

How crisis-resistant and competitive are Europe's Eco-Industries?

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Main findings of the study

Since 2007, Eco-Industries have been growing globally at a relatively stable pace of around 3-4% a year. Compared to the rest of the economy, and especially compared to other industrial output, the rate of growth of Eco-Industries was much higher during the financial and economic crisis of 2008 and 2009, but slightly lower since then. Eco-Industries thus served as an economic stabilizer during the recession. Eco-Industries in Europe have been able to consolidate and defend their competitive position in recent years. The global market share (22%) of European Eco-Industries was stable over this period, despite the fact that overall economic growth in Europe was much weaker than the world average during this period. European Eco-Industries have thus remained globally competitive and are keeping up with the global expansion of the sector, and act as a stabilising factor in the turbulent economic climate in Europe.

But Eco-Industries have not only had a stabilising effect – they have also been a driver of growth, particularly in Europe. In four of the five European countries considered in this study, Eco-Industries have grown faster than GDP between 2008 and 2012. In Italy and Portugal, where nominal GDP has stagnated during this period, Eco-Industries have grown by 9.4 and 5%, respectively, from 2008 to 2012. But also in Germany, whose economy remained relatively robust during the crisis, Eco-Industries were a driver of growth, with an increase of 13% between 2008 and 2013.

There are inherent reasons why Eco-Industries have outperformed the rest of the economy, particularly during the economic crisis. For instance, Eco-Industries are a highly innovative segment of the economy. Particularly since 2005, innovation activity in most Eco-Industries has increased markedly. This is documented by an increasing number of patents: particularly for renewable energy and energy efficiency technologies, patenting activity has grown much quicker than the economy-wide average across all technologies.

Another main reason why Eco-Industries could play this counter-cyclical role is the dependence of many Eco-Industries on government spending, policies, and investments. Many governments increased public spending during the crisis and some of that spending was used on energy and other infrastructure, specifically benefiting or intentionally stimulating the Eco-Industries. On the other hand, after the stimulus spending of 2009 many governments have had to cut their spending, which in many countries has led predictably to slower growth of Eco-Industries.

This is not to say that Eco-Industries have gone through the crisis unscathed: Eco-Industries are not detached from the rest of the economy. Thus, the overall weak investment in the crisis years and its aftermath has also affected investment in Eco-Industries, albeit to a lesser degree than the rest of the economy.

For the purposes of this study, we analysed eight countries (five from Europe and three outside Europe) in more detail, looking at the characteristics of their Eco-Industries, the countries' respective policies and investment strategies, as well as the areas where their economies or private sectors are global leaders in Eco-Industry subsectors. Our analysis found that the countries differed both in the growth rate of Eco-Industries and in the current size of Eco-Industries. Compared to GDP, the size of the Eco Industry sector ranged

between 3.5% and 5% and growth rates varied between 5% and 25% between 2007 and 2011.

In looking at the role that national policies play in driving investment and growth of Eco-Industries, we found that green government policies tended to be responsible for strong growth of Eco-Industries, but with exceptions. Thus, the overall economic situation is another key factor for the development of Eco-Industries, with countries with poor economic performance also lagging behind in the development of Eco-industries. By contrast, a country such as Poland has seen strong growth in Eco-industries in a rapidly growing economy – and yet, Poland is the only European country considered in this study where Eco-Industries have grown less than GDP. The fact that this growth was not underpinned by an equally strong government strategy for Eco-Industries in Poland as in other countries may have contributed to this result. Another case in point is the US example, where modest growth in Eco-Industries coincides with limited environmental policy ambition, at least at the national level.

One reason for a strong link between overall economic development and development of Eco-Industries is the predominantly local structure of many Eco-Industries. Even though equipment can be exported and imported, much of the value added of Eco-Industries is locally bound as installation and maintenance of appliances have to be provided regionally. This means that the economic effects of Eco-Industries can be substantial, even if there is no large domestic industry for the manufacture of equipment. But it also means that the local business climate, and propensity to invest, is an important factor for the growth in Eco-Industries.

To examine the growth of Eco-Industries, we focused on different sub sectors in the countries observed. While renewable energy was an important industry in nearly all countries, sometimes its importance was even eclipsed by the classical environmental goods and services sector. One example of this was Poland, where the EU structural funds were used to update the infrastructure in waste treatment, water treatment and air pollution leading to growth in Eco-Industries; the case is the same in Mexico. These industries may be less dynamic – and, possibly, less glamorous than the renewable energy industries, yet they still provide an important part of the value added of Eco-Industries.

Using OECD data on patent applications for environment-related technologies, we also analysed the innovation performance of Eco-Industries. According to the data, Eco-Industries outperformed the rest of the economy in terms of patent applications, especially since 2005, when patent applications for environmental technologies increased markedly. Most of this increase stems from energy-related technologies (renewable energy technologies and energy efficiency); the performance of the classical environmental management technologies (such as water and air pollution abatement or waste management) is less dynamic. This increase in innovation activity is fairly consistent across countries – yet the overall distribution of patenting activity between countries is very unequal, with some (particularly larger) countries featuring a large number of patent applications, and some (particularly smaller) countries hardly registering at all. In terms of the distribution of patenting activity beyond the EU, the big picture is that of a neck-to-neck race between the EU and the US, with advantages in some technologies for Europe, and in others for the US. China ranks much lower in terms of the absolute amount of patent applications, yet features very high growth rates in patent applications for many technologies, and could catch up with Europe and the US in a decade or two if these trends persist. In terms of annual renewable energy investment and systems manufacturing, China leads both the US and the EU.

One key lesson from recent experience with Eco-Industries is that policymakers should not rely on a strict one-to-one relationship between investment volumes in Eco-Industries and green economy infrastructure and the permanent establishment of (global) market leaders in those Eco-Industries. While this has been achieved in some Eco-Industries, especially mass-produced, transportable products, this is not the case of every element of the value chain. Also, the example of solar photovoltaic (PV) manufacturing shows that industrial leadership always needs to be defended against competitors and may erode very quickly. Yet the important observation is that international competition will only affect part of the value chain, particularly the manufacturing equipment. While it may be desirable for different reasons to have international champions in the Eco-Industries operating out of Europe, it is also true that most of the value added and employment is generated by other activities, such as the planning, installation or maintenance of equipment. Thus, local and regional employment effects from investment in Eco-Industries remain robust regardless of where equipment is manufactured; by tailoring government support in a way that encourages innovation and investment the EU can create sustainably competitive jobs in the Eco-Industries; it just will not be able to capture all manufacturing value-added and employment.

Many of the most successful government interventions have been investment support schemes, which provided investors with a high degree of investment certainty. Especially in difficult economic times, governments can induce significant private investment in the Eco-Industries by providing the certainty that investors cannot get elsewhere.

I Introduction

According to OECD and Eurostat, Eco-Industries are “activities which produce goods and services to measure, prevent, limit, minimise or correct environmental damage to water, air and soil, as well as problems related to waste, noise and eco-systems. This includes technologies, products and services that reduce environmental risk and minimize pollution and resources”.¹ Eco-Industries are more than renewable electricity hardware, energy efficiency improvements, electric vehicles, and advanced biofuels. In fact, many of the categories contained under Eco-Industries are established and robust industries (like wastewater management) that require significant capital investments and employ large numbers of people.

The European Union and its Member States have identified Eco-Industries as an important pillar of growth and international competitiveness in the near- and medium-term. In this, the EU is not alone, as policymakers in China, the USA, and other global competitors have also recognized the importance and (export) growth potential of Eco-Industries.

This study can build on previous research assessing the size and robustness of European Eco-Industries. A 2009 study on Eco-Industries is highlighted by the European Commission on its website:

"in 2008, the EU eco-industry provided 4 million jobs. With a turnover of €300 billion and a growth rate of 8% a year, eco-industries are a key contributor to the Europe 2020 strategy for smart, sustainable and inclusive growth. Europe is leading the way globally in exploiting technological and economic opportunities in eco-industry. It is ahead in recycling with a 50% market share, water supply with 30% and renewable energy with 40%. However, in certain areas, global competitors are in a better position. While the EU focuses on pollution abatement, waste management and integrated chain management, Japan and the USA concentrate on hardware development and eco-design, enabling them to take the lead in hybrid cars, cradle-to-cradle approach and eco-design."

This study provides an overview on how the Eco-Industries have developed in five European countries over the last six years and whether their competitive position has been strengthened or weakened. The study provides an internal assessment of the situation in Europe, allowing for inter-country comparisons. Further, it assesses the performance of three non-EU countries: China, Mexico, and the USA. These countries were selected for their different economic compositions (which allow for comparisons either to the EU as a whole or individual Member States), but also due to the size of their Eco-Industry sectors, which generally tracked values in the EU. For these eight countries, the main driving factors of Eco industry growth were assessed and summarised. The sectors where a country's Eco-Industries have established market leadership positions are highlighted, as are areas of weakness or those in need of improvement. The report also develops recommendations for supporting further growth in Eco-Industries in the assessment countries.

