the EU's political leadership on climate action has positioned its businesses at the forefront of low carbon technology growth, but the landscape of innovation leadership is changing with new emerging players, and globalisation of investment and research. As a technology leader, European businesses are well positioned to exploit their existing competitive advantage over low carbon innovation in order to benefit from a growing and increasingly competitive global market for low carbon technologies and services. However, there is a danger that a narrow focus on national competitive advantage would increase protectionism, slowing down both development and diffusion of low carbon technologies globally and provoking retaliatory actions in other sectors.

Europe can respond to these challenges but needs to step up its action. Below are three strategic proposals to guide such response. These proposals do not aim to prescribe policy 'silver bullets', instead they draw from current policy and investment trends, and an assessment of the scale of the challenges for low carbon transformation:

- > **Developing a system-wide risk management approach** would help responding to the challenges of a complex world. This should aim to reliably achieve the agreed temperature objective, while simultaneously ensuring that budgeting and contingency plans are effectively shaped to respond to potential future risks. Specific actions could include:
  - **Develop a portfolio of technologies and policies** to manage potential technology and policy failures;
  - **Systematic scientific research of climate 'tipping points'**, which would support decision making and reduce uncertainty;
  - **Establishing a robust multilateral climate regime beyond 'pledge and review'**, with further resources dedicated to climate diplomacy;
- > **Coordinated action for innovation at EU level** would deliver faster technology innovation at scale, and provide more certainty for low carbon investors. Specific actions could include:
  - **An ambitious short and medium-term EU target**, i.e. 30% by 2020, to catalyse policy decisions aligned with the scale of the challenge;
  - **Double the speed of diffusion of existing technologies** through a mixture of public policy instruments including reforming the EU budget and EU ETS;
  - **Spur early stage RD&D through the SET Plan** for low-carbon technologies to early commercialisation before 2020, which, otherwise, would remain underinvested by private sector.
- > **Developing new modes of international cooperation** would support the creation of integrated global markets, and balance cooperation to build international markets with domestic action to ensure it remains competitive. Specific actions could include:

- **Joint RD&D and knowledge sharing**, to achieve the scale and speed in global innovation, simultaneous problem solving;
- **Provide support to make the Technology Mechanism under UNFCCC operational**, with some dedicated fast-start finance for joint RD&D;
- **Engaging through Technology Action Plans**, providing focus for further cooperation around a portfolio of technologies.

# 1. The role of technology in tackling climate change and avoiding high carbon lock-in

Transformational innovation is essential to prevent high carbon lock-in and deliver climate security for Europe. This matters both in terms of Europe's domestic actions but also its ability to shape a global response to climate change. Infrastructure and energy investment decisions taken today will dictate emissions pathways for the next 20-30 years, potentially locking the economies into a high carbon pathway under business-as-usual. Currently operating global long-lived energy and transportation infrastructure is estimated to contribute substantial CO<sub>2</sub> emissions and a mean warming of 1.3°C above the pre-industrial era by 2060<sup>1</sup>. This is relevant both for Europe's own choices (for example power sector investment in the UK, Germany and new Member States) but also for rapidly industrialising countries such as China and India. The scale and speed of innovation needed to shift our economies into a low carbon path and stabilise below dangerous levels of climate change is unprecedented. Pielke et al. (2008)<sup>2</sup> argue that the challenge to stabilization could in fact be much larger than presented by the IPCC since technological advances are unlikely to happen spontaneously; therefore, we need to focus on creating the conditions for such innovations to occur. Tackling this challenge will take a step-change in global innovation and diffusion to make a low-carbon energy economy feasible before 2050.

There are no 'silver bullet' technologies to solve climate change and transform our economies to low carbon – instead we need to focus on a portfolio of technologies across all of the major sectors. These new and existing technologies will need to be deployed and diffused globally in order to avoid high carbon lock-in. Building international markets for new innovations would help reduce the cost of production for low-carbon technologies as well as increasing financial returns through the possibility of larger volume sales.

Preventing high carbon lock-in will require a significant increase in innovation and diffusion in developing countries, especially emerging economies. IEA scenarios for technology development and deployment assume that in order to stay below 2°C just over half of the overall abatement potential of key low carbon technologies will be captured in non-OECD countries by 2050<sup>3</sup>. The diffusion time for new energy technologies is currently about 24 years on average<sup>4</sup>; this will need to be halved by 2025 to have a realistic chance of meeting climate goals.<sup>5</sup> In a global market the cost of technological deployment can come down fast through economies of scale. To harness this potential, cross-border trade and investment in low carbon

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<sup>1</sup> Davis et al. (2010) Future CO<sub>2</sub> emissions and climate change from existing energy infrastructure, *Science*, **329**: 1330-1333.

<sup>2</sup> Pielke et al. (2008) Dangerous assumptions. *Nature*, Vol:452 (3), 531-2

<sup>3</sup> Project Catalyst analysis 2009 - It is estimated that the cost of reducing emissions will be 20% higher if developing countries do not participate

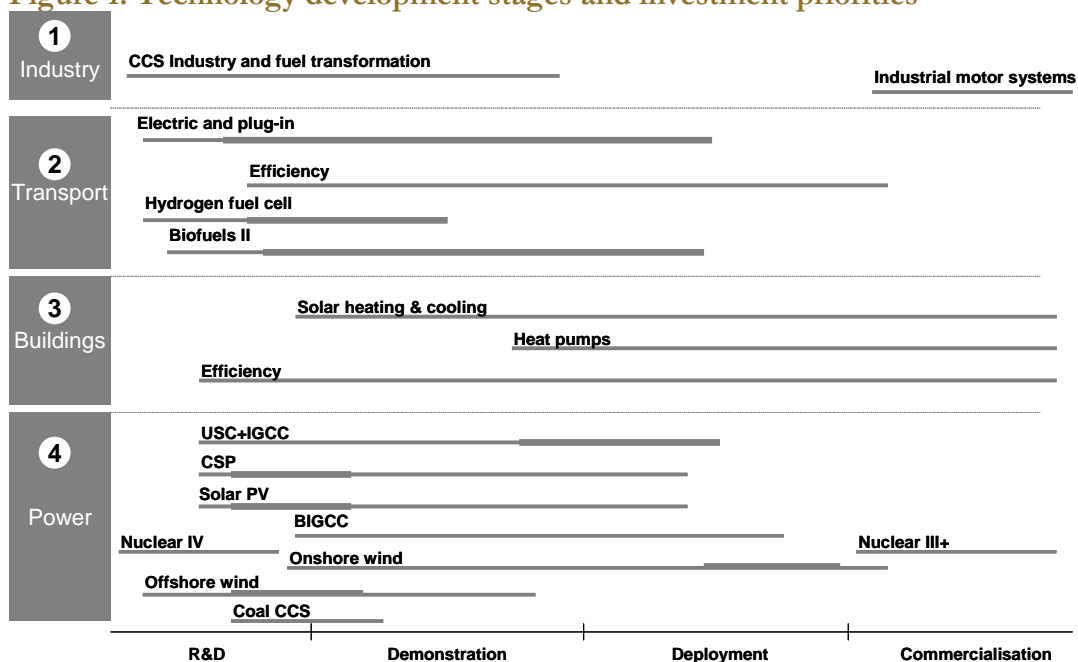
<sup>4</sup> Data on the top 30 most-cited patents from each of the six sectors examined in this study indicate that it takes between 19 and 30 years with an average of around 24 years or any patented technology to become widely used in subsequent inventions.

<sup>5</sup> Lee et al. (2009) Who Owns Our Low Carbon Future: Intellectual Property and Energy Technologies. Chatham House.

and energy-efficient goods, services and technologies need to be encouraged and scaled up. Targeted policy interventions to strengthen cooperation between developing and developed countries will also be needed if accelerated and wholesale deployment of these technologies is to be achieved.

Low carbon technologies are at various stages of development, but there is a long way to go before they reach full commercialisation (Figure 1). Given the difference in their maturity, we must focus on both near-term commercialisation for those technologies near the market, and research, development and demonstration (RD&D) for those further away. This dual focus would be needed to aggressively deploy existing options to peak and reduce global emissions by 2020, and to enable longer term cuts out to 2050 by investing in the technologies of the future.

**Figure 1: Technology development stages and investment priorities**



Source: Tomlinson (2009)<sup>6</sup> based on IEA (2008)<sup>7</sup>

The solutions are achievable, affordable and realistic but will require concerted effort and international cooperation to be successfully executed. Project Catalyst analysis suggests that the costs of low-carbon transition are manageable provided a mixture of aggressive abatement actions are taken<sup>8</sup>. The incremental cost of achieving a 450 ppm path is less than 1% percent of global GDP in 2020 (€95-130 billion), compared with the €215 billion per year fossil fuel subsidies, even if energy efficiency savings are not counted and transaction costs are

<sup>6</sup> Tomlinson, S. (2009) Breaking the Climate Deadlock: Technology for a low carbon future. The Office of Tony Blair and the Climate Group.

<sup>7</sup> IEA (2008) Energy Technology Perspectives: Scenarios and Strategies to 2050. OECD/IEA, Paris.

<sup>8</sup> Project Catalyst (2009) Towards a Global Climate Agreement: Synthesis Briefing Paper June 2009.

included.<sup>9</sup> It is crucial that options at higher costs are simultaneously considered as well as 'low hanging' efficiency solutions to balance the risk of policy, market or technology failures. These technologies require investment across different stages of their innovation chain. Investment is needed now to develop and demonstrate early stage technologies; so that they can reach maturity after 2020 when they are expected to contribute significantly to emissions reduction. For example, key technologies in transport (e.g. electric cars, fuel switch and efficiency) account for about 22% of overall reductions in 2050 scenarios (see Annex I for a case study on electric vehicles)<sup>10</sup>. IEA assumes that electric and plug-in vehicles will reach commercialisation between 2020 and 2030, with 20 million on the roads by 2020. Similarly, carbon capture and sequestration (CCS) has been identified as one of the key technologies and is expected to contribute 20% of global emission reductions by 2050. However, there are currently no full-scale CCS plants up and running anywhere in the world which risks its full-scale deployment beyond 2030.

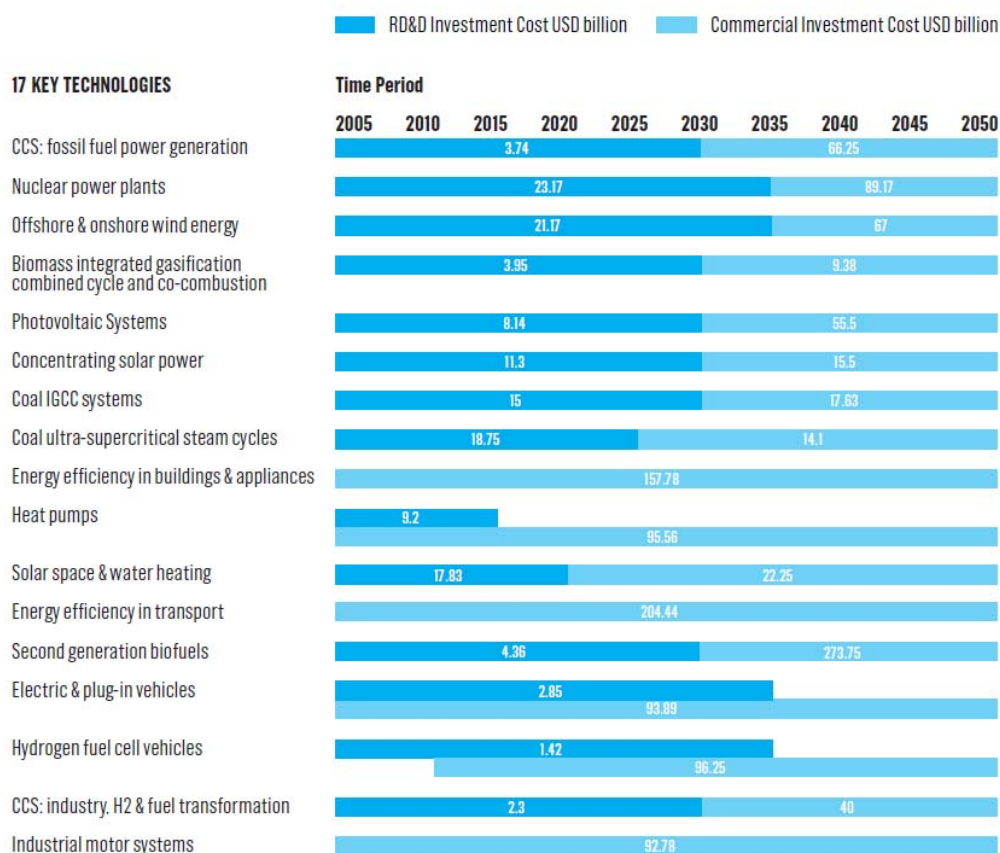
Figure 2 shows that between now and 2030, RD&D investment is required for most technologies to drive them towards deployment. Meanwhile, energy efficiency technologies, electric and hydrogen fuel cell vehicles and heat pumps will require deployment and commercialisation investment between now and 2050.

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<sup>9</sup> McKinsey (2009) Pathways to a Low Carbon Economy: Version 2 of GHG Abatement Cost Curve

<sup>10</sup> IEA (2010) Energy Technology Perspectives: Scenarios and Strategies to 2050. OECD/IEA, Paris.

**Figure 2: Technology roadmaps – annual average investment costs for RD&D and commercialisation of new technologies (\$ billion)**



Source: Tomlinson (2009)<sup>11</sup> based on IEA (2008)<sup>12</sup>

### **Role of public sector in driving innovation**

It is suggested that about 80% of the additional cost of the investment will need to be covered by the private sector. However, several market failures and barriers to innovation are likely to lead to underinvestment and therefore a lack of scale and speed in development and deployment of technologies. These include<sup>13</sup>:

Significant learning curves locking-in to existing technologies: New technologies may not become cost effective until significant investment has been made and experience developed. Significant learning effects may reduce the incentive to invest in innovation, if companies wait until the innovator has already proven a market for a new cost effective technology.

<sup>11</sup> Tomlinson, S. (2009) op.cit.

<sup>12</sup> IEA (2008) Energy Technology Perspectives: Scenarios and Strategies to 2050. OECD/IEA, Paris.

<sup>13</sup> Milford, L. and Morey, J. (2009) Climate crash course for Copenhagen – the six simple reasons why we need global technology collaboration. Clean Energy Group; Avato, P. and Coony, J. (2008) Accelerating Clean Energy Technology Research, Development and Deployment. World Bank Working paper: 138, The IBRD/ the World Bank; Stern, N. (2006) Stern Review Report on the Economics of Climate Change. London, UK: HM Treasury.

Lack of certainty over the future pricing of the carbon externality: The patchwork of climate policies around the world and consequent political and financial risk reduce incentive to innovate, such as in the EU, major fluctuations in carbon prices fail to provide security for medium- and long-term investment in low-carbon technologies (see Box 1).

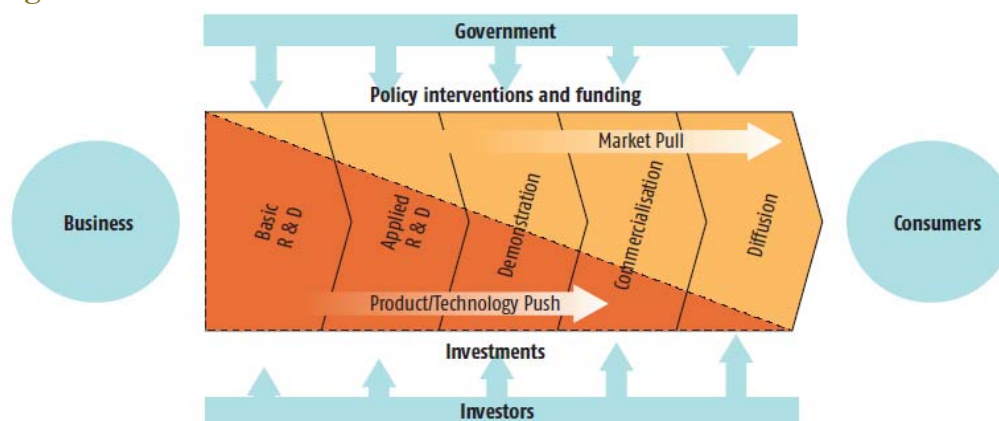
Innovation as a global public good: Due to public good nature of innovation, an individual company may be unable to capture the full economic benefit of its investment in innovation. These knowledge externalities (or spillovers) from technological development will tend to limit incentives for innovation, and lead to underinvestment in these critical areas.

Technology risks associated with the “valleys of death”: There are two recognized “valleys of death” in the technology development chain – first at the early product development stage between public and private sector funding and later at the commercialization stage, when first- and second-of-kind plants require large-scale investments.

Energy RD&D can require large sunk capital investments: It is difficult to attract sufficient capital without actions to reduce investor risk through specific government technology support.

These market failures and non-market barriers will mean a sub-optimum level of innovation is created in the private sector. Because of this and the associated societal and strategic importance of low carbon innovation, the public sector has a key role in creating these markets (‘pull’ mechanisms) and supporting early-stage research, development and demonstration of critical technologies (‘push’ mechanisms). Creating technology solutions will require a balance of action all the way along the innovation chain, with varying levels of public-private finance and policy interventions at different stages (Figure 3). A key consideration for governments, therefore, should be creating the right balance of risk and reward in innovation markets to leverage private sector activity, especially in riskier technologies.

**Figure 3: Innovation chain**



Source: Adapted from Grubb, 2004<sup>14</sup>

<sup>14</sup> Grubb, M. (2004) Technology Innovation and Climate Change Policy: an overview of issues and options. Submitted (in review) Keio Journal of Economics.

Supportive policy, investment and institutional frameworks could shift the balance of risk for the private sector in investing in these technologies. Redirecting technical change through regulation and policies are needed until clean sectors take off without costly delay<sup>15</sup>. Otherwise, market size and the initial productivity advantage of the high-carbon sector would drive innovation and production to that sector, and therefore create technology lock-in and dependency.

### **Box 1: Carbon price and low carbon innovation**

The carbon price alone cannot deliver the scale and speed of technology development and deployment needed<sup>16</sup>. The levels of required CO<sub>2</sub> prices, exceeding €100 per tonne of CO<sub>2</sub>, possibly by a wide margin, do not seem to be a realistic option in the near future<sup>17</sup>, given the European Commission reduced its carbon price estimate from around €32 (2008 prices) per tonne of CO<sub>2</sub> to €16 in 2020 to take into account the effect of the economic crisis<sup>18</sup>. This is unlikely to stimulate sufficient technological upgrading and innovation, especially investment in risky and expensive technologies such as CCS<sup>19</sup>. Also, the overarching objective of the ETS is cost effectiveness of 20% GHG emissions reductions in 2020<sup>20</sup>. Therefore, it typically encourages the deployment of the cheapest existing low carbon technologies and energy efficiency measures (given there are no other non-cost barriers). Reaching the target through lowest carbon price and as many cheap offsets as possible in the short term “masks the fact that over the long-term – 2050 and beyond – an efficient climate change policy will need to accelerate the development and diffusion of new and breakthrough technologies. If not, the EU risks being locked into high carbon technologies, which, once carbon carries a higher price (either explicitly through taxation or emissions trading or implicitly through regulation) will create stranded assets and risk its industry becoming uncompetitive”<sup>21</sup>.

Technologies at different stages of maturity would require different types of public support (Figure 4). Early stage technologies would need financial support for research, development and capital cost support especially for large scale demonstrations which the private sector would not finance alone where there might be high level of technology risks and uncertainty over future financial returns. Creating markets for these technologies (i.e. ‘market pull’) through a mixture of supportive policy frameworks (e.g. standards, public procurement, feed-

<sup>15</sup> Acemoglu et al. (2010) The Environment and Directed Technical Change. Fondazione Eni Enrico Mattei "Note di Lavoro".

<sup>16</sup> Stern, N. (2006) op.cit.

<sup>17</sup> Egenhofer, C. et al. (2011) The EU Emissions Trading System and Climate Policy towards 2050: Real incentives to reduce emissions and drive innovation? CEPS Special Report, CEPS, Brussels.

<sup>18</sup> European Commission (2010) Analysis of Options to Move Beyond 20% Greenhouse Gas Emission Reductions and Assessing the Risk of Carbon Leakage. COM (2010) 265 final.

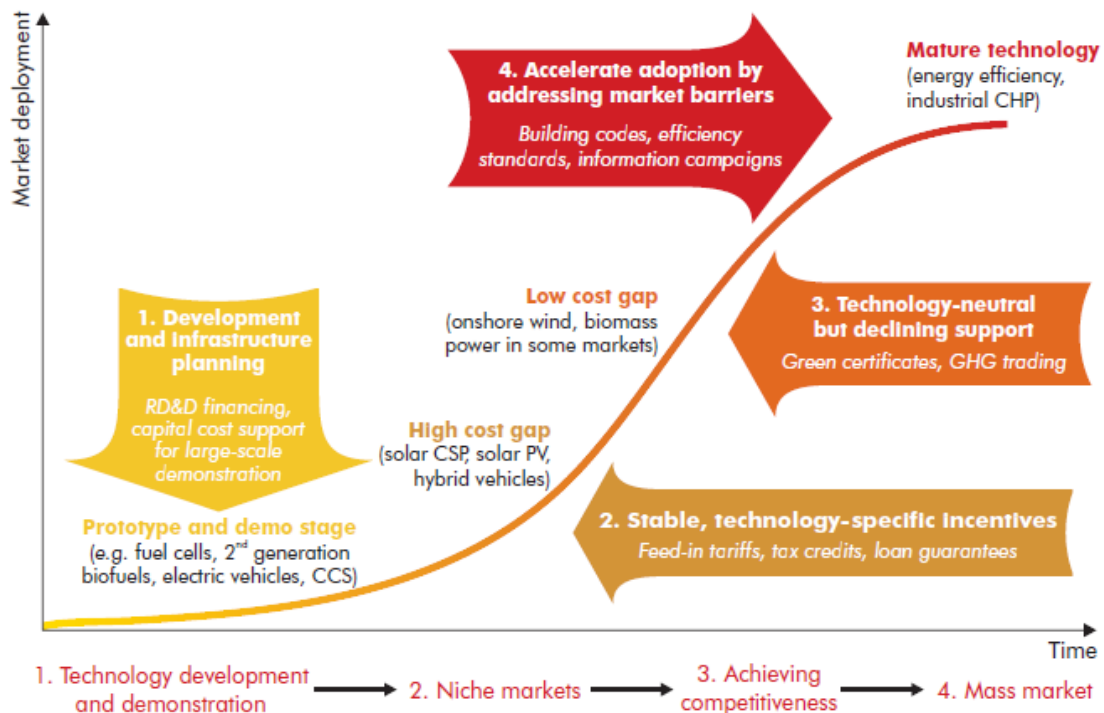
<sup>19</sup> European Commission (2010) EU Energy Trends to 2030 – update 2009. Directorate-General for Energy in collaboration with Climate Action DG and Mobility and Transport DG, Brussels.

<sup>20</sup> According to Art 1 of ETS Directive; see Egenhofer et al. (2011) op.cit.

<sup>21</sup> Egenhofer et al. (2011) op.cit.

in tariff) and infrastructure would also accelerate the deployment and diffusion of near-competitive or already commercial technologies, and provide more certainty to investors.

**Figure 4: Policies for supporting low carbon technologies along the innovation chain**



Source: IEA (2010) op. cit.

**Why we need to do more now rather than later?**

Technology policy can act as a key risk management tool for decarbonisation and climate security. Mitigation scenarios lay out possible pathways for the future technology mix and the investment cost required to achieve these. Underlying the emission reduction trajectories produced by the Stern review, IPCC and IEA, are aggressive assumptions on the early commercialisation of a portfolio of key technologies. Although the above scenarios provide good examples of required technologies, investment needs, and the associated timeframes, they do not effectively account for unforeseen risks such as technology and market failure or enhanced climate sensitivity:

- > Climate sensitivity: Current best estimates suggest that if all emissions reduction efforts registered under the Copenhagen Accord and subsequently captured in the Cancun Agreements are fully delivered, global average temperature is likely to rise by 3-4°C. This is about 10-20% higher than today's levels and would result in a greater than 50% chance that warming will exceed 3°C by 2100<sup>22</sup>. Delayed action will require much faster rates of reduction later. If there is a ten-year delay in reducing emissions, then the rate of cuts

<sup>22</sup> Rogelj, J., Nabel, J., Chen, C., Hare, W., Markmann, K., Meinshausen, M., Schaeffer, M., Macey, K., Höhne, N. (2010) Copenhagen Accord pledges are paltry. *Nature*, 464, Pages: 26–1128

required increases over a five-year period from 14% to 31%<sup>23</sup>. Similarly if climate science continues to indicate a more sensitive climate and stronger feedback mechanisms, suggesting impacts are occurring faster than we previously thought, we will have to deliver new innovations sooner than is currently anticipated, including those relevant for adaptation. This will require a strategic perspective beyond least-cost emission reductions.