¹ Bilsen and Rademaekers, *Study on the Competitiveness of the EU Eco-industry*.

The contents of the report are divided as follows:

- Chapter 2 describes the data source of the report;
- Chapter 3 summarizes the development of Eco-Industries in Europe and the world;
- Chapter 4 provides an overview on innovation in Eco-Industries; and
- Chapter 5 summarises and highlights the development of Eco-Industries in the eight sample countries.

2 Data source

Assessing Eco-Industries across countries in the EU and internationally presents predictable data gathering and comparability challenges. One major challenge is the identification of a dataset capable of providing comparable statistics for a number of relevant countries. As the definitions of environmental goods and services differ widely between countries and no international data provider (e.g. OECD or Eurostat) could provide a consistently defined dataset over the relevant period of 2007 to 2012, we had to turn elsewhere.

The UK Department for Business, Innovation and Skills (BIS) has collected information on low carbon and environmental goods and services (LCEGS) since 2006/07 and provides a yearly update of this assessment. The BIS definition of LCEGS offers a more comprehensive look at the data than the Eurostat definition,² as BIS includes the value chain of environmental goods and services. Thus, for instance, the Eurostat definition would include the manufacture of wind turbine components as an Eco-Industry, if these components are built by a specialised manufacturer who reports this activity as environment-related. Yet, the manufacture of a gearbox for a wind turbine by an external supplier might not be included, but rather classified as general manufacturing.

As many countries are specifically interested in capturing elements of the value chain, there is also a strong argument to be made that this dataset gives a more robust view of developments in Eco-Industries. The 2009 EU-commissioned report on the Competitiveness of the EU Eco-Industry credits the BIS LCEGS report for its exhaustive and comprehensive LCEGS methodology.³ The BIS dataset is also fairly large in terms of country coverage, giving an overview on the development of Eco-Industries in the last 5 years in up to 50 countries worldwide.

The BIS defines the LCEGS sector as a “flexible, umbrella” term for capturing activities across a range of traditional sectors.⁴

The sectors and major subsectors in the BIS assessment are clarified as follows:

Environmental (Air Pollution, Contaminated Land, Environmental Consultancy, Environmental Monitoring, Marine Pollution Control, Noise & Vibration Control, Recovery and Recycling, Waste Management, Water Supply and Wastewater Treatment)

Renewable Energy (Biomass, Geothermal, Hydro, Photovoltaic, Wave & Tidal, Wind, Renewable Consulting)

² The methodology is set out in: *Low carbon and environmental goods and services: an industry analysis*, 2009, <http://www.bis.gov.uk/assets/biscore/business-sectors/docs/l/09-570-low-carbon-environmental-industry-analysis.pdf>

³ *Study on the Competitiveness of the EU eco-industry*. DG Enterprise and Industry, 2009, page 122-123, http://ec.europa.eu/enterprise/newsroom/cf/_getdocument.cfm?doc_id=5416.

⁴ U.K. Department for Business Innovation & Skills, *Low Carbon Environmental Goods and Services (LCEGS) Report for 2011/2012*.

Low Carbon (Additional Energy Sources, Alternative Fuel/ Vehicle, Alternative Fuels, Building Technologies, Energy Management, Carbon Capture & Storage, Carbon Finance, Nuclear Power)⁵

The LCEGS analysis includes:

- “Companies that solely provide LCEGS products and services”
- “Companies who are 100% providers of components or inputs into sub assemblies or final LCEGS products and services delivered by others”
- “Companies who provide components or inputs into sub assemblies or final assemblies of LCEGS products and services.”⁶
- How resilient have eco-industries been to the impacts of the economic crisis, esp. in comparison to other economic sectors?
- In which eco-industries where is the EU leading, where are competitors leading, have there been changes over the last five years?

We have chosen a subset of 8 countries (5 EU member states and 3 others) for the purpose of our analysis. The main criteria for the choice of the countries were:

- Data availability
- Importance of country as an industry location
- Significantly slower or stronger growth of Eco-Industries
- Significant (relative) size of eco-industries

Using those criteria, the following countries were selected: Germany, UK, Portugal, Poland and Italy, as the EU Member States and China, Mexico, and the USA as non-EU countries. These 8 countries should provide a broad overview of the development of the Eco-industries and allow interesting points of comparison. For example, the relative position of the USA and China is valuable as a point of comparison to the EU as a whole – notwithstanding the ability to compare their respective performance to the individual Member States – while Mexico is a good point of comparison to EU Member States still building out elements of their Eco-Industries.

⁵ A note on nuclear power: the LCEGS definition includes nuclear powers among a range of low-carbon technologies. This marks a difference to other definitions of Eco-Industries, as applied e.g. by Eurostat or the OECD. Given that a number of European countries have decided that nuclear power cannot be part of a sustainable energy mix, we would have preferred to present the analysis excluding nuclear. Unfortunately, it has not been possible to obtain the revised data without nuclear power, or to gain access to the underlying raw data and perform the corrections ourselves. It should be kept in mind, though, that including nuclear only has a small effect on the numbers presented in the following. Nuclear accounts for less than 3% of all LCEGS: geothermal or wind contribute 3 to 4 times as much, respectively. Also, it is the least dynamic of the LCEGS sectors: of the 24 subsectors included in the LCEGS, nuclear (together with alternative fuel vehicles) reported the lowest rate of increase during 2007-2011, at 4%. Thus, the fact that nuclear is included in the dataset is unlikely to affect the results much. Without nuclear, the growth performance of the sector would even have been marginally better.

⁶ U.K. Department for Business Innovation & Skills, *Low Carbon Environmental Goods and Services (LCEGS) Report for 2011/2012*.

3 Development of Eco-Industries 2007-2011

3.1 Turnover and growth of Eco-Industries

Since 2007, the global Low Carbon and Environmental Goods and Services sector has grown by 2% overall from about €3.6 billion to €4.1 billion. Unlike overall economic growth, which fell dramatically in 2008/2009 and then recovered, the growth rate in LCEGS was more stable, averaging between 3-4% in the years covered by this study.

Countries experienced very different growth rates in LCEGS between 2007 and 2011. While Eco-Industries in Poland and Mexico grew by 5% or more per year, other countries like the US or Portugal experienced only modest growth in LCEGS of less than 2% per year.

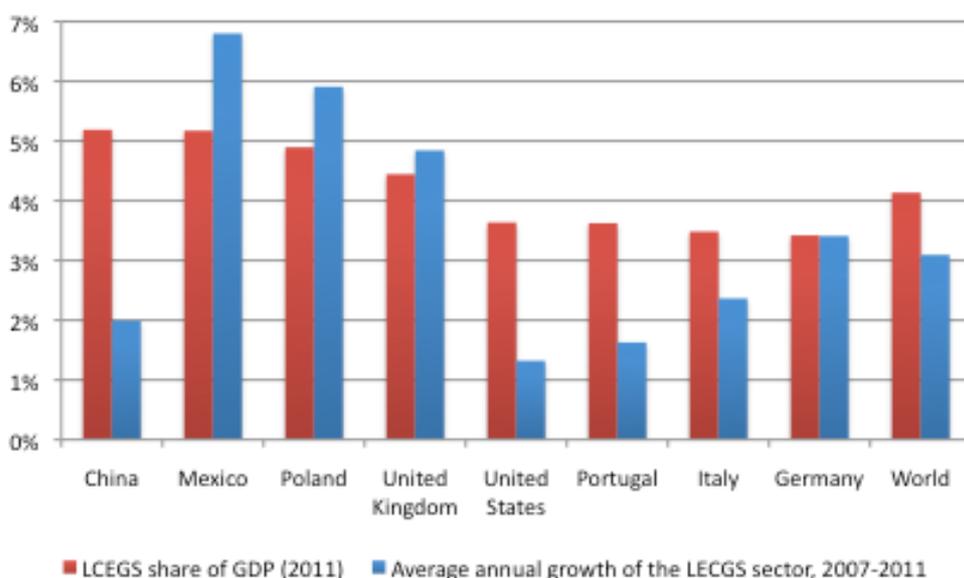


Figure 1: Size of the LCEGS sector (in % of GDP) and annual growth, 2007-2011

The absolute size of the LCEGS in comparison to overall GDP differed less in the sample countries. The biggest LCEGS sectors provided just over 5% of GDP, while the smallest were around 3.5% of GDP. It is worth noting here that the comparison with GDP figures is only indicative as the turnover figures provided for Eco-industries use a different methodology than the “value-added” methodology of GDP. Interestingly, there is no correlation between GDP shares of LCEGS and annual growth rates, i.e. there is no conclusion as to whether the laggards are catching up, or the pioneers expanding their lead.

Overall growth in LCEGS was stable but slightly lower than GDP growth in the study period. One important reason for this was the cycle of government spending in that period. Many sub sectors of LCEGS depend on public spending (e.g. the water industries) or government subsidies or other support frameworks (e.g. renewable energy). In 2008-2009 nearly all governments increased spending significantly, preventing any downturn for the sector, but, on the other hand, the austerity measures enacted since 2010 by many governments have clearly affected the sector’s growth. Additionally, the lack of investment in developed economies during the period as a whole has limited growth in the LCEGS sector, due to its strong orientation in capital investment goods.