- > Investment failure: The market will not automatically bring technologies forward at the pace required due to various barriers discussed in section 1, and may not account for future risks such as climate sensitivity or policy failure.
- > Policy failure: If some major emission reduction policies fail, or markedly underperform (e.g. energy efficiency or reduced emissions from deforestation and degradation), then more low carbon technology options will be needed earlier than predicted to keep on track.

Marlay and Koske (2005)<sup>24</sup> suggests if risks are threatening at some level of probability, and if the consequences are potentially serious, a portfolio approach including technology policy initiatives for scaling up RD&D and technology adoption could act as a “hedging strategy”. These could reduce uncertainty, create options for action, and spread costs over all of society through government funding. Investing early and in a wider portfolio of low carbon innovation would mitigate against these risks. Government leadership would help to underwrite risk for investment and create new industries and growth. Stern agrees that “technology-neutral incentives should be complemented by focused incentives to bring forward a portfolio of technologies. The externalities, uncertainties and capital market problems in some sectors combine with the urgency of results and specificity of some of the technological problems that need to be solved when tackling climate change, all point to the necessity to examine the issues around particular technologies and ensure that a portfolio develops”<sup>25</sup>. This is not about creating a policy of ‘picking winners’, instead it is investing to ensure there are enough winners for the market to pick from.

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<sup>23</sup> Meinshausen, M. (2005) On the Risk of Overshoot – Two Degrees. Presented at “Avoiding Dangerous Climate Change”, 1-3 February, Met Office, Exeter, UK.

<sup>24</sup> Marlay, R. and Koske, B. (2005) Technology Policy for Energy and Climate Change. Lessons From the Past 30 Years. CFE Policy Paper Series, IFRI, Paris.

<sup>25</sup> Stern, N. (2006) op.cit.

## 2. Meeting the challenges of global low carbon innovation

The unique public good nature of climate security and low carbon innovation requires a more active public sector role in identifying and responding to emerging challenges. Drawing from Chapter I, we identified three overarching challenges:

- > **Managing risks:** Currently, systemic risks of climate change are not well managed. Even though major steps were taken in relation to the establishment of the Technology Mechanism in Cancun Summit, all emissions reduction efforts registered under the Copenhagen Accord and the Cancun Agreements still result in more than 50% chance of exceeding 3°C warming by 2100. A system-wide risk management approach would be needed to address different kinds of risks, such as climate sensitivity, technology and policy failures. Governments could manage these risks through a mixture of ‘tools’, such as a robust multilateral climate regime beyond ‘pledge and review’, investing in a portfolio of low carbon technologies and policies, and comprehensive scientific research, in particular of tipping points, integrated with decision making tools.
- > **Increasing the scale and speed of innovation:** In order to develop and deploy technologies to stay below 2°C, we need to bring early stage technologies to commercialisation much faster. We will also need to double the current speed of diffusion. ‘Push and pull’ public policy frameworks and financial instruments are key levers for increasing scale and speed. The market will not automatically bring technologies forward at the pace required given various market failures and barriers.
- > **Creating integrated global markets:** Preventing high carbon lock-in will require a significant increase in innovation and diffusion in developing countries, especially emerging economies. Therefore, concerted action at international level will be needed to create truly global markets, and address problems simultaneously. Bilateral and multilateral cooperation between developed and developing countries in key technologies through, for example, joint RD&D, standards, sectoral technology agreements and capacity building would help to capture higher global public good value from innovation and balance innovation driven by narrow national competitiveness.

This chapter aims to illustrate current trends of actions in meeting these challenges. The lessons are mixed and some areas are better explored than others. While supportive public policy frameworks and financial mechanisms are relatively well mapped out, a clear understanding of what works and what does not is limited. Also, a holistic assessment of risk management tools remains underdeveloped.

### ***Global low carbon technology race with new emerging players – preliminary trends in capacity and investment***

Both developed and major emerging economies are increasingly investing in low carbon technologies in order to secure their competitiveness and prosperity in future global markets.

New clean energy investment in key production technologies reached \$162 billion in 2009, down from \$173 billion in 2008 but nearly four times 2004's total<sup>26</sup>.

Europe currently leads in clean energy investment globally (Figure 5). In 2009, it accounted for 44% of the world's financial investment in clean energy (\$43.7 billion)<sup>27</sup>. However, it is followed very closely by Asia, driven primarily by strong growth in China. For the first time, China overtook US in clean energy finance and investment in 2009.<sup>28</sup> Brazil, India and China represented 37% of the global financial investment in clean energy. China and Brazil also ranked as top countries for low carbon technology investment alongside France and Germany among major economies<sup>29</sup>.

All the major economies are betting on a clean energy future with China, US, Japan and South Korea channelling more of their stimulus packages to low-carbon investment than Europe (Figure 6). South Korea has dedicated 80% of stimulus spending to low carbon investments. China also ranks highly (37%), dedicating around \$200billion to low carbon investments – although a substantial amount of this is committed to rail and grid infrastructure with uncertain climate benefits. China's energy saving and environmental protection sector is expected to be worth \$715 billion (¥4.5 trillion) by 2015<sup>30</sup>. In contrast, the EU Member States collectively had the lowest proportion of green investments in their stimulus packages of the major economies (\$24.3 billion). For a region leading on climate change policy Europe had the lowest portion of its low carbon recovery package dedicated to green investment.<sup>31</sup> The European Energy Programme for Recovery (EPR), as part of the stimulus package, allocated € 1.6 billion to get started with the first demonstration plants for CCS and the Wind European Industrial Initiatives of the SET-Plan. Overall implementation of flagship EU SET Plan requires an additional €50 billion public and private investment in the next decade; yet how Europe will lever the financing remains unclear. Given the scale of the challenge, European initiatives remain piecemeal and fragmented both at the EU and member state level.

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<sup>26</sup> UNEP (2010) Global Trends in Sustainable Energy Investment 2010: Analysis of Trends and Issues in the Financing of Renewable Energy and Energy Efficiency. UNEP and New Energy Finance.

<sup>27</sup> UNEP (2010) *ibid*.

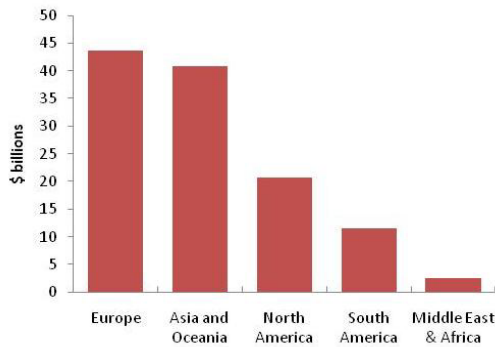
<sup>28</sup> Pew Charitable Trusts (2010) Who's Winning The Clean Energy Race?

<sup>29</sup> Deutsche Bank (2010) Global Climate Change Policy Tracker – The Green Economy: The Race is On.

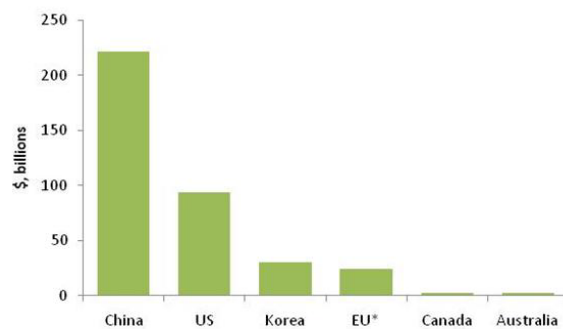
<sup>30</sup> Ng, S.W. and Mabey, N. (2011) Chinese Challenge or Low Carbon Opportunity? The implications of China's 12th Five-Year-Plan for Europe. E3G, London.

<sup>31</sup> E3G (2010) Building a sustainable and low carbon European recovery: How moving to a 30 percent emissions target is in the European interest.

**Figure 5: New financial investment in sustainable energy, 2009**



**Figure 6: Green investment in stimulus packages**



Source: UNEP (2010) op.cit.; E3G (2010) op.cit.

Although Europe also had the highest installed renewable power capacity (Figure 7), China and US<sup>32</sup> are catching up fast. China, India and Brazil are now among the top ten countries in installed renewable energy capacity with fast growth rates. China has doubled its wind capacity within a year and overtaken Germany (Figure 8).<sup>33</sup> If China's 12<sup>th</sup> five year plan is successfully implemented, renewable energy capacity will match growth in the EU with installed capacity increasing by 64% to 427 GW by 2015, compared to 322 GW in the EU by 2015. China will decisively out invest the EU in grid infrastructure with 500 billion yuan (€57 billion) allocated to ultra high voltage (UHV) transmission lines by 2015, and more than 4 trillion yuan (€460 billion) on "smart grids" in the next decade<sup>34</sup>.

Future demand is hard to predict. However, there are a number of scenarios assessing future markets and leadership. HSBC estimates that the low-carbon energy market (including both renewable energy, nuclear, and energy efficiency/management) could triple to \$2.2 trillion by 2020<sup>35</sup>. The Conviction scenario, the most likely pathway to 2020 according to HSBC,<sup>36</sup> estimates that the EU will retain its lead in future markets, but its share will fall to 27%. The main riser is China, which climbs to a 24% market share, while the US share falls back to 20%. Japan falls from fourth to fifth behind India. Despite various uncertainties underlying these estimates, they reflect current trends of investment and the low carbon race in key markets. Future low carbon technology markets are likely to pose risks as well as opportunities to European leadership and businesses.

<sup>32</sup> REN 21 (2010) Renewables 2010: Global Status Report

<sup>33</sup> REN 21 (2010) Ibid.

<sup>34</sup> Ng, S.W. and Mabey, N. (2011) op.cit.

<sup>35</sup> HSBC (2010) Seizing the climate economy

<sup>36</sup> The Conviction scenario assumes that there will be diverging growth paths in the three key markets. In the EU, they expect renewable but not energy efficiency targets to be met; in the USA, they project limited growth in clean energy; and in China, they expect current targets for clean energy to be exceeded.

Figure 7: Renewable power capacities: developing world, EU and top six countries, 2009

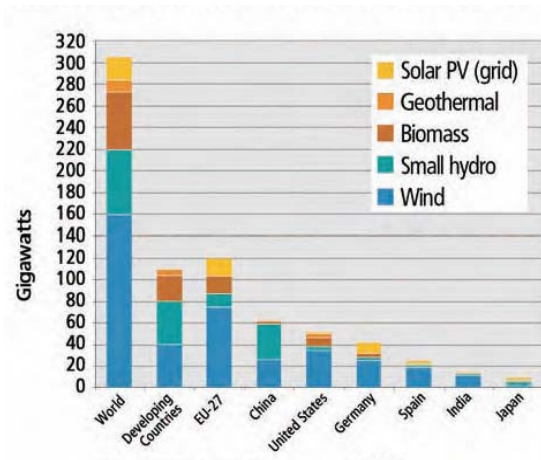
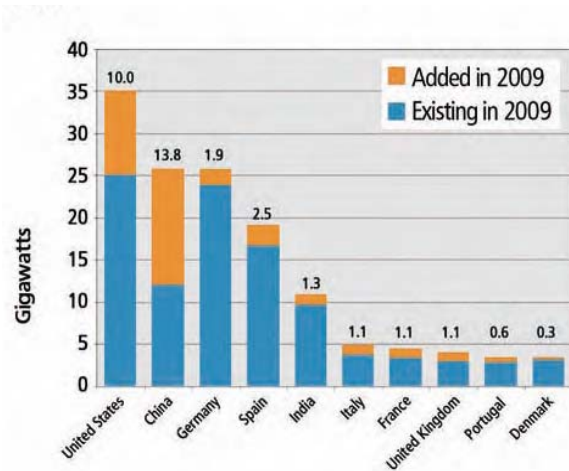


Figure 8: Wind power capacity, Top 10 countries, 2009



Source: REN 21 (2010) op.cit.

### Changing landscape of low carbon technology ownership

Innovation is increasingly becoming international both in terms of finance and actual research<sup>37</sup>. Until now, European companies have developed a strong global market share of 30-50% across many clean technology sectors<sup>38</sup>; for example, the UK was a net exporter of Low Carbon and Environmental Goods and Services (LCEGS) in 2007/08, with China the single largest destination for UK exports<sup>39</sup>. However, European companies face increasing competition. They now represent only 25 percent of the top twenty innovators (as measured by patent holdings) across the major clean energy technologies: solar PV, wind, biomass, clean coal, carbon capture and storage, and concentrated solar power<sup>40</sup>. Japanese, German and US companies are the top patent owners (Figure 9). Germany overtakes US in the wind sector – largely owing to two companies, Enercon and Siemens. Other major European companies in the UK, France and Italy have much less significant shares in these technologies. Japanese organizations have a strong presence in five fields, while the United States is far ahead on carbon capture technology and second strongest in four technologies. Although much has been made of the recent rise of China, the low share for China suggests that most patents ‘originating’ from the country are in most cases filed by foreign subsidiaries at the moment.

<sup>37</sup> OECD (2007) Science, Technology and Industry Scoreboard 2007: Innovation and Performance in the Global Economy. OECD, Paris.

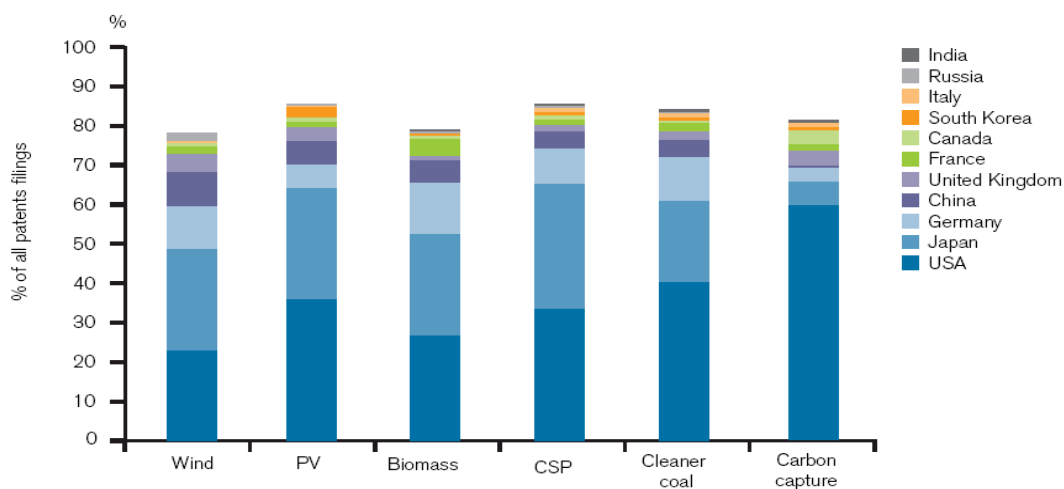
<sup>38</sup> European Commission (2010) Europe 2020: A European strategy for smart, sustainable and inclusive growth, COM (March 2010), Brussels.

<sup>39</sup> BIS (2009) Towards a Low Carbon Economy: economic analysis and evidence for a low carbon industrial strategy. BIS Economics Paper no: 1, UK HMG, Department for Business, Industry and Skills (BIS), London.

<sup>40</sup> Lee, B. et al. (2009) op. cit.

Clean energy technology patenting rates duly surged in the mid-1990s, with a rapid increase in deployment coming a few years later. They have increased roughly 20% per year since 1997 (overlapping with the adoption of the Kyoto Protocol), outpacing the traditional energy sources of fossil fuels and nuclear energy (Figure 10). There was a nine-fold increase in wind patents and a five-fold increase for solar PV<sup>41</sup>. The timing of their take-off seems to reflect the impact of the introduction of stronger policy incentives, such as feed-in tariffs in key wind markets (i.e. Germany in 1991, US in 1992). This might also reflect that political decisions can be important in creating an ambitious policy framework to stimulate the development of technologies crucial for low carbon transformation<sup>42</sup>.

**Figure 9: Geographical origins of parent companies of patent assignees (with more than four patents)**



Source: Lee, B. et al. (2009)

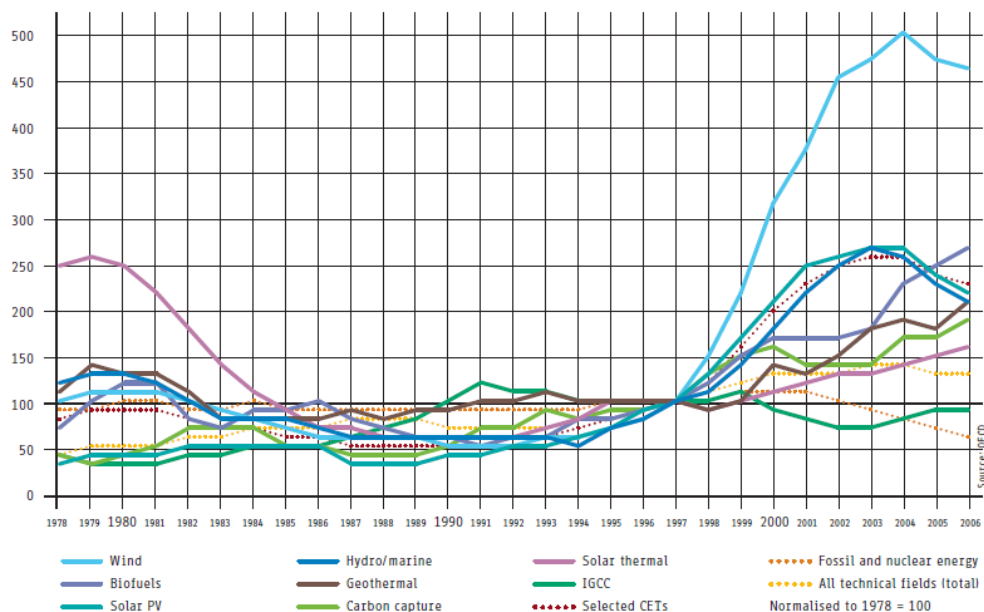
Although patents are useful indicators of innovation activities, they are not the sole determinants of their success in the marketplace<sup>43</sup>. Companies' business models and the structure of markets, in addition to the role patents play in the sector would determine who succeeds. What is clear is that no one country will own all the options. Currently, companies not countries own most of the technologies and patents; it is likely that globalised networks of companies will largely own and drive the scale and speed of innovation and diffusion.

<sup>41</sup> Lee, B. et al. (2009) op.cit.

<sup>42</sup> UNEP, EPO and ICTSD (2010) Patents and clean energy: bridging the gap between evidence and policy - final report.

<sup>43</sup> For example, the top four wind patent owners – who collectively own 13 % of all wind patents – have a 57% share of the global market. In solar PV, many of the top 10 manufacturers are not patent holders.

Figure 10: Disaggregated data showing post-Kyoto growth in patenting for CETs



Source: UNEP, EPO and ICTSD (2010)

However, even though China, Brazil and India do not currently have any companies or organizations in the top 10 patent owners for the moment, many leading companies set up R&D centres in key emerging markets to complement their established investments in the US and Europe (e.g. GE, Siemens, Alstom, Phillips). The OECD confirms that R&D activities are becoming globally dispersed “as they move closer to markets and to sources of knowledge (poles of excellence)”<sup>44</sup>. The average R&D intensity of affiliates under foreign control is higher than the R&D intensity of domestically controlled firms in most countries. Meanwhile, Chinese firms also set up 26 R&D units in developed countries (including 11 in the US and 11 in the EU). Large Chinese corporations acquired the financial power to execute acquisitions either through their own funds, financial backing from the Chinese government, or participation of local and foreign private equity investors. In addition, the global financial crisis has opened up opportunities to buy firms that are struggling or whose market capitalisations have been depressed<sup>45</sup> (see Box 2). This has allowed to access to intellectual property and markets of merged or acquired companies.

<sup>44</sup> OECD (2007) op.cit.

<sup>45</sup> Smith-Gillespie, A. (2009) *Low Carbon Technology: A Framework for EU-China Dialogue*. E3G, London;

## **Box 2: Case studies of mergers and acquisitions on renewable technologies in key emerging countries**

### Goldwind, China – Vensys, Germany

In 2008, Xinjiang Goldwind Science & Technology Co. (Goldwind) acquired a 70% stake for €41 million in Vensys AG, a German wind turbine manufacturer that previously licensed technology to Goldwind. The purchase enabled Goldwind to acquire core IP in direct-drive (i.e. gearless) turbine technology, as well as IP in converters and variable propeller systems owned by a Vensys subsidiary. Future development plans include building a €5 million wind turbine manufacturing plant in Germany through the acquired company, providing a further foothold for Goldwind in the European market. The Vensys acquisition has enabled Goldwind to internalise core technology as well as gaining a strategic advantage on competitors that also licensed technology from Vensys. It will also enable Goldwind to build its capability for offering higher-capacity wind turbines.

Earlier on, Goldwind had obtained a license from Vensys for a gearless 1.2 MW turbine. When Vensys developed a low wind speed version with a larger 64 m-diameter rotor that increased output to 1.5 MW, Goldwind acquired the license for that turbine as well. The company worked with Vensys to produce 2.0 and 2.5 MW turbines with a view toward offshore applications<sup>46</sup>.

### Suzlon, India – Hansen, Belgium and REpower, Germany

A leading Indian wind turbine manufacturer, Suzlon Energy, recently acquired majority control of several wind turbine technology and components suppliers, including Hansen and REpower<sup>47</sup>. In early 2006, Suzlon purchased Hansen, the second largest gearbox manufacturer in the world, expanding its access to gearbox technology, for USD 565 million. This deal marked the second largest foreign corporate takeover by an Indian company in any industry.

In May 2007, Suzlon acquired German manufacturer for approximately \$1.6 billion<sup>48</sup>. Following a number of separate transactions since throughout 2008 and 2009, in June 2009, with the conclusion of the acquisition of Martimer's stakes for about \$400 million, a Portuguese company, Suzlon currently holds 90.72% stake in REpower.

### Suntech, China - MSK Corporation, Japan<sup>49</sup>

In August, 2006 Suntech Power Holdings closed the transaction to acquire the remaining one-

<sup>46</sup> Lewis, J. (2007) Technology Acquisition and Innovation in the Developing World: Wind Turbine Development in China and India. Studies in Comparative International Development, Volume 42 (3-4), 208-32.

<sup>47</sup> Lewis, J. (2008) Energy Leapfrogging in China and India. The Ecologist [Internet], 28 March.

<sup>48</sup> UNEP (2008) Clean Energy Investments Charge Forward Despite Financial Market Turmoil. Press Release available at

<http://www.unep.org/Documents.Multilingual/Default.asp?DocumentID=538&ArticleID=5849&l=en>

<sup>49</sup> PowerPulse (2006) Suntech Signs Agreement to Acquire MSK Corp. Available at:

<http://www.powerpulse.net/story.php?storyID=15745>;

<http://www.powerpulse.net/story.php?storyID=16620>

third equity interest in MSK Corporation. Suntech acquired a two-thirds equity interest in MSK Corporation in August 2006 for US \$107 million in cash through a combination of subscription to new shares and purchase of existing shares. Suntech has now acquired the remaining 476,576 shares of MSK from MSK shareholders through the issuance of 1,310,328 Suntech shares as consideration.

The CEO of Suntech noted that "with the growing support for integrated solar solutions in many regions, including enhanced subsidies for BIPV systems in France, Germany and Italy, we are gaining significant traction and building a strong pipeline of projects for our MSK Solar Design Line(TM) of BIPV products." Less than a year later, in February 2007, Suntech has established Suntech Europe Ltd., with London headquarter, in order to expand its customer base as well as to deepen the service and support offered to its customers in Europe, the Middle East and Africa.