Lastly, it is important to reiterate that the LCEGS sector is a diverse amalgam comprising subsectors with relatively low growth (e.g. air pollution or alternative vehicle fuels) and sectors growing much stronger than the average (wind or solar PV). The following table provides more detail on the global growth of LCEGS sectors.

Sector	Annual average growth 2007-11	Overall share of LCEGS (2011)
Air Pollution	1.9%	0.9%
Contaminated Land Reclamation & Remediation	2.9%	0.9%
Environmental Consultancy and Related Services	3.1%	0.8%
Environmental Monitoring, Instrumentation and Analysis	3.2%	0.1%
Marine Pollution Control	3.2%	0.1%
Noise & Vibration control	3.3%	0.2%
Recovery and Recycling	3.0%	6.1%
Waste Management	2.6%	4.5%
Water Supply and Waste water Treatment	2.4%	7.5%
Additional Energy sources	11.4%	1.5%
Alternative Fuel Vehicles	1.1%	10.3%
Alternative Fuels	4.6%	16.2%
Nuclear Power	1.1%	2.8%
Building Technologies	2.8%	12.6%
Carbon Capture & Storage	3.2%	0.4%
Carbon Finance	8.1%	1.2%
Energy Management	3.6%	2.4%
Biomass	3.4%	4.6%
Geothermal	2.9%	9.0%
Hydro	3.2%	0.4%
Photovoltaic	3.6%	4.7%
Renewable consulting	6.3%	0.6%
Wave & Tidal	3.2%	0.1%
Wind	4.3%	12.0%

Table 1: Growth rates and shares of different LCEGS sub-sectors

This means that overall growth in the LCEGS market was very concentrated in specific subsectors. Globally, wind energy production provided more than 20% of total growth in this period. All new renewable energy production sectors combined (Wind, Geothermal, Photovoltaic and Biomass) were responsible for about 40% of the growth of the total LCEGS sector. Other important growth drivers were additional energy sources and waste and water management.

3.2 Competitiveness and Resilience of Eco-Industries

As mentioned above, the growth rates of the LCEGS sector were more stable than overall economic growth in the study period (see Table 2).⁷ While nearly all countries suffered a drop in overall economic activity in 2008-2009, the LCEGS sector grew in that period in all but two countries of our sample (US and Portugal, which saw a small contraction of LCEGS in 2009). Remarkably, for every year in Italy and Portugal, annual growth in LCEGS has been higher than the respective GDP growth. Across the entire study period, LCEGS growth was higher than GDP growth in all European countries except Poland, i.e. the LCEGS sector has outperformed the wider economy. In the cases of Italy and Portugal, nominal GDP has stagnated between 2008 and 2011, yet the LCEGS sector has grown by 9.4 and 5%, respectively. Poland stands out in that it has achieved the highest relative growth of the LCEGS sector – at 23.6% between 2008 and 2011 – and yet, because nominal GDP has grown even more in this period, it is the one European country where LCEGS has grown in line with GDP, rather than acting as a driver of growth in turbulent times.

For the non-European countries in our sample the development was quite different. China saw a much slower growth in the LCEGS sector than in the overall economy – in fact since the LCEGS growth rates are nominal growth rates, the Chinese LCEGS sector may not have grown at all in real terms. In the US, the LCEGS sector only outperformed the economy in the crisis year 2009, but not for the study period as a whole. In the case of Mexico, LCEGS growth was generally in line with GDP growth: somewhat stronger in the crisis year 2009, and weaker in the other years, For the global LCEGS sector, growth was somewhat slower in 2009 than in other years, but remained positive.

	2008		2009		2010		2011		2008 - 2011	
	LCEGS	GDP	LCEGS	GDP	LCEGS	GDP	LCEGS	GDP	LCEGS	GDP
China	1.8%	18.1%	1.8%	8.6%	2.0%	17.8%	2.1%	17.8%	7.9%	78.0%
Germany	3.0%	1.9%	3.0%	-4.0%	3.5%	5.1%	3.5%	4.6%	13.6%	7.5%
Italy	2.1%	1.3%	2.1%	-3.5%	2.4%	2.1%	2.5%	-0.8%	9.4%	-1.0%
Mexico	5.8%	7.5%	5.9%	-1.3%	6.5%	9.4%	6.6%	9.0%	27.2%	26.5%
Poland	5.1%	8.4%	5.1%	5.4%	5.7%	7.9%	5.9%	4.4%	23.6%	28.7%
Portugal	n/a	1.6%	-1.3%	-2.0%	3.1%	2.6%	3.1%	-1.0%	4.9%	1.1%
UK	4.3%	2.4%	4.3%	-3.1%	4.7%	4.8%	4.8%	3.5%	19.4%	7.6%
US	0.8%	1.7%	-0.5%	-2.1%	2.5%	3.7%	2.5%	3.8%	5.4%	7.2%
World	3.1%		1.8%		3.2%		3.8%		12.4%	

Table 2: Growth rates in LCEGS and GDP for eight countries, 2007-2011. Source: Eurostat and IMF

⁷ Please note that Table 2 presents nominal growth rates for both LCEGS and GDP, i.e. not accounting for price changes, hence the very high growth rates for Chinese GDP. Producing inflation-adjusted growth rates for a particular sector (such as LCEGS) can be misleading, as the commonly used GDP deflators only consider the average rise in prices for a representative range of goods and services. Applying such a general deflator to a particular sector may not capture adequately the reality of this sector; therefore the table presents nominal growth rates.

Generally, the market share of European Eco-Industries in the global market did not change during or after the crisis. The EU-28 Eco-Industries grew at the same speed as the global Eco-Industries and the market share of EU-28 producers stayed at 22% from 2008 to 2011. The same is true for the different sub-sectors of the Eco-industries. In all sub-sectors the market share of European producers remained fairly constant over the study period.

As the European economy was growing much slower in the respective period than the world economy, this is a substantial achievement. It underscores the competitiveness of European Eco-Industries and could provide justification for a strong, continued commitment to a green economic transition.

4 Innovation in the Eco-Industries

While innovation may not be as important of an input for more established Eco-Industries like wastewater management, innovation is a production growth factor in the Eco-Industries like any other component of the economy. There are several ways of measuring innovation. Unfortunately each method has drawbacks, in particular when comparing innovations across sectors within an economy or the same sectors in different countries. One of these ways is a post-facto assessment of market capture and market leadership over time. In the country assessments below, we provide snapshots of the present position of the respective countries in some of the key Eco-Industries.

This chapter looks at two other proxy measures used to indicate innovation potential: R&D spending (both public and private) as one major input to the innovation activity, and the number of patents filed in a country as one major output of innovation activity. These measures are not foolproof measures of innovation, and have their limitations especially when drawing comparisons across countries, but they have proven robustly indicative of innovation potential.

4.1 Patenting activity in environmental industries

The number of patents issued to applicants from a particular industry, or from a particular country, is often used to approximate the innovativeness of industries. Patents represent one key output of the innovation activity, and patenting activity is well document. Yet, while there is certainly a correlation between innovation and patenting, it should be acknowledged that patent data has some limitations as an indicator of innovativeness. First, not all inventions are patented; second, the raw patenting data does not allow to distinguish the value of a patent (all patented inventions have to be novel, but some patented inventions are more innovative than others); and third, the propensity to patent and the patent regime differ between countries.⁸ Finally, much of the private R&D takes place in multinational enterprises, the patent may be counted towards the country where the company is based, which may not necessarily be the same country where the research has taken place that has led to the invention. These limitations mean comparisons of patenting data across countries, across technologies or across economic sectors need to be viewed with some caution. Nonetheless, some insights can be inferred from them.

4.1.1 Patenting activity in environmental industries across countries

Drawing on international patenting data, the OECD has developed the indicator of environmental technologies (ENV-Tech Indicator), which provides good evidence on the patents issued for a defined set of environment-related technologies across the OECD countries and a number of non-OECD countries.⁹ The environment-related technologies are

⁸ OECD, *Energy and Climate Policy: Bending the Technological Trajectory*, 58.

⁹ See <http://www.oecd.org/env/consumption-innovation/indicator.htm>

grouped into seven categories, from general environmental management (water, air or waste management) to renewable energies to energy efficiency technologies in transport and buildings.

Figure 2 presents the patenting activity in all environment-related technologies (as identified by the OECD) for the period 1990 – 2009, for the eight countries analysed in greater depth in this paper. Some notable facts can be observed: first, with the exception of one year (2003), patenting activity has increased continuously, but particularly in the late 1990s and since 2005. The financial and economic crisis, starting in 2008, may have reduced the growth rate of patent applications, but did not lead to an absolute decline in the number of patent applications. Second, of the eight countries considered here, patenting activity is essentially limited to the five biggest countries – the US, Germany, China, the UK and Italy. The remaining three (Poland, Portugal and Mexico) account for less than one percent of the patent applications from the eight-country set. Given the acknowledged limitations for comparing patenting data across countries, however, this fact should be interpreted with caution. Third, and again acknowledging the limitations in cross-country comparisons, it is noticeable that while US-based applicants have filed most applications throughout, the absolute number is only about 50% higher than for Germany; in the late-1990s, Germany almost reached parity in terms of the number of patent applications. Third, China has been gaining ground: starting from zero patents in 1990, China overtook the UK in 2008 as the third largest country in the eight-country set.