### ***Supportive policy, investment and institutional frameworks to increase scale and speed***

The last decade has seen a substantial growth in supportive public policy frameworks for low carbon innovation in both developed and key emerging economies. The signing of the Kyoto Protocol in 1997 had a positive impact on clean energy technology investment<sup>50</sup>. Although the Copenhagen Summit did not result in a comprehensive outcome, the momentum it generated a catalytic impact as 154 new climate policy announcements were made between October 2009 and early 2010<sup>51</sup>, in addition to existing 270 policies in MEF countries. Countries such as UK, Germany and China have developed robust policy frameworks, including national targets and strong incentives, as well as EU-wide emissions reduction, energy efficiency, and renewable energy targets. The EU also made an attempt to overcome fragmentation of its innovation policy by establishing the Innovation Union strategy which aims to steer European structural funds and public procurement towards innovation, as well as removing bottlenecks in market penetration. In addition, the major European technology initiative SET-Plan aims to bridge the "valley of death" demonstration-stage gap between technology R&D and ETS market deployment; its implementation requires tripling of public and private investment from its current €3 billion pa to €8 billion pa over the next decade<sup>52</sup>.

In renewable energy, countries have put a number of different supportive policies in place<sup>53</sup> which have been crucial in 'pushing' technologies and creating market 'pull'. Different countries have employed a variety of supportive policy instruments to increase the speed and scale of renewable energy technology deployment (Table 1). For example, Denmark has been a leading player in the wind energy industry, especially in early stages of development and deployment. It has gone from being 99% dependent on foreign oil sources to becoming energy

<sup>50</sup> UNEP, EPO and ICTSD (2010) op.cit.

<sup>51</sup> Deutsche Bank (2010) op. cit.

<sup>52</sup> Euractiv (2009) EU to invest billions in energy research. Available at: <http://www.euractiv.com/en/energy/eu-invest-billions-energy-research/article-186164>

<sup>53</sup> REN 21 (2010) op.cit.

self-sufficient after 30 years of focused energy policy (Box 3). China’s 12<sup>th</sup> five-year development plan (2011-15) is expected to place low carbon and clean energy industries at the heart of China’s forward strategy for growth, exports and industrial modernisation. Even though absolute emissions are likely to increase, further implementation plans for its energy and carbon intensity targets would save between 0.5-2.5 Gt of CO<sub>2</sub> emissions in 2020 (compared to EU’s 0.5 Gt in 2020 under 20% target), providing a strong domestic market in low carbon industries. The Chinese government is backing these goals with large scale public investments in clean energy and infrastructure. The 12<sup>th</sup> FYP is also likely to launch pilots in emissions trading, introduce a national resource tax, and experiment with new governance approaches in ‘low carbon zones’, covering over 300 million people<sup>54</sup>.

**Table 1: Renewable energy promotion policies**

• <b>Feed-in tariff</b>	<i>e.g. Germany, Denmark, Spain (most EU member states), China, Korea, Argentina, Brazil</i>
• <b>Renewable portfolio standard/quota</b>	<i>e.g. UK, Sweden, China, Chile, Korea</i>
• <b>Capital subsidies, grants, rebates</b>	<i>e.g. US, UK, France, Germany (most EU member states), China, India, Japan</i>
• <b>Investment or other tax credits</b>	<i>e.g. Denmark, Italy, Spain (most EU member states), US, China, Mexico</i>
• <b>Sales tax, energy tax, excise tax or VAT reduction</b>	<i>e.g. Finland, France, Hungary (most EU member states), US, India</i>
• <b>Tradable RE certificates</b>	<i>e.g. Denmark, Finland, France (most EU member states), Australia, Norway</i>
• <b>Energy production payments or tax credits</b>	<i>e.g. Finland, Sweden, US, Argentina</i>
• <b>Net metering</b>	<i>e.g. Denmark, Italy, Mexico</i>
• <b>Public investment, loans or financing</b>	<i>e.g. Australia, France, Spain (most EU member states), Brazil, China, India</i>
• <b>Public competitive bidding</b>	<i>e.g. France, Denmark, China, India</i>

Source: REN 21 (2010) op.cit.

In addition, **new institutions** have been created to support this transformation. In order to speed up development and early deployment of riskier new technologies, for example, the US Advanced Research Projects Agency—Energy (ARPA-E) within the Department of Energy (DoE) was established. Unlike conventional DoE research, the core objective of ARPA-E is to focus on ‘out-of-the-box’ transformational energy research that industry by itself cannot or will not support due to its high risk but with potential high reward. The ARPA-E programme aims “to

<sup>54</sup> Ng, S.W. and Mabey, N. (2011) op.cit.

create an intellectual property strategy, technical data strategy, and procurement or financial assistance instrument that best manages the high risk inherent in this kind of R&D and optimizes the likelihood that the technology will move forward to market”<sup>55</sup>. Although officially authorised in 2007 but without an initial budget, it received \$400 million funding in April 2009 through the American Recovery and Reinvestment Act. By April 2010, \$257 million was awarded to 74 projects. It has been modelled after the successful Defense Advanced Research Projects Agency (DARPA) which has an impressive track record of supporting innovation in strategic military technologies.

Some other institutional innovation attempts to address the challenge of unlocking private sector investment needed for low carbon transformation, such as the Green Investment Bank (GIB) in the UK. The UK Green Investment Bank Commission has proposed that the primary focus of the GIB should be on lowering risk for investors, rather than simply providing capital. It would work towards removing barriers and rapidly increase investment in areas where maximum impact and speed to implementation can be achieved. For example, the scale up of investment in proven energy efficiency projects that can lower the overall development need of renewable energy sources; investment in enabling technology, such as smart grids, that reduce the cost for other low carbon investments; and support of both proven and high impact third-round offshore wind, should all be priorities<sup>56</sup>. In the US, the proposal for a federal “Green Bank” is also being discussed to support early commercialisation of low carbon technologies. A parallel proposal to the “Green Bank”, Clean Energy Deployment Administration (CEDA), aims “to encourage deployment of [clean energy] technologies that are perceived as too risky by commercial lenders.”; hence aiming to bridge the commercialisation ‘valley of death’.

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<sup>55</sup> Bloomberg New Energy Finance (2010) Crossing the Valley of Death: Solutions to the next generation clean energy project financing gap. Commissioned by Clean Energy Group. Bloomberg New Energy Finance.

<sup>56</sup> Green Investment Bank Commission (2010) Unlocking investment to deliver Britain’s low carbon future.

### **Box 3: Danish leadership in renewable energy**

Danish wind companies accounted for 40% of the world market in 2004, employing approximately 20,000 people, with a combined turnover of €3 billion<sup>57</sup>. Danish support for the renewables industry uses both push and pull measures:

- A tax on the use of fossil fuels;
- A spot price environmental premium (€13/MWh) and an additional compensation for balancing costs (€3/for 20 years are available for new onshore wind farms);
- Fixed feed-in tariffs exist for solid biomass and biogas under certain conditions, and subsidies are available for CHP plants based on natural gas and waste (biomass, being CO<sub>2</sub> neutral, is exempt from CO<sub>2</sub> duty);
- Fiscal support through taxation: a CO<sub>2</sub> tax is levied on electricity production from fossil sources. Renewable energy receives compensation from this, in order to internalise the external costs of fossil fuels;
- For cooperative operations, no income tax is payable on dividends up to DKK3000 (€400);
- Administrative support at the municipal level and active involvement of local utility;
- Technological development through early government support, starting in the 1980s, focused on creating an indigenous wind energy manufacturing industry.

### ***Creating integrated global markets***

Technology roadmaps, which set out the pathway to reduce emissions in line with 2°C, assume global innovation and deployment of these technologies almost simultaneously. However, the global public good nature of low carbon innovation means that in the absence of additional multilateral action, private markets will under-invest in low carbon innovations relative to the global social optimum. Similarly, one of the main barriers to optimal innovation provision is that it is largely dealt with at the national level and tends to be viewed as an extension of R&D policy<sup>58</sup>.

Although Europe is a powerful actor in its own right its internal market is not large enough to support the full commercialisation of many low carbon technologies at scale needed. For example, Europe is not large enough to sustain a CCS market - the EU CCS demonstration programme only makes sense in the context that there will be opportunities for European businesses deploy this technology in international markets and, in particular, in large emerging economies such as China<sup>59</sup>.

<sup>57</sup> Ministry of Foreign Affairs of Denmark website; Danish Wind Industry Association website

<sup>58</sup> OECD (2005) Governance of Innovation Systems. Volume 1: Synthesis Report. OECD, Paris.

<sup>59</sup> IEA (2008) op. cit. IEA BLUE Map scenarios assume that just over half of the abatement potential will be captured in developing countries including China and India. 64% of CCS abatement potential in 2050 will be captured in developing countries, including India and China. Electric, hydrogen and hybrid

Meanwhile, innovation and invention remains overwhelmingly a high income country activity<sup>60</sup>. Driven partly by lack of demand and innovative capacity (especially in lower income countries) may severely limit their ability to engage in effective decarbonisation and adaptation. Diffusion of new innovations is as much about the institutions, structures and organisations in a country as it is about funding support to access specific technologies. International cooperation would be required to adopt a broad approach to capacity building to enable developing countries to generate their own innovation systems, not just a narrow focus on technology transfer<sup>61</sup>.

This requires international cooperation to build global markets for low carbon technologies both to avoid high carbon lock-in and increase the pace of technology innovation globally. For example, governments and the private sector are betting on substantial growth in electric vehicles and supporting infrastructure in the coming decades. To support the development and roll out of electric vehicles (EVs), governments around the world, including Europe, US, Japan and China, are increasingly setting up supportive schemes for potential consumers and the industry. On the other hand, the widespread introduction of EVs will depend on an unprecedented degree of international coordination (see Annex I for a case study on EVs).

Currently public energy RD&D cooperation remains limited, except in nuclear technologies and information sharing platforms such as IEA implementing agreements. However, governments are increasingly aware of the crucial role that international cooperation needs to play. US Energy Secretary Chu noted that while competing for leadership in energy innovation, “[US has] much to gain by cooperating with China, India and other countries”<sup>62</sup>. In the past few years, high-level low carbon technology cooperation projects have been launched:

- > In 2009, US and China launched the joint Clean Energy Research Centre which will focus on buildings efficiency, clean vehicles and advanced coal technologies.
- > At the July 2009 G8/G20 summit in L’Aquila, MEF leaders committed to double their national public investment in the research, development and demonstration of transformational low-carbon technologies by 2015. They also launched the process to develop Technology Action Plans (TAPs) in order to facilitate the development and diffusion of a number of key low-carbon technologies.
- > At the Clean Energy Ministerial in Washington in July 2010, the ministers launched the Electric Vehicles Initiative (EVI) as a forum for global cooperation on the development and deployment of electric vehicles, and accelerating their commercial uptake.

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vehicles will constitute 60% of global vehicles market in 2050;. 64% of CCS abatement potential in 2050 will be captured in developing countries, including India and China. Electric, hydrogen and hybrid vehicles will constitute 60% of global vehicles market in 2050.

<sup>60</sup> World Bank (2008) *Global Economic Prospects: Diffusion of Technology in Developing Countries*. The IBRD/ The World Bank, Washington, D.C.

<sup>61</sup> Ibid.

<sup>62</sup> Chu, S. (2010) *Is the Energy Race our new “Sputnik” Moment?* Speech at the National Press Club Washington, D.C., 29 November.

Positive outcomes from these processes could help build trust and support agreement within the UNFCCC process, and explore different modes of effective collaboration to speed up key technology development and deployment at scale.

### 3. Balancing acts: Europe's race for low carbon competitiveness and scaling up international cooperation

Innovation and technological upgrading is key for countries' growth strategies and global competitiveness<sup>63</sup>. How each nation adapts to a carbon constrained world will, to a large extent, determine its future economic competitiveness and ability to create prosperity for its citizens<sup>64</sup>. Policy interventions to create market demand have been key in driving innovation and diffusion in low carbon technologies such as in the particular examples of Spain, Germany, and Japan. These markets are created by political agreement, constructed through policy, and driven by technology. So far, the EU's political leadership on climate action has positioned its businesses at the forefront of low carbon technology growth, but competitors are catching up fast. Major European countries (France, UK and Germany) are front-runners today in the transition to a low carbon world, thanks in part to structural economic changes in the 1990s, but some emerging economies are catching up fast.