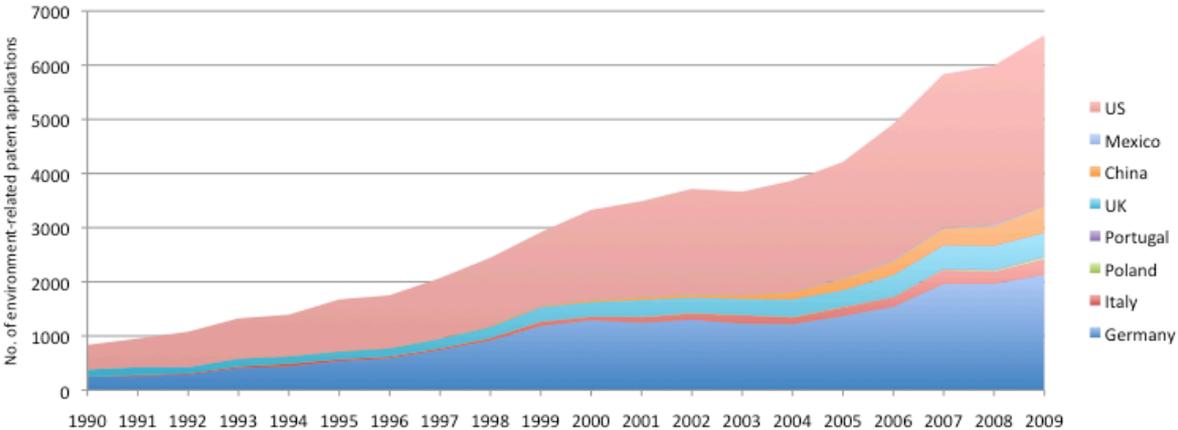


Figure 2: Number of patent applications for environment-related technologies in eight selected countries, 1990-2009. Source: OECD ENV-Tech Indicator Set

A comparison of country-specific growth rates in patenting activity is of limited value, due to the small absolute number of patent applications in most of the countries concerned. Thus, the number of patent applications in China has increased 11-fold between 2000 and 2009, yet starting from a low base of only 43 patent applications during 2000. Likewise, applications have increased sixfold in Poland and still more than threefold in Portugal. For the three countries in the set that already had a mature patenting activity already in 2000 – Germany, the UK and the US, with some 3,200 patent applications among them – the rate of increase from 2000 to 2009 has been more modest, ranging from 65% in Germany and the UK to 90% in the US.

4.1.2 Patenting activity for selected environment-related technologies

Figure 3 presents an overview of the patent applications in the EU-28 for nine selected environment-related technologies. The bottom three technologies are examples of typical environmental management technologies: water pollution abatement, air pollution abatement and waste management. The middle three represent the most important renewable energy technologies in Europe (wind energy, solar PV and biofuels). The top three are selected examples of technologies related to energy use and energy efficiency: energy storage technologies, technologies specific to propulsion using electric motors (e.g. electric vehicle, hybrid vehicle), and insulation technologies (e.g. thermal insulation or double glazing). Taken together, these nine technologies accounted for about 60% of all patent applications for environment-related technologies filed in the EU-28 in 2009.

One key insight is, again, that the growth in patenting activity has accelerated markedly since 2005, and that the 2008 financial and economic crisis has only temporarily dented this growth trend, but did not reverse it. In fact, only for one of the nine technologies (electric vehicle technologies) the number of patent applications declined from 2007 to 2008. A second remarkable point is that the growth in patenting activity comes predominantly from the energy-related technologies (both renewable energy technologies and energy efficiency). By contrast, the development in the classical environmental management technologies – which accounted for the bulk of environment-related technology patents still in 2000 – was more sluggish.

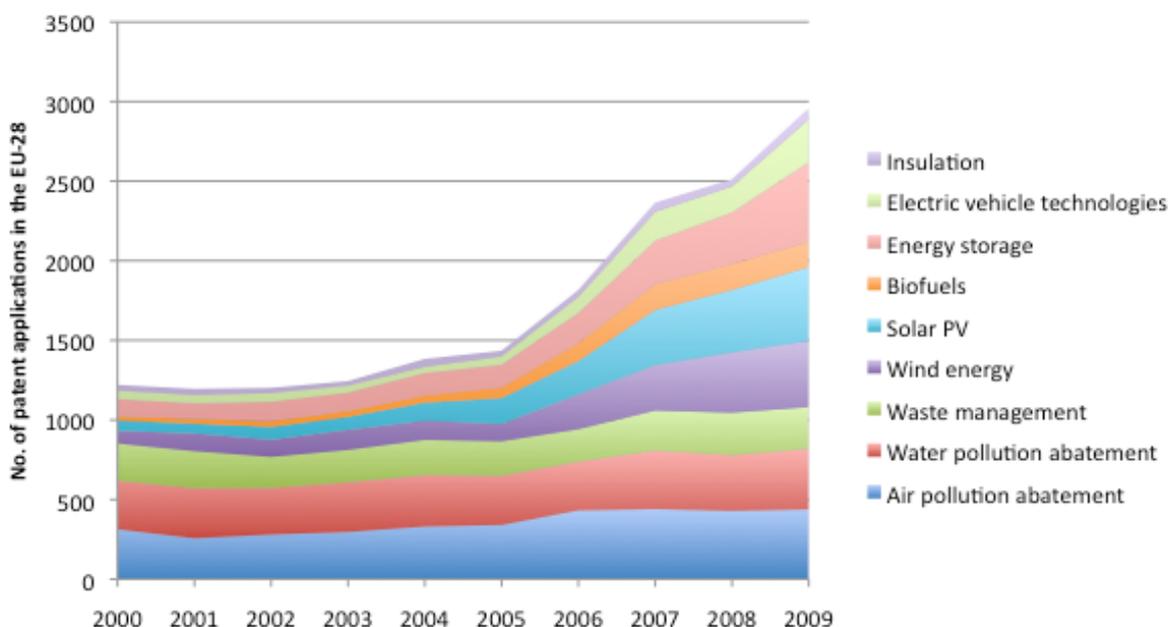


Figure 3: Patent applications for selected environment-related technologies in the EU-28, 2000 – 2009. Source: OECD ENV-Tech Indicator Set

The impression of an uneven growth in patenting activities for the different sectors is also evident from Figure 4, which presents the growth in patenting relative to the year 2000. Apart from documenting the stellar growth in patenting for renewable energy technologies (with patent applications for solar PV, biofuels and wind energy increasing by a factor of seven, six and five respectively), it also documents that the patenting activity for all environment-related technologies has been stronger than the average for all patent applications. Since 2006, the

number of patent applications has remained almost constant (at about 30% above the 2000 level), whereas the number of patent applications for environment-related technologies has continued to increase, and was twice as high in 2009 compared to 2000. This also implies that the share of environment-related technologies as a share of all patents has grown – from 6.6% in 2000 to 10.5% in 2009. One other notable observation is that the growth in patenting activity for classical environmental management technologies (air, water, waste) has been slower than for the energy-related technologies in the set – here, the growth in patenting activity was largely in line with the overall growth in patents, or at times somewhat weaker.

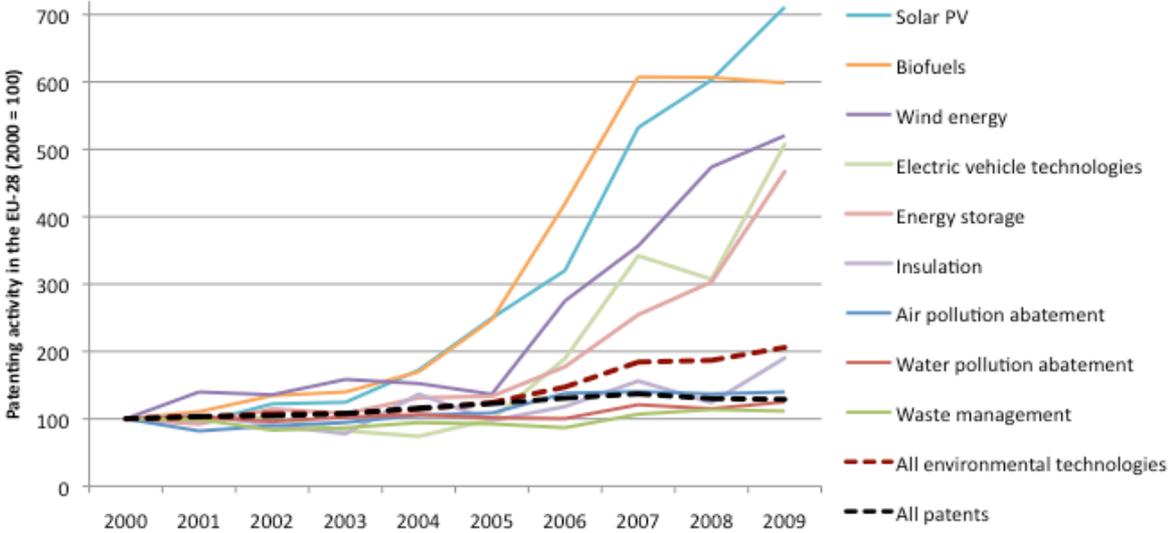


Figure 4: Patenting activity for selected technologies in the EU-28, 2000 - 2009 (2000 = 100). Source: OECD ENV-Tech Indicator Set

4.1.3 Patenting activity in Europe compared to the US and China

Finally, this section assesses how the patenting activity for environment-related technologies in the EU-28 compares to the US and China as two major competitors on the world market for such technologies. Again recalling the limitations of the patenting data for cross-country comparison, the analysis compares the patenting record for the nine selected technologies.