As a technology leader, European businesses are well positioned to exploit their existing competitive advantage over low carbon innovation in order to benefit from a growing and increasingly competitive global market for low carbon technologies and services. However, there is a danger that a narrow focus on national competitive advantage would increase protectionism, slowing down both development and diffusion of low carbon technologies globally and provoking retaliatory actions in other sectors<sup>65</sup>.

The previous chapter set out three overarching challenges that low carbon innovation poses in an increasingly globalising economy with emerging players and where risks are not well managed. We think Europe can respond to these challenges by 1) developing a risk management approach; 2) coordinated action for innovation at EU level; 3) developing new modes of international cooperation.

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<sup>63</sup> Solow, R.M. (1957) Technical Change and the Aggregate Production Function. *The Review of Economics and Statistics* Vol. 39, No. 3, pp. 312-320.

<sup>64</sup> European Commission (2007) *Towards a low carbon future': a European Strategic Energy Technology Plan (SET-PLAN)*. COM (2010) 723 final.

<sup>65</sup> Kirkegaard et al (2010) *Toward a Sunny Future? Global Integration in the Solar PV Industry*; Kirkegaard et al (2009) *It Should Be a Breeze: Harnessing the Potential of Open Trade and Investment Flows in the Wind Energy Industry*

### ***Developing a system-wide risk management approach would help responding to the challenges of a complex world***

Any government intervention in creating and supporting infant industries involves risks and there are likely to be failures. However, instead of ‘no-action’ in front of uncertainty over climate impacts, technologies and policy choices, Europe should have a clear strategy for managing risks and exploring the rewards of low carbon transformation. A responsible risk management strategy will aim to reliably achieve the agreed temperature objective, while simultaneously ensuring that budgeting and contingency plans are effectively shaped to respond to potential future risks identified by different climate scenarios<sup>66</sup>. Therefore, a prudent risk management approach should be built on a three-tier “ABC” framework: 1) Aim to mitigate to stay below 2°C; 2) Build and budget for resilience to 3-4°C; 3) Contingency plan for capability to respond to 5-7°C. These entail different responses and trade-offs for decision makers.

Recommendations on some key areas for action include:

- > ***Portfolio of technologies and policies:*** There is no silver bullet solution to low carbon innovation challenge; some technologies will move forward while others will fail. Therefore, a portfolio approach to technology and policy choices would be essential to manage risks.
- > ***Systematic scientific research of climate ‘tipping points’:*** There is an urgent need for a comprehensive, long-lived monitoring system that integrates Earth and socioeconomic observations and prioritizes issues of highest potential threat. This could support the development of tools enabling decision-making under uncertainty. Europe should help building such system drawing from its existing research and satellite capabilities.
- > ***Establishing a robust multilateral climate regime beyond ‘pledge and review’:*** Europe should deploy further resources for its climate diplomacy to establish the foundations for a fair, ambitious and legally binding multilateral agreement. A top-down agreement is essential to ensure that the aggregation of global mitigation effort matches the imperative to reduce global climate risks.

### ***Coordinated action for innovation at EU level would deliver faster technology innovation at scale***

Current EU 20% emissions reduction target provides very little incentive to invest beyond business-as-usual technology innovation and deployment. Without a clear and ambitious short to medium term target, it will be unlikely that we develop and deploy new and existing technologies in the scale and speed needed within the next decades to stay below 2°C. Coordinated action at the EU level is needed; otherwise “it is highly unlikely that the critical

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<sup>66</sup> Mabey, N., Gullede, J., Finel, B. and Silverthorne, K. (2011) *Degrees of Risk: Defining a Risk Management Framework for Climate Security*. E3G, London and Washington, D.C.  
Defining a Risk Management: Framework for Climate Security. E3G, London and Washington, D.C.

mass of investment and hence the necessary breakthrough RD&D in low carbon technologies will be achieved”<sup>67</sup>.

Also, European companies need domestic growth if they are to retain their lead in low carbon markets. The European Commission suggests that “if we fall behind in the intensifying global race to win low carbon technology markets, we may need to rely on imported technologies to meet our targets, missing out on huge commercial opportunities for EU businesses”<sup>68</sup>. Also, Europe could fail to capture important ‘first-mover advantages’ for the EU-based industry such as market attractiveness for investment; skill base; and creating cross-sectoral knowledge pool.

Recommendations on some key areas for action include:

- > **An ambitious short and medium-term EU target:** A more ambitious political target of 30% emissions reduction by 2020 would catalyse the right policy decisions aligned with scientific limits and challenge of decarbonisation, and provide more certainty for low carbon investors. Without higher ambition and directed technical change, Europe may struggle to capture the full advantages of new low-carbon markets such as technological know-how, know-why, research capacity, supply chains, companies and domestic markets, given that investment is moving toward emerging markets where the demand is higher.
- > **Double the speed of diffusion of existing technologies:** Supportive public policy and financing frameworks to ‘pull’ technologies would help speeding up diffusion and create incentives for investment for demonstrating pre-commercial technologies. This may involve a mixture of public policy instruments including reforming the EU budget and EU ETS, and create new institutions such as the UK GIB.
- > **Spur early stage RD&D through the SET Plan:** As a major European technology initiative, the SET-Plan remains the only EU instrument which can bring forward essential European low-carbon technologies from R&D stage to early commercialisation before 2020, which, otherwise, would remain underinvested by private sector. Therefore, it is crucial that SET Plan remains in the European energy and innovation agenda following the renewed high-level political commitment at the February 2011 Energy Council meeting. Both public and private financial instruments need to be explored in depth to raise the additional investment of €5billion pa in the next decade. In addition, Europe should gear towards increasing public energy-related RD&D, with a clear shift to low carbon technologies, at least four-fold its current level by 2020<sup>69</sup>.

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<sup>67</sup> European Commission (2009) Impact Assessment for the Communication on Investing in the Development of Low Carbon Technologies (Set-Plan). COM (2009) 1297.

<sup>68</sup> European Commission (2007) op.cit.

<sup>69</sup> European Commission (2009) Towards a comprehensive climate change agreement in Copenhagen. COM(2009) 39/3.

### ***Developing new modes of international cooperation would support the creation of integrated global markets***

Resolving the competition versus collaboration dynamic is essential to deliver the innovation required and enable the EU benefit from adopting higher ambition reductions. In a globalised world, Europe needs to balance cooperation to build international markets with domestic action to ensure it remains competitive. Furthermore, Europe achieving its own transformational change it has been advocating to other countries, would increase its credibility internationally and avoid marginalisation in the emerging global economic and political dynamics.

International cooperation would be critical in creating truly global markets. Collaborative international RD&D on joint problems at the same time, not sequentially, is essential to overcome the underinvestment challenge and the other barriers to technology scale<sup>70</sup>. Keeping global low carbon technology markets open would also encourage lower cost global integration and broader technology deployment<sup>71</sup>, benefiting European consumers.

Recommendations on some key areas for action include:

- > ***Joint RD&D and knowledge sharing:*** To achieve the scale and speed in global innovation, simultaneous problem solving is essential both in developed and developing countries. This requires strengthening existing innovation systems and capacity in developing countries. EU needs to foster stronger bilateral or multilateral cooperation, through projects such as the EU-China Near-Zero Emissions Coal demonstration project (NZEK).
- > ***Provide support for operationalising the Technology Mechanism under UNFCCC:*** Europe should support operationalisation of the mechanism as soon as possible. It should also allocate some portion of its fast start finance for joint technology development and demonstration in developing countries.
- > ***Engaging through the Technology Action Plans:*** In order to have successful outcome, some degree of prioritization over technology options is needed. The Technology Action Plans (TAPs), initially developed under the Major Economies Forum, could provide the focus for further cooperation around a portfolio of technologies. Europe should revive and take leadership in elaborating cooperation options, including ‘orphan’ areas of research, with developing and developed countries.

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<sup>70</sup> Milford, L. and Morey, J. (2009) op.cit.; OECD (2011) Green growth strategy synthesis report.

<sup>71</sup> Kirkegaard et al (2010) and Kirkegaard et al (2009) op.cit.

## Annex I- Electric Vehicles Case Study

### *Decarbonising transport – role of EV*

Over the past decade, transport sector's GHG emissions have increased at a faster rate than any other energy using sector. In 2004, transport was responsible for 23% of world energy-related GHG emissions with about three quarters coming from road vehicles. Current transport sector mainly relies on fossil-fuels (95% oil)<sup>72</sup>. Decarbonising transport will require a mixture of supply of low carbon fuels, including renewable electricity, biofuels and hydrogen as well as increased roll out of new technologies such as electric vehicles.

Electric vehicles are likely to play a key role in low carbon transformation. IEA Blue Map scenario estimates EVs and plug-in hybrids could account for 17% of transport-related emissions reduction in 2050 compared to baseline scenario (or 5% of total energy-related CO<sub>2</sub> emissions reduction) (Figure A1)<sup>73</sup>. In addition to significant carbon emissions reductions, decarbonising transport would contribute to substantial energy cost savings, increased energy security as well as reduction in pollutant emissions. Electric vehicles could also help to manage the variable output of an increasing share of wind and solar-based power generation and act as additional storage which could feed back into the grid when needed.

In order to stay below 2°C, IEA BLUE Map scenario estimates electric vehicles will need to be fully commercial between 2020-2030. Transport accounts for the largest single area of investment in IEA scenarios. A significant amount of the additional \$45 trillion investment needed to 2050 (i.e. about 70%) will need to occur in this sector as it shifts to more expensive low carbon vehicles with lower fuel costs<sup>74</sup>.

However, there are still significant barriers to large scale deployment of electric vehicles including limitations in battery technology, embryonic charging infrastructure, and high upfront cost of the vehicles. Also EVs and PHEVs can only be as 'green' as the electricity used to charge their batteries. To have a major effect, the introduction of electric vehicles must be accompanied by an almost total decarbonisation of the electricity supply. According to CE Delft scenarios, the additional energy demand from these vehicles will remain limited in the coming decade compared to the current electricity demand in Europe: less than 0.3% of current consumption in the moderate scenario, and 2.9% and 2.6% by 2020 in the fast and ultra-fast uptake scenarios<sup>75</sup>. The Royal Academy of Engineering in the UK also suggests that the additional power requirements caused by a mass take-up of electric vehicles would be

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<sup>72</sup> Ribeiro, K. et al. (2007) Transport and its infrastructure. In Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.

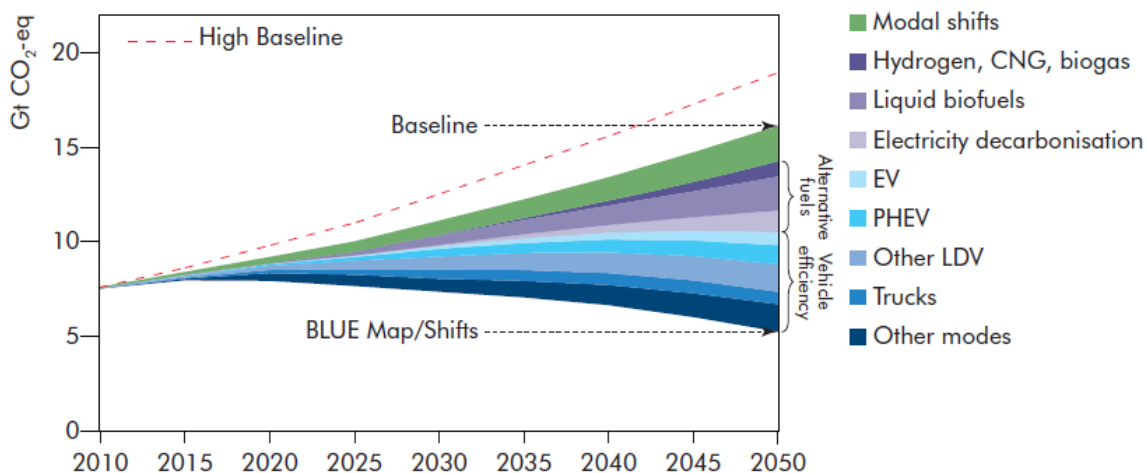
<sup>73</sup> IEA (2010) op. cit.

<sup>74</sup> IEA (2008) op. cit.