For the classical environmental management technologies (water pollution abatement, air pollution abatement and waste management), the technological leadership currently clearly rests with the EU. Not only did the EU account for at least half (or, in the case of waste management, two thirds) of the joint patent applications of the three. Patent applications also increased between 2006/2007 and 2008/2009, albeit at a much slower rate than for the energy-related technologies. By comparison, China achieved a higher growth of patent applications in water and air pollution abatement, yet starting from a low level. In the US, the number of patent applications declined for all three environmental management technologies between 2006/2007 and 2008/2009. The analysis also confirm the earlier observation that, while there has been some growth in the number of patent applications for environmental management technologies since 2000, this growth is much smaller than for the energy-related technologies. In absolute numbers, though, the number of patent applications for the different technologies is of a comparable magnitude.

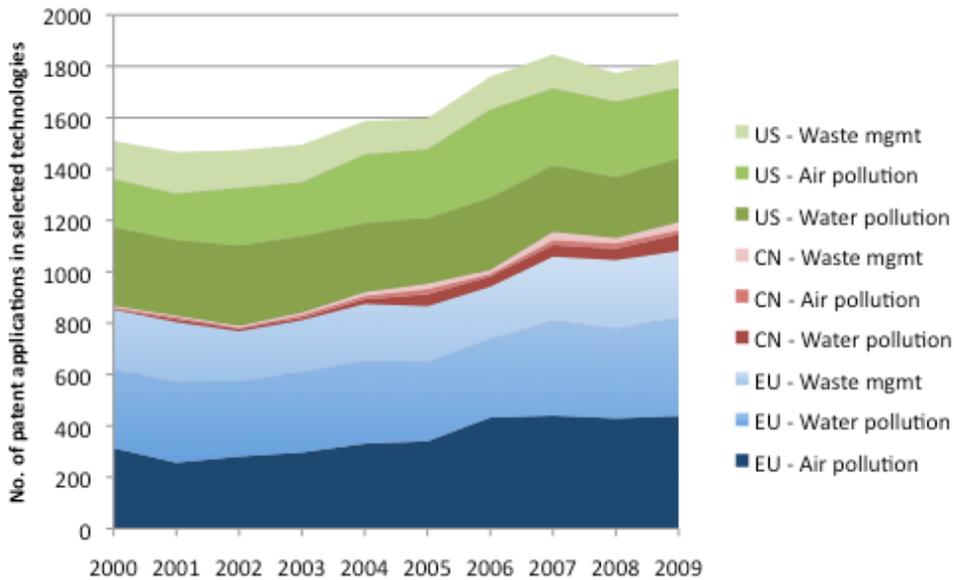


Figure 5: Number of patent applications for selected environmental management technologies in the EU, China and the US, 2000 - 2009. Source: OECD ENV-Tech

Renewable energy technologies witnessed very rapid growth of patenting activity, especially since 2005. Among the three countries / regions considered, the US has the technological leadership for Solar PV and Biofuels technologies, while the EU leads for wind. China, again, accounts for a smaller but rapidly growing share of the patent applications. Between 5 and 11% of the joint patent applications in the three countries came from China – and the number of patent applications was growing at 40 – 50% per annum between 2006/2007 and 2008/2009). In fact, all countries saw a rapid growth in patent applications in this period – but in Europe less so than in China and the US. For wind, for instance, patent applications in Europe grew by almost 30% per year between 2006/2007 and 2008/2009 – which is remarkable, but not fast enough to prevent US and China from catching up. For Solar PV, the situation is even between the EU and the US, with a slightly higher share of patents in the US, but a marginally higher growth rate of patenting in the EU. China features a higher growth rate than both EU and US, but also still has some distance to cover. For Biofuels, the EU position is weaker to begin with, and added to this growth in patents is lower than in China and the US.

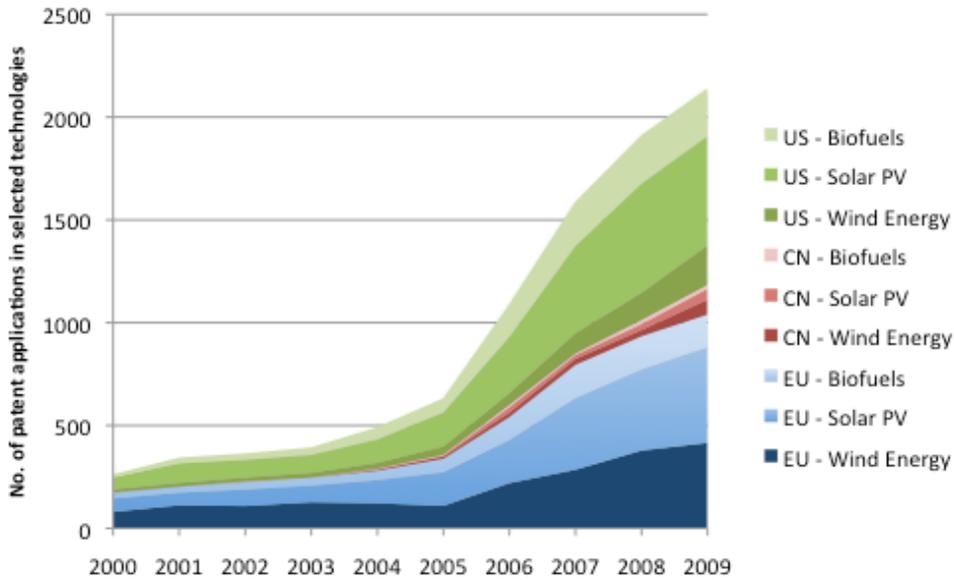


Figure 6: Number of patent applications for selected renewable energy technologies in the EU, China and the US, 2000 - 2009. Source: OECD ENV-Tech Indicator Set

For energy efficiency technologies, the picture is similar to renewables in the sense that patenting activity has accelerated markedly since 2005. Also notable is the outlier year 2008, when growth in patenting was much lower than in the preceding and the following year (mostly due to a falling number of patents for electric vehicle technologies in Europe). In terms of technological leadership, Europe is well-positioned: among the three countries and regions, the EU accounted for 70% of patents in electric vehicle technologies in 2009, for almost two thirds of insulation technologies, and just below half of energy storage. Also, the EU has the highest growth rate for patents on electric vehicle technologies in 2006/2007 – 2008/2009, and is on par with China for patent growth in energy storage technologies.

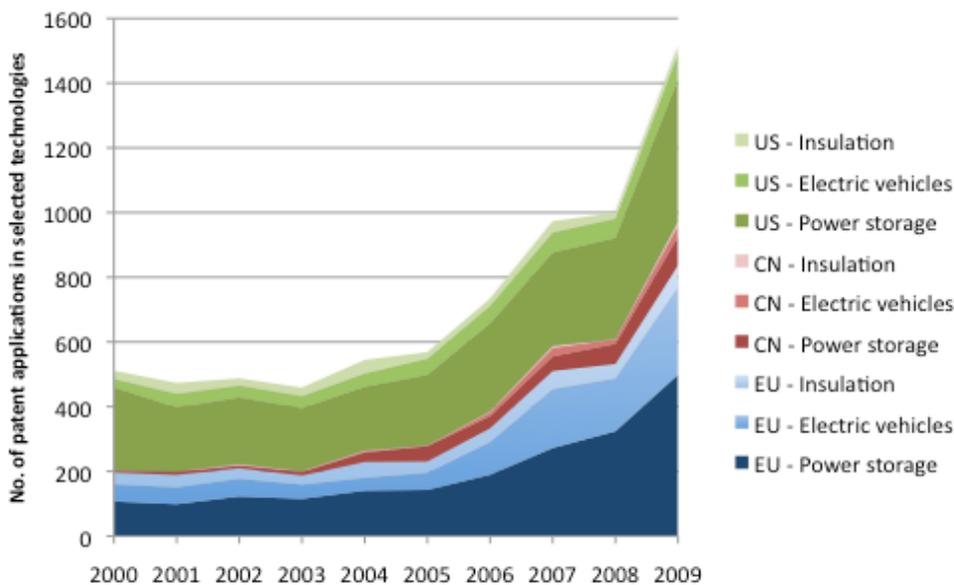


Figure 7: Number of patent applications for selected energy efficiency technologies in the EU, China and the US, 2000 - 2009. Source: OECD ENV-Tech Indicator Set

Finally, the following table presents an overview of the data presented in the graphs above, focusing here on the each country or region's share of patenting activity among the three, as well as the annual growth of patent applications between 2006/2007 and 2008/2009 (i.e. based on the respective two-year average figures). From a European perspective, the table demonstrates that the EU is very well positioned for waste management and electric vehicles – and, to a lesser degree, energy storage – where it leads innovation activity with an increasing margin. For a number of technologies, such as air and water pollution abatement, wind energy and insulation, the EU is currently the technological leader, but the gap is closing particularly due to rapid innovation in China. Finally, for solar PV and in particular for biofuels, the EU is neither the technological leader nor does it feature the highest growth rates.