<sup>75</sup> CE Delft (2010b) Green Power for Electric Cars: Development of policy recommendations to harvest the potential of electric vehicles

manageable, but an optimized smart grid will be essential to supply sufficient low carbon power at times of peak demand<sup>76</sup>.

**Figure A1: Sources of greenhouse-gas emissions reduction, transport sector**



**State and the future of the market**

Only a few thousand electric cars are presently on the roads. They are either expensive niche models, such as the Tesla Roadster, or prototypes designed to test consumer reaction, notably BMW’s Mini-E. But the numbers are likely to rise markedly with the launch of two models aimed at the mass market, Nissan Leaf and GM Chevrolet Volt<sup>77</sup>. Chinese BYD is also preparing to launch its all-electric car to mass market.

The world’s first mass-produced plug-in hybrid was launched by Chinese company BYD in December 2009. BYD already has an all-electric car of its own, the e6, which has found its way into Chinese government fleets so far. The company signed a memorandum of understanding with Daimler AG to jointly develop electric vehicles for the Chinese market. Other major automotive giants also made deals with Chinese companies, including Ford with Chang’an Motors and Nissan with Dongfang Motors<sup>78</sup>. German automaker Volkswagen plans to introduce its hybrid Touareg to China next year and produce Golf and Laida electric cars in 2013. The Laida electric car is under development by Chinese and German engineers at the Sino-German joint venture Shanghai Volkswagen<sup>79</sup>. Japanese Toyota and American Tesla have partnered to produce a new brand of electric car. German Daimler also has a minor stake in Tesla.

<sup>76</sup> The Royal Academy of Engineering (2010) Electric Vehicles: charged with potential  
<sup>77</sup> Simon, B. (2010) US tops electric-vehicle index. Financial Times [Internet], 9 August.  
<sup>78</sup> De Boncourt (IFRI) <http://www.energypolicyblog.com/2010/10/27/electric-cars-charging-standards-does-it-matter/>  
<sup>79</sup> Zhengzheng, G. and Han, X. (2010) Dongfeng drives new energy strategy. China Daily [Internet], 16 August.

Japanese companies are currently market leaders globally in hybrid cars. Toyota is the clear global leader in hybrid vehicle sales with Honda really only starting its volume push. Japanese companies with global manufacturing bases are increasingly investing in the other key EV markets. Many German auto giants, such as BMW, Daimler and Volkswagen, are planning to unveil their electric models to the public within three years and have begun initial tests.

There are numerous estimates about the future size and shape of EV markets, with varying definitions of EV and underlying assumptions. IEA Blue Map scenario projects that by 2020, PHEV sales reach 5 million and EV sales 2 million per annum worldwide<sup>80</sup>. From 2030, EV and hydrogen fuel cell vehicles (FCVs) sales increase significantly, taking a progressively higher proportion of the overall light duty vehicles sales. By 2040, more EVs and FCVs are sold than any fossil fuel cars. By 2050, FCVs, EVs and PHEVs will have 60% of global market with equal shares. From a cumulative perspective, by 2020, the scenario assumes 20 million EVs and PHEVs on the road by 2020, and if the trajectory is maintained, 200 million by 2030 and one billion vehicles by 2050.

Deutsche Bank estimates the global market for EVs (including hybrid) will rise to 5.6 million vehicles in 2015 (7% of global light vehicle volume) and 17.3 million vehicles in 2020 (20% of global volume up from 1% today), up from approximately 1.3 million in 2010<sup>81</sup>. Pure electric vehicles and PHEV will account for more than half of the growth in 2020, while hybrids will hold the lead in the market.

HSBC estimates that the electric vehicle market will grow more than twenty-fold by 2020 to reach \$473billion, with faster growth in the second half of the decade as prices fall, more products are launched and policies become more supportive<sup>82</sup>. HSBC's Green Growth scenario assumes global sales of 8.65m electric vehicles (EV) and 9.23m plug-in hybrid electric vehicles (PHEV) in 2020.

It is not clear which technologies will eventually dominate — gas-electric hybrids, plug-in hybrids, pure electric vehicles or even fuel-cell cars. Deutsche Bank suggests that the market is likely to be dominated by HEV in earlier roll-out. According to their estimates, at least 120 hybrid (HEV), plug-in hybrid (PHEV), and electric vehicle (EV) models will be available onto the market by 2012, compared with 29 (mostly hybrid) vehicles on the market today. HSBC scenarios estimate EVs and plug-in hybrids will have almost equal share of the market in 2020 mainly due to significant cost reduction in EVs.

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<sup>80</sup> IEA (2010) op. cit.

<sup>81</sup> Deutsche Bank (2009) Electric Cars: Plugged in 2

<sup>82</sup> HSBC (2010) Sizing the climate economy

**Table A1: Summary of future market projections for clean energy vehicles**

	2015	2020	2030	2050
<b>IEA BLUE Map (per year)</b>		<ul style="list-style-type: none"> <li>• 5 m EV</li> <li>• 2 m PHEV</li> </ul>	<ul style="list-style-type: none"> <li>• 30 m EV and PHEV</li> </ul>	<ul style="list-style-type: none"> <li>• 100 m EV, PHEV, Fuel Cell (60% of market share)</li> </ul>
<b>IEA BLUE Map (cumulative)</b>		<ul style="list-style-type: none"> <li>• 20 m EVs and PHEVs</li> </ul>	<ul style="list-style-type: none"> <li>• 200 m EVs and PHEVs</li> </ul>	<ul style="list-style-type: none"> <li>• 1 billion EV, PHEV, Fuel Cell</li> </ul>
<b>HSBC</b>		<ul style="list-style-type: none"> <li>• 8.65 m EV</li> <li>• 9.23 m PHEV</li> </ul>		
<b>Deutsche Bank</b>	<ul style="list-style-type: none"> <li>• 0.7 m EV</li> <li>• 1 m PHEV</li> </ul>	<ul style="list-style-type: none"> <li>• 4 m EV</li> <li>• 5.5 m PHEV</li> </ul>		
<b>CE Delft (EU only)<sup>83</sup></b>		<ul style="list-style-type: none"> <li>• 0.5-5 m EV</li> <li>• 1.5-15 m PHEV</li> </ul>		

***Policies and measures in key markets to support development and deployment of EV***

Both the public and private sector in key markets see low carbon as a strategic market for investment; in particular are betting on enormous growth in electric vehicles and supporting infrastructure in the coming years. To support the development and roll out of electric vehicles, governments around the world are increasingly providing supportive policy and financial frameworks for consumers and the industry.

**European Union**

The European Commission’s communication of "European strategy on clean and energy efficient vehicles"<sup>84</sup> launched in April 2010 builds on the on-going measures and sets out an ambitious medium- to long-term policy through an Action Plan. The Competitiveness Council conclusions emphasized that the European Union should take leadership in supporting the roll-out and consumer acceptance of alternative power-trains and energy efficient vehicles, building on existing national action in some member states. Meanwhile, Spain, Germany, France and Portugal joint declaration suggested the electric vehicle needs to be placed in the centre of development and competitiveness agenda. They called for the creation of an integrated, fully interoperable pan-European charging system and a rapid and effective approach to standardization at EU level. An expert group is expected to draw the outlines for a common EU standard on electric vehicles by mid-2011. The EU 5 billion Euro “Green Car

<sup>83</sup> CE Delft (2010b) op. cit.

<sup>84</sup> European Commission (2010) A European strategy on clean and energy efficient vehicles. COM (2010), 186 Final. Available at : <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2010:0186:FIN:EN:PDF>

Initiative” funded by FP7 and EIB was partly dedicated to electric cars. This fund was allocated to a variety of research and demonstration projects. In particular, it led to the development of different EV charging models. However, there is still considerable fragmentation in private sector which could create market inefficiencies potentially<sup>85</sup>. The new transport white paper expected by the end of March 2011 looks at infrastructure as a way to promote more sustainable transport. The draft Communication<sup>86</sup> envisages a radically different transport system by 2020, with a single European transport area, open markets, greener infrastructure and low-carbon technologies, including zero-emission vehicles and smart grid for electric transport networks.

Many European countries already offer substantial consumer sales incentives for EVs—among the most aggressive comes from Denmark, which exempts EVs from vehicle taxes, followed by UK with £5000, France €5000 and Spain €6000<sup>87</sup> per vehicle. Part of the European fiscal stimulus has been oriented toward infrastructure for electric driving, and build-out of battery technology. For example, Germany has dedicated €500m towards investments into battery technology, infrastructure and R&D projects. France has moved even more aggressively, spending €1.5billion on infrastructure to recharge vehicle batteries with a target of achieving 4.4 million vehicle recharge points by 2020. Furthermore, the French government is providing loans to transform existing Original Equipment Manufacturer (OEM) plants into EV factories. Earlier this year, Nissan announced a £200m battery factory in Sunderland, UK. Public procurement is likely to play a key role in the uptake of EVs – for example several countries (France for example) have announced to buy 50-100k EVs over the next few years<sup>88</sup>.

## **United States**

Regulatory standards in the US have up to now fallen well short of Europe in promoting stricter fuel-efficiency and bringing down greenhouse-gas emissions. However, the US has recently provided large-scale financial support to the electric car industry. The United States Department of Energy has its own \$25 billion program to develop electric-powered cars and improve battery technology. The American Recovery and Reinvestment Act of 2009 also allocated \$2billion in grants to support the development and manufacture of advanced batteries and other EV components.<sup>89</sup> The Obama administration has made electric vehicles a centerpiece of its drive to reduce the nation's reliance on oil, and is providing substantial subsidies with a goal of getting a million electric cars on the road by 2015<sup>90</sup>. Sponsored by both Republican and Democrat representatives, Electric Drive Vehicle Deployment Act of 2010 (EVDA) aims to electrify half of US cars and trucks by 2030. The most recent version of the

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<sup>85</sup> De Boncourt, M. (2010) *Electric Cars: the Orient and the Occident*. IFRI, Paris.

<sup>86</sup> European Commission (2009) *A sustainable future for transport: Towards an integrated, technology-led and user friendly system*, COM 279 Final. Available at : <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2009:0279:FIN:EN:PDF>

<sup>87</sup> Deutsche Bank (2009) *op. cit.*

<sup>88</sup> Deutsche Bank (2009) *op. cit.*

<sup>89</sup> Bradsher, K. (2009) *China Vies to Be World's Leader in Electric Cars*. New York Times [Internet], 1 April.

<sup>90</sup> Vlastic, B. (2010) *First Buyers of Nissan Leaf Get a Trunkful of Perks*. New York Times [Internet], 7 October.

legislation would appropriate a total of \$4 billion to up the existing \$7,500 federal electric vehicle subsidy to \$10,000 and provide funding for public and private charging infrastructure within the deployment communities. The EVDA would also fund battery research and establish a \$10 million prize to the first company to produce a "cost effective" battery capable of yielding 500 miles of range on a single charge.

## China

China has overtaken the US as biggest automotive market in sales in 2009 and is still growing with the passenger car population projected to grow from currently 52 million cars to 171 million in 2020, to reach 293 million by 2030<sup>91</sup>. It is also showing intentions of becoming market leader in clean energy vehicles. The draft 12th Five Year Plan for China's auto industry is set to make new energy vehicles a top priority with China targeting annual sales of one million units by 2015<sup>92</sup>. The Chinese government has announced that they will spend ¥20 billion (\$3billion) for the promotion, manufacture and sale of new energy cars, focusing on EVs<sup>93</sup>. To help achieve these goals, the government has devised the Ten Cities, One Thousand Vehicles Demonstration project which is now expanded to 20 cities. To boost the adoption of EVs in the country, the Chinese government has recently unveiled a new subsidy programme. The pilot programme will initially involve five cities: Shanghai, Changchun, Shenzhen, Hangzhou and Hefei. Consumers of fully electric vehicles will be eligible for subsidies of up to ¥60,000 (\$8,783), and subsidies of up to ¥50,000 (\$7,320) will be available for buyers of plug-in hybrids<sup>94</sup>. The Chinese government recognises the key role establishing national standards would play in meeting its EV deployment targets. New electric vehicle standards are expected before National People's Congress in March 2011 where its 12<sup>th</sup> five year plan will be adopted.