Table 3: Shares and growth rates of patent applications for environment-related technologies, EU, China and USA

	EU-28		China		USA	
	Share	Growth rate	Share	Growth rate	Share	Growth rate
Air pollution abatement	60.2%	-0.3%	2.1%	14.4%	37.6%	-5.9%
Water pollution abatement	54.9%	4.2%	9.4%	14.2%	35.7%	-5.0%
Waste management	64.6%	8.1%	7.9%	4.1%	27.5%	-7.1%
Wind energy	61.2%	28.6%	10.7%	50.6%	28.2%	54.5%
Solar PV	44.3%	27.1%	5.0%	41.5%	50.7%	26.2%
Biofuels	38.7%	8.7%	4.8%	51.6%	56.4%	12.6%
Energy storage	48.6%	39.1%	8.6%	40.8%	42.8%	17.1%
Electric vehicles	70.4%	26.6%	8.9%	13.5%	20.7%	10.0%
Insulation	64.8%	7.3%	12.2%	19.9%	23.0%	-12.5%

Note: "Share" refers to the share of the respective country or region in the total of the three countries and regions in 2009; "Growth rate" is the annual growth between the 2006/2007 and the 2008/2009 two-year average. Source: OECD ENV-Tech Indicator Set.

4.2 Public funding for environmental research

Complementing the earlier discussion, which looked at patents for environment-related technologies as one of the most important – and most easily quantifiable – *outputs* of innovation activity, the following section looks at one important *input* to innovation: public research funding. The following table provides an overview of public funding for environmental research in selected countries between 1991 and 2009. The indicator used is the share of environmental research in total state expenditure for civil R&D.¹⁰

Table 4: Share of environmental research in state expenditure for civil R&D, 1991 - 2009

	1991	1995	2001	2002	2003	2004	2005	2006	2007	2008	2009
Germany	3.8	3.9	3.4	3.3	3.5	3.7	3.7	3.3	3.4	3.2	3.3
Italy	3.1	2.5	2.4	–	–	–	2.8	2.6	3.6	4.1	3.2
Poland	-	-	-	-	-	0.1	2.4	1.4	2.7	3.4	-
Portugal	3.0	4.5	3.7	3.6	3.4	3.9	4.0	3.4	3.7	3.7	-
UK	2.6	3.7	2.7	2.4	2.6	2.6	2.5	2.4	2.5	2.8	-
Mexico	1.1	0.6	1.0	1.8	1.9	2.2	2.1	2.1			
US	1.7	1.7	1.3	1.2	1.1	1.2	1.1	1.1	1.2	1.2	
EU-15	2.9	3.3	3.2	3.4	3.6	3.6	3.0	3.1	3.1	3.2	
OECD	2.2	2.4	2.3	2.4	2.4	2.4	2.3	2.3	2.4	2.4	

Source: BMU Report on the Environmental Economy 2011.¹¹

One observation is that the share of funding is consistently higher in Europe than in the US. This might be seen as a contradiction to the fact that the US is en par with the EU in terms of the patents generated. However, the observed differences may also be due to a higher propensity to patent in the US, or to structural differences in the way that R&D funding is measured. What is also remarkable is that the shares do not exhibit any particular trend – in some countries, there are considerable variations year-on-year, in others the trends were fairly static. But in no country was there a clear trend to increase the share of environmental research funding: where this occurred (e.g. Italy in 2007/2008, or Portugal 2004/2005), it was mostly as a short-lived expansion, after which the share returned to previous levels. Germany is notable: despite its credentials as a green technology leader in Europe, the share of environmental R&D funding has actually fallen since the 1990s.

¹⁰ Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit and Umweltbundesamt, *Report on the Environmental Economy 2011. Facts & Figures for Germany*.

¹¹ Ibid., 26.

5 Country Briefs

5.1 European countries

5.1.1 Germany

The performance of the German Eco-Industries stands out in several ways: first, Germany is one of the leaders in Europe in terms of the transformation to a green economy, particular in terms of decarbonising the energy sector and promoting energy from renewable sources. In 2010, Germany alone accounted for more than half of all new PV solar installation worldwide.¹² Second, the German economy is also one of the most industrialized economies in the EU, with a large export-oriented manufacturing sector. With an energy sector that was traditionally reliant on coal, it is also among the more carbon-intensive economies in Europe, and, despite the reductions achieved, its per-capita CO₂ emissions remain above the EU average. Third, the German economy has gone through the financial and economic crisis relatively unscathed: while GDP contracted by 4% in 2009, this drop was compensated by a GDP rise of 5.1% in 2010 and 4.6% in 2011 (all in real terms).

When looking at the performance of the environmental goods and services sector in Germany, the picture is very positive overall, with a few minor weaknesses. Thus, the general trend has been a rapid growth of the market for environmental goods and services. Yet this growth was achieved almost exclusively in the climate-related sectors. The bricks-and-mortar environmental goods and services (such as waste treatment, water management, soil remediation or air protection equipment), which had traditionally dominated the environmental industry, has remained relatively stagnant during the last decade.¹³ For wastewater treatment investment in particular, there was a declining trend from 2000-2010, as the infrastructure investment backlog in the former GDR had been cleared during the 1990s. Expenditure on pollution abatement and control expenditure is largely stagnant.

Due to the rapid expansion of climate-related activities, and in particular renewable energy deployment, these activities have come to dominate the environmental industry sector in Germany. According to Federal Statistical Office's (DESTATIS) definition of EGS, the total turnover of environmental goods and services sector came to 44.6 billion Euro in 2009 (2% of GDP), of which climate-related goods and services accounted for more than half (about 27 billion Euro), the remainder being distributed between waste, water, noise and air. Solar PV alone accounts for 8 billion Euro of the 27 billion of climate-related turnover.¹⁴ While these figures are based on the definition of environmental goods and services used by DESTATIS, the environment ministry uses a broader definition of environmental technology services

¹² OECD, *OECD Environmental Performance Reviews*, 2012.

¹³ Ibid.

¹⁴ Ibid.

sector, according to which the sector accounted for 123 billion Euro of value added in 2008, or about 5% of GDP.¹⁵

Germany's strong position in the environmental goods and services sector, combined with the traditional export orientation of the German economy, results in a strong position on the global market. As one of the largest suppliers of environmental goods and services worldwide, Germany alone has a share of more than 5% in global trade in products related to renewable energies. German manufacturers are industrial leaders particularly in the wind sector, with two German-based producers among the world's top ten, and $\frac{3}{4}$ of the wind power equipment deployed in Germany is produced domestically.¹⁶ At the same time, the technological and economic leadership of German companies in the solar PV industry has eroded considerably since 2010, mostly due to intensive competition from Chinese manufacturers. Thus, between 2011 and 2012 alone, about 20% of the jobs in the German solar PV sector were lost as a number of manufacturers filed for bankruptcy.¹⁷

In terms of their performance during the financial and economic crisis Investment, the renewable sector in particular has proven very resilient – while it has weathered the crisis well, the sector was much more affected by the increased competition and falling prices in the PV sector since 2011. Thus, private investment in renewables (excluding public R&D funding) more than doubled between 2005 and 2010, but since its peak in 2010 investment has fallen by about a quarter. This contraction can mostly be attributed to the rapid decline in prices for PV modules as well as market share losses, and hence falling revenues, for German PV manufacturers. While investments have fallen, both installed capacity and output has continued to increase for PV.

Table 5: All private investment vs. investment in renewables in Germany, 2005 - 2012¹⁸

	2005	2006	2007	2008	2009	2010	2011	2012
All private investment	330,52	360,2	387,2	394,8	342,1	368,1	403,0	401,8
Year-on-year change		9,0%	7,5%	2,0%	-13,4%	7,6%	9,5%	-0,3%
Investment in renewables	10,60	12,7	13,7	16,5	22	26,4	23,2	19,5
Year-on-year change		19,8%	7,9%	20,4%	33,3%	20,0%	-12,1%	-15,9%

The contrast with the general pattern of economic development, and the special position of the renewable sector, is particularly apparent for the crisis year 2009: in this year, overall private investment (mobile equipment and construction) fell by 52 billion Euro, or 13.4%. In contrast, investment into renewable energy installations grew by a third during the same year. This investment pattern is also mirrored in the employment that renewable energies

¹⁵ Ibid., 67.

¹⁶ Ibid.

¹⁷ O'Sullivan et al., *Bruttobeschäftigung Durch Erneuerbare Energien in Deutschland Im Jahr 2012*.

¹⁸ Sachverständigenrat für Wirtschaft, "Zeitreihen Für Deutschland"; Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit, *Erneuerbare Energien in Zahlen. Nationale Und Internationale Entwicklung*.

have generated: total (gross) employment in the sector has increased continuously – and has more than doubled since 2004 – to reach 381,600 in 2011. Since then, the observed 20% decline in solar PV has mostly been offset by increases in wind and biomass, so that total employment in the sector has stagnated.¹⁹

The resilience of the renewable sector to the impact of the economic crisis, as evident from the investment volume, is also reflected in the output figures: When considering the gross electricity generation from different sources in Germany, the following picture emerges:

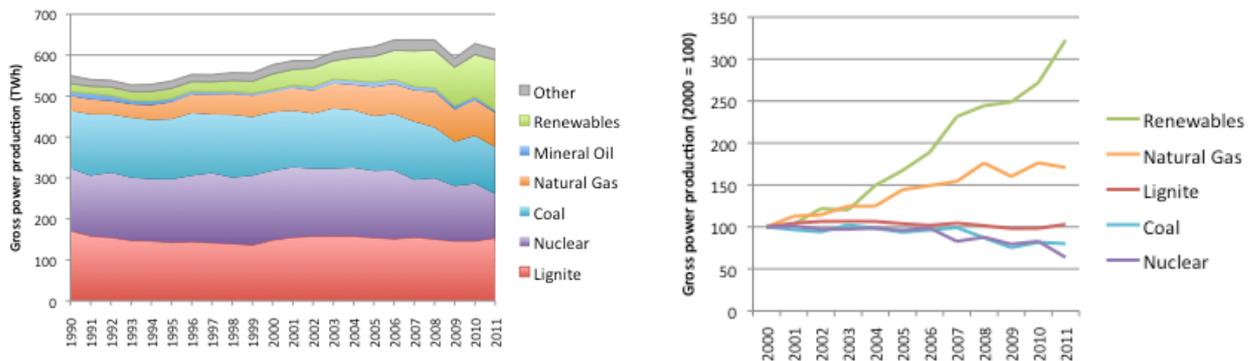


Figure 8: Power production in Germany

Focusing on the years of the financial and economic crisis, the change in output is apparent in the case of natural gas and hard coal, for which output contracted markedly in 2009. Lignite-based power production has remained virtually unchanged for the last 10 years. Nuclear output has fallen most, yet this is due to the nuclear-phase out policy rather than economic circumstances. Power production from renewables has increased continuously, and tripled since 2000. The financial and economic crisis in 2009 has affected the sector rather merely by slowing down the rate of expansion for one year, while absolute output continued to increase.

5.1.2 Italy

The development of Eco-Industries in Italy has to be seen in the context of the general economic situation in Italy. Italy has always had limited fossil fuel resources at its disposal, which meant that it was more dependent than other industrial countries on energy imports. Historically, energy prices were comparatively high in Italy and energy intensive industries were less important than in some other European countries. Nonetheless, Italy is still one of the most important manufacturing countries in Europe. The steel and ceramic industries in particular contribute significantly to the economic performance of Italy. Compared to other

¹⁹ Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit, *Erneuerbare Energien in Zahlen. Nationale Und Internationale Entwicklung*; O'Sullivan et al., *Bruttobeschäftigung Durch Erneuerbare Energien in Deutschland Im Jahr 2012*.

countries with a strong manufacturing base, Italy has more small and medium-sized manufacturing companies and fewer large companies.

Since 2000, Italy's economic growth rates have been consistently lower than those of other European countries.²⁰ The particular nature of Italy's manufacturing industry has resulted in it facing strong competition from developing countries. Further, the lack of political reforms and political turmoil in general has been responsible for a low investment rate in the economy overall.

Due to its high level of government debt, Italy was forced to scale back government spending in the middle of the economic crisis.²¹ This led to the Italian economy suffering one of the longest recessions of its history.

The development of Italy's Eco-industry over the assessment period has to be seen in this context. Overall growth was significantly slower than in other countries, but in some areas important progress has been achieved:

- Italy has abandoned nuclear energy production by 1990 and a recent attempt to revive it has been rejected in a referendum. Following a series of power cuts in 2004/05 Italy invested heavily in power generation, predominantly in natural gas facilities but also in renewable energy production. In 2011, investments in renewable energy generation amounted to €21 billion and the Italian market was the second biggest market in the EU. Renewable energy generation increased from 18 GW in 2000 to over 40 GW in 2011. In 2010 108.000 people in Italy were employed directly or indirectly in the renewable energy sector.²² This major investment boom was achieved by a similar set of policies as in other European countries mainly a feed in tariff and green certificates.
- Waste management services (27%) and water supply services (10%) have grown considerably between 2000 and 2009.²³ At the same time those services were increasingly provided by private utilities and not by government bodies. The increased output in those sectors was mainly caused by the stricter requirements of European waste and water directives coming into force since 2000.
- Italy has become a leader in the development of eco-labeled products. Overall, nearly 50% of all products with an EU eco label were developed in Italy.²⁴
- Italy is also as leader in organic farming in line with an agricultural sector which focuses more and more on high quality output. In 2011 nearly 9% of Italy's agricultural output was from organic farming.²⁵

The ongoing economic crisis in Italy has important consequences also for its Eco-Industries. The Italian economy as a whole has been falling behind in most indicators of innovation for

²⁰ OECD, *OECD Environmental Performance Reviews*, 2013.

²¹ Ibid.

²² Ibid.

²³ Ibid.

²⁴ Ibid.

²⁵ Ibid.

some time. Italy spends less on R&D and produces fewer patents (only 2.5% of all OECD patents) than other economies of its size.²⁶ For an emerging sector like the Eco-Industries, such a lack of innovation is obviously more threatening than for mature industries, as without innovation the danger of competition from low cost countries is higher. Recently, many universities mainly in the North of Italy have created private sector technology spinoffs that might in time improve the innovation performance of Italy.

Generally, it is worth noting that the economic North-South divide in Italy is also important to understand the economic performance of green industries in Italy. Traditionally, regional development policy in Italy was focused on industrializing the South of Italy, very often with capital intensive and also pollution intensive industries. On the other hand, Northern Italian industries were more knowledge-based with a stronger innovative focus. These different development tracks have led today to a strong concentration of green industries in Northern Italy with only small pockets of such industries in Southern Italy (eg. Catania).

In conclusion, although a relative latecomer in the development of Eco-Industries, Italy has developed a very remarkable core of Eco-Industries, especially in the renewable energy sector (which has been led by policy support). Compared to other European industries growth in LCEGS was slow in Italy mostly due to the overall poor economic performance. But nonetheless growth in LCEGS in Italy by far outstripped the negative development of GDP, which has contracted by 1% in nominal terms between 2008 and 2011. To achieve more growth in the LCEGS sector, Italy needs to strengthen its innovation basis further and provide policy and investment stability.

	2008	2009	2010	2011	2008-2011
LCEGS	2.1%	2.1%	2.4%	2.5%	9.4%
GDP	1.3%	-3.5 %	2.1%	-0.8%	-1.0%

Table 6: Nominal growth rates in LCEGS and GDP for Italy, 2008-2011

5.1.3 Poland

Economic growth in Poland has been comparatively high in recent years. Poland’s economy did not enter into recession in 2008/09 and has grown at a stable rate since. Important reasons for this were more efficient regulation of banks, meaning Poland did not face a banking crisis, and also a substantial program of infrastructure investment, which helped economic growth in the short and in the long term. Poland has become an important manufacturing location regionally, a development that was boosted by its EU accession in 2004. Poland very often also captures the complete manufacturing value chain.

Due to the relative benign economic climate, Poland did not enact a large stimulus package. Further, public investment, helped by EU structural funds, was high in the respective period, underpinning growth.

²⁶ Ibid.

The estimates provided by the BIS studies reports that Polish Eco-Industries grew strongly in the last five years. This was at the first glance a surprising result, as Poland would generally not be expected at the forefront of green economies in Europe; for instance, the European Eco-Innovation Index ranks Poland bottom for its eco-innovation capacity. Looking at the results more closely, nonetheless, there are several factors that can explain the strong growth of the Polish Eco-Industries:

- Renewable energy production increased strongly in Poland in recent years although from a low base. In 2011 9%²⁷ of energy generation was from renewable energy sources – a tripling in only six years. As the German manufacturing sector and the Polish manufacturing sectors are tightly interlinked, it is also reasonable to assume that Polish suppliers of intermediate products benefited from the boom in renewable energy production in Germany. Overall the sector employs about 20,000 people in Poland.
- Water protection and sustainable waste management also developed very dynamically in the respective period. Between 2007 and 2015²⁸ € 7.3 billion will be spend to upgrade sewage treatment in Poland. Substantial investments were also conducted in waste infrastructure.