Meanwhile, an alliance of sixteen of the largest state-owned companies wants to accelerate development of electric vehicles in China, a move which underscores the country's ambition to be a world leader in new energy vehicles. The alliance was formed by almost all the major players in the related sectors, including the country's top three oil majors, top two power grid operators, and two major automakers (i.e. China FAW Group Corp and Dongfeng Auto Corp), and is gearing up to invest 100 billion yuan (\$14.7 billion) on electric vehicles by 2012<sup>95</sup>. Looking more broadly at low carbon transport, China plans to spend \$300billion into dedicated high-speed-rail corridors by 2020<sup>96</sup>.

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<sup>91</sup> Cars 21 (2010) SAE Shanghai Battery Summit 2010: China is moving fast into the EV market. Available at : <http://www.cars21.com/content/articles/2010-09-02-sae-shanghai-battery-summit-2010--china-is-moving-fast-into-the-ev-market.php>

<sup>92</sup> TheGreenCarWebsite (2010) China makes new energy vehicles the priority. Available at : <http://www.thegreencarwebsite.co.uk/blog/index.php/2010/10/30/china-makes-new-energy-vehicles-the-priority/>

<sup>93</sup> Royal Academy of Engineering (2010) Electric Vehicles: charged with potential

<sup>94</sup> Royal Academy of Engineers (2010) op. cit.

<sup>95</sup> China Daily (2010) Alliance drives promotion of electric cars. Available at : [http://www.chinadaily.com.cn/imqq/bizchina/2010-08/19/content\\_11178635.htm](http://www.chinadaily.com.cn/imqq/bizchina/2010-08/19/content_11178635.htm)

<sup>96</sup> Glave, J. and Swaby, R. (2010) Superfast Bullet Trains Are Finally Coming to the US. Wired [Internet], January 25.

## Japan

The Japanese auto industry has made significant efforts to improve fuel economy over the last ten years, and the government has already set a 15% average fuel efficiency improvement target for 2015 compared to 2007 levels.

The Japanese government has rolled out tax policies to stimulate demand for more fuel efficient vehicles through an Eco Tax program<sup>97</sup>. Under this program, next generation vehicles such as EVs, PHEVs, HEVs, clean diesels, and natural gas vehicles are exempt from acquisition and tonnage taxes. Japan has also launched programs that subsidize the cost of electrifying a standard car up to a maximum value of the cost of the base car. The subsidy offsets 50% of the cost of electrification for a mini car, and 25% of the cost of electrification for a non-mini. Both utility and industrial companies made commitments to infrastructure projects, ranging from Nippon Oil Corporation's pilot 22 charging spots at gas stations to Better Place setting up battery replacement stations. Government projected increased penetration of next generation vehicles—pure hybrids, PHEVs, and EVs—to 40% of new vehicle sales by 2020, up from 10% in 2009.

### *Future competitiveness in EV markets*

Scaling up the EV market will be a major challenge and will require restructuring the overall industry. The Shizuoka Economic Research Institute suggests almost 30% of sales in Japan's 34.6 trillion yen (\$430 billion) auto parts industry comes from parts that could be rendered obsolete by electricity-powered vehicles<sup>98</sup>.

It is uncertain who will have the largest share of the future EV market but currently couple of major companies (mainly Japanese) have the market lead in hybrid cars. Pure electric car market is much smaller; however this might change with the roll out of Japanese Nissan Leaf, one of few mass-market pure electric cars, manufactured in the US. On the other hand, US made a strong push in electric vehicle funding which put the US on top of McKinsey electric vehicle index and ahead of France, Germany, and several other western European countries.<sup>99</sup> China and Germany share the third place on the index.

Battery technology is key for companies' competitiveness in EV markets. Various car companies are forming alliances with electronics companies for EV parts, in particular batteries. Toyota, for example, is working with Panasonic, while General Motors is working with a unit of LG Corporation of South Korea<sup>100</sup>. Compared to Pre-Recovery Act, the U.S. produced just 2% of the world's batteries for advanced vehicles<sup>101</sup>. Deutsche Bank estimates

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<sup>97</sup> Deutsche Bank (2009) op. cit.

<sup>98</sup> Tabuchi, H. (2010) Japan's Auto Parts Makers Try to Anticipate Shift to Electric Cars. New York Times [Internet], 2 November.

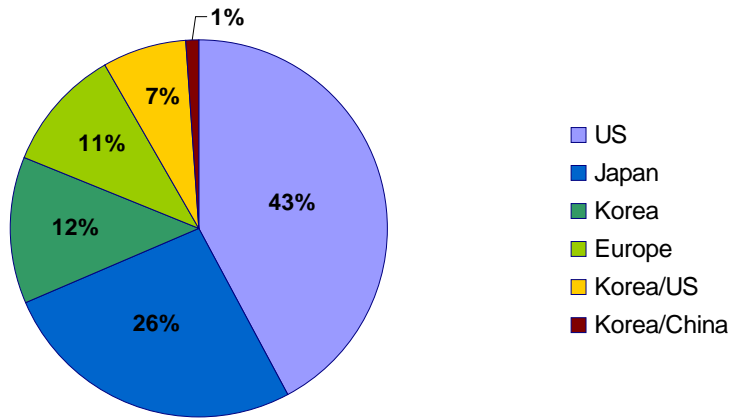
<sup>99</sup> Simon, B. (2010) US tops electric-vehicle index. Financial Times, August 9.

<sup>100</sup> Tabuchi, H. (2010) op. cit.

<sup>101</sup> Lee, J. (2010) Electric Vehicles, Advanced Batteries, and American Jobs: Another Piece of the Puzzle in Holland, Michigan. White House Blog, 15 July. Available at:

for 2015 advanced vehicle battery production capacity shows a clear lead of US and Japan in terms of key manufacturing bases (Figure A2).

**Figure A2: Lithium ion battery production capacity from key U.S., Japanese, South Korean, and European producers (2015 estimate)**



Source: Deutsche Bank (2009) op.cit.

The European automotive industry is a world leader in developing clean and energy efficient technologies. The automotive industry is central to Europe's prosperity with a turnover of over €780 billion, making a significant contribution to European GDP. It provides 12 million jobs across Europe, which account for 5.5% of overall employment in the EU-27. In 2007, the European automotive industry produced about 27% of total vehicle production (cars, buses, trucks) worldwide, and holds a 30% global market share of car production. Exports of cars from EU-27 countries amounted to €125 billion, with imports of €65 billion, giving a trade surplus of €60 billion<sup>102</sup>.

Present expectations in European countries for introducing electric vehicles by 2020 range from 40 thousand cars in Sweden to 1 million in Germany and 2 million in France. But for EVs and plug-in hybrids to make a significant difference to energy use and reduction in CO<sub>2</sub> emissions, total market penetration will have to be measured in many millions. New factories will be needed to mass-produce motors and power semi conductor assemblies<sup>103</sup>.

The European Commission's recent communication on clean energy vehicles argues that the European automotive industry can only remain competitive by leading in green technologies given the global trend towards sustainable transport<sup>104</sup>. Countries which create the supportive policy framework and infrastructure are likely to have an early mover advantage and set the industry standards and market structure for late comers (e.g. such as in the case of Europe's

<http://www.whitehouse.gov/blog/2010/07/15/electric-vehicles-advanced-batteries-and-american-jobs-another-piece-puzzle-holland->

<sup>102</sup> European Commission (2009) European Industry in a Changing World: updated sectoral overview 2009. Staff Working Document.

<sup>103</sup> Royal Academy of Engineering (2010) op. cit.

<sup>104</sup> European Commission (2010) A European strategy on clean and energy efficient vehicles. COM (2010), 186 Final.

fuel-efficiency standards). While European Commission sees the quick adoption of a European standard as a way to reinforce European competitiveness globally, others argue that European competitiveness will depend on what kind of EV they produce and at what price<sup>105</sup>. A collaborative approach on standards would be more conducive to scaling up the market and also prevent retaliation from key competitors.

Having a more ambitious decarbonisation agenda would help Europe gain a competitive advantage over rolling out electric vehicles. This would help capture knowledge and learning, and build future manufacturing and innovation hubs in the region. Up to now, Japanese and European car companies have led the market in fuel efficient cars driven mainly by government fuel efficiency standards. Given incremental efficiency improvements in conventional internal combustion engines would reach a bottleneck; therefore, electrification of transport would be needed to reduce emissions substantially and stay below 2°C. Roadmap 2050 suggests that full decarbonisation of the power sector by 2050 is a prerequisite if Europe will remain on the path to reduce emissions by at least 80% below 1990 in 2050<sup>106</sup>. The current 20% emissions reduction target is likely to be insufficient to put us on the path for achieving nearly full decarbonisation of the European power sector by 2050<sup>107</sup>. As well as jeopardising our high-level emissions reduction target, this would also either remove the carbon benefits of large-scale EV deployment, or make it very costly. Large-scale EV deployment would shift demand from oil to electricity. Without rapid decarbonisation of the power sector, further investment would be made in unabated coal and gas power generation. If a more ambitious (e.g. 30%) target is adopted at a later date, these investments would become costly stranded assets, since they would need to be replaced by new low carbon generation.

On the other hand, moving to an ambitious 30% target would incentivise investment in decarbonised electricity through, for example, the deployment of renewables and smart grids. This would avoid high carbon lock-in and allow large-scale EV deployment which would be genuinely low-carbon. It could also provide a competitive advantage to the European EV sector by attracting investment, skills and capturing learning benefits.

### ***Role of international cooperation***

The automotive industry is already globally integrated with worldwide manufacturing bases and joint ventures, mergers and acquisitions with other key players. However, the widespread introduction of EVs would require an unprecedented degree of international coordination<sup>108</sup>.

Currently, there is limited but growing international cooperation in electric vehicle technologies. US-led Clean Energy Ministerial and Major Economies Forum (MEF) have

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<sup>105</sup> De Boncourt, M. (2010) Electric Cars Charging Standards: Does it matter? EU Energy Policy Blog [Internet], 27 October.

<sup>106</sup> European Climate Foundation (2010) Roadmap 2050 – A Practical Guide to a Prosperous, Low Carbon Europe, The Hague.

<sup>107</sup> See Committee on Climate Change report for their suggestions of radical decarbonisation of power sector by 2030 on the path to meeting the 2050 economy-wide emissions target; CCC (2010) The Fourth Carbon Budget - Reducing emissions through the 2020s.

<sup>108</sup> Royal Academy of Engineering (2010) op. cit.

identified EVs as a key technology where cooperation is crucial for scaling up its development and deployment. At the last Clean Energy Ministerial in Washington in July 2010, ministers from eight countries, along with the IEA, created an Electric Vehicles Initiative aimed at greater cooperation on electric and advanced vehicles<sup>109</sup>.

Last year, China and the US also launched a joint electric vehicles initiative and recently held an advanced vehicle summit<sup>110</sup>. EU should engage more extensively with major economies, such as US, China and Japan, to create global markets for electric vehicles building on existing activities under the US-China initiative:

- > **Joint standards development:** Development of joint product and testing standards for electric vehicles; common design standards for plugs to be used in electric vehicles; common test protocols for batteries and other devices;
- > **Joint demonstrations:** Lessons sharing and joint electric vehicle demonstration programs; collecting and sharing data on charging patterns, driving experiences, grid integration, consumer preferences and other topics;
- > **Joint technical roadmap and R&D:** A U.S.-China task force will create a multi-year roadmap to identify R&D needs as well as issues related to the manufacture, introduction and use of electric vehicles. Engagement of other key countries would be important. Joint R&D could target areas where there is limited private sector investment;
- > **Public awareness and engagement** to increase consumer acceptability of the technology;
- > **Knowledge sharing arrangements** to maximise public benefit and speed up deployment globally where public money was involved.

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<sup>109</sup> The initiative partners are China, France, Germany, Japan, Spain, South Africa, Sweden, United States. [http://www.iea.org/press/pressdetail.asp?PRESS\\_REL\\_ID=398](http://www.iea.org/press/pressdetail.asp?PRESS_REL_ID=398)

<sup>110</sup> The White House (2009) Fact Sheet: U.S.-China Electric Vehicles Initiative. Press Release, 17 November, [http://www.energy.gov/news2009/documents2009/US-China\\_Fact\\_Sheet\\_Electric\\_Vehicles.pdf](http://www.energy.gov/news2009/documents2009/US-China_Fact_Sheet_Electric_Vehicles.pdf)