Many commentators point out that Poland has not yet put together a consistent set of policies to support the nurture of Eco-Industries. This lack of a strategy is also one reason for Poland’s low score in the Eco-Innovation index. Nonetheless, Eco-Industries in Poland managed to expand significantly, and currently employ an estimated 190,000 people.²⁹ Yet, although the overall showing of the Polish LCEGS sector is strong, it is nonetheless remarkable that Poland was the only European country among the eight countries considered where (nominal) GDP growth was stronger than growth in the LCEGS sector (at 28.7 vs. 23.6%, respectively, between 2008 and 2011).

In view of the relatively strong manufacturing sector and export orientation of the Polish economy, more chances for growth in the LCEGS sector could be tapped with a consistent strategy. This is especially true as some of the past growth in LCEGS was due to the EU structural funds that went into water and waste infrastructure, which will not continue at the same rate in the future as the backlog in environmental infrastructure is being closed.

Overall these factors have contributed to a strong showing of the LCEGS sector even compared to the strong economic growth experienced by Poland during and after the crisis. During the four years observed, growth in the LCEGS was about 50% higher than GDP growth. Again the difference was most relevant in the year 2009 where GDP growth was slow in Poland while LCEGS grew unaffected by the crisis.

	2008	2009	2010	2011	2008-2011
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²⁷ Kassenberg and Kassenberg. *Eco Innovation in Poland*. Eco-Innovation Observatory, 2011. http://www.eco-innovation.eu/media/EIO_Country_Brief_2011_Poland.pdf

²⁸ Kassenberg and Kassenberg. *Eco Innovation in Poland*. Eco-Innovation Observatory, 2011. http://www.eco-innovation.eu/media/EIO_Country_Brief_2011_Poland.pdf

²⁹ Szwed, Dariusz and Beata Maciejewska. *Green Jobs in Poland – Potentials and Prospects*. Friedrich Ebert Stiftung, 2012. http://www.fes-asia.org/media/publication/2012_GreenJobsInPoland_FES-EoT_Study_Szweed_Maciejewska.pdf

LCEGS	5.1%	5.1%	5.7%	5.7%	23.6%
GDP	8.4%	5.4%	7.9%	4.4%	28.7%

Table 7: Nominal growth rates in LCEGS and GDP for Poland, 2008-2011

5.1.4 Portugal

Portugal is among the EU countries that were most severely affected by the 2008 – 2009 financial and economic crisis, and the ensuing sovereign debt crisis. The Portuguese economy contracted by 2.9% in 2009, recovered slightly in 2010, and shrank again by 1.3% in 2011 and 3.2% in 2012. In response to the economic crisis, Portugal adopted a package of stimulus measures in 2009 equivalent to 08% of GDP. Of this, about 18% were considered as environmental stimulus, mostly geared at the energy sector, such as investment into the power grid or renewable energy generation capacity, but also investment into energy efficiency improvements in public buildings.³⁰ This stimulus package has managed to achieve its short-term objective of stabilising the economy. Yet in the subsequent years the focus moved toward fiscal consolidation, in order to address the soaring budget deficit, which had reached more than 9% in 2009.

One outstanding aspect of Portugal's recent economic performance was the remarkable growth in renewable energies – and in particular renewable electricity generation – that Portugal achieved since 2006, despite the dismal economic performance. Thus, the share of renewables in electricity generation increased from 30% in 2006 to 46.5% in 2011.³¹ In the first quarter of 2013, according to media coverage, it even reached 70%.³² One of the reasons for this success was investment into the electricity grid, in order to absorb the increasing share of decentralised electricity from renewables, often from more remote parts of the country.

Table 8: GDP growth and renewable share in Portugal, 2006 - 2011

	2006	2007	2008	2009	2010	2011
GDP growth	1.4%	5.3%	1.6%	-2.0%	2.6%	-1.0%
Share of renewables in electricity	30.0%	32.7%	34.6%	38.2%	41.2%	46.5%

Investment into environmental infrastructure has also been a strong driving force for the greening of the Portuguese economy in other environmental areas, such as wastewater treatment and waste management. Since its accession to the EU, considerable investment has gone towards environmental infrastructure, often supported with EU funding. Thus,

³⁰ OECD, *OECD Environmental Performance Reviews*, 2011.

³¹ Source: Eurostat nrg_ind_335a

³² Morris. "Portugal Reaches 70 percent Renewable Power." 2013.

between 2000 and 2006, Portugal invested almost 8 billion Euro, or 0.8% of its GDP, into upgrading the environmental infrastructure, including an EU contribution of 2.3 billion Euro.³³

In terms of developing green jobs and stimulating green innovation, there remains much room for improvement. So far, the employment in Eco-Industries in Portugal is predominantly low-skilled, most of this in waste collection.³⁴ The move towards a knowledge-based Eco-Industries is taking root only in recent years – in the past, Portugal did not have a centrally coordinated strategy to foster innovation in environmental goods and services. Thus, in terms of Portugal its innovation performance in the Eco-Industries, Portugal has long been a laggard compared to other EU countries, as evidenced by a low number of patents for environmental technologies. On the input side, there have been some encouraging signs before the recession: Thus, Portugal featured the second highest government R&D budget of all OECD countries in 2008, and an above-average share of funding for environmental research, ranging up to 4% (compared to an OECD average of 2.4%). In real terms, expenditure for environmental R&D increased by almost half between 2000 and 2007. Alas, it is unclear how these trends have been, or will be, affected by the austerity policy.

In terms of the international competitiveness of its Eco-Industries, Portuguese industry has traditionally held a strong position in the manufacture of solar thermal technologies and air pollution control equipment. More lately, it has also developed manufacturing capacities for solar PV and wind technologies, and has started to export these. For renewable energy technologies, Portugal has traditionally been a net exporter due to solar thermal exports, and returned to this status in 2008. For environmental technologies generally, it continues to be a net importer of technologies.

In absolute terms, the LCEGS sector has been one of the more positive developments in an otherwise desolate economic climate: while nominal GDP was only 1% higher in 2012 than it had been in 2008 (and real GDP fell by about 5%), the LCEGS sector grew by about 5% during this period. A review of Portugal’s low-carbon and economy-wide performance in the studied period is presented below in Table 9.

	2008	2009	2010	2011	2008 - 2011
LCEGS	n/a	-1.3%	3.1%	3.1%	4.9%
GDP	1.6%	-2.0%	2.6%	-1.0%	1.1%

Table 9: Nominal growth rates in LCEGS and GDP for Portugal, 2008-2011

5.1.5 UK

As in most other countries the development of Eco-Industries in the UK has to be understood in the context of the general economic strengths of the UK and the most recent economic developments.

³³ OECD, *OECD Environmental Performance Reviews*, 2011, p. 12.

³⁴ *Ibid.*, 49.

Since the Second World War, the UK economy has transformed from an economy dominated by manufacturing to an economy dominated by service industries. This visible general trend in all developed countries was markedly stronger in the UK than in other countries. One example of strong service industries that have developed in the UK is the international service financial services industry, which includes consultancy and legal services. The importance of financial services in London also paved the way for a more intense and longer lasting economic crisis of 2008/09. The UK economy's financial sector has only rebounded in 2013, and investment is still very low by any possible comparison. Government spending has also been paired pack very significantly since the current government was elected in May 2009.

Considering this context, the growth of Eco-Industries in recent years in the UK was especially remarkable. The UK has developed a very strong market position, especially in Green service industries. In 2011 the UK was the second biggest provider of carbon finance services worldwide and also had a strong market position in other consultancy services. Other than that the UK has a strong position in nearly all sub-sectors, being the sixth biggest producer of LCEGS (after the US, China, Germany, India, and Japan) in 18 of the 24 sub-sectors.

	Global market share of UK industry	Growth 2007-2011
Air Pollution	3.4%	8.5%
Contaminated Land Reclamation & Remediation	3.4%	11.6%
Environmental Consultancy and Related Services	3.2%	13.9%
Environmental Monitoring, Instrumentation and Analysis	3.5%	14.7%
Marine Pollution Control	3.5%	15.8%
Noise & Vibration Control	3.3%	16.1%
Recovery and Recycling	3.6%	14.1%
Waste Management	3.4%	11.1%
Water Supply and Waste Water Treatment	3.3%	7.0%
Additional Energy Sources	2.7%	15.9%
Alternative Fuel Vehicle	3.9%	10.7%
Alternative Fuels	3.4%	28.5%
Nuclear Power	4.1%	8.1%
Building Technologies	3.6%	19.2%
Carbon Capture & Storage	3.6%	14.1%

Carbon Finance	16.1%	29.1%
Energy Management	3.5%	13.7%
Biomass	3.8%	20.7%
Geothermal	3.6%	21.4%
Hydro	3.9%	11.5%
Photovoltaic	3.5%	27.0%
Renewable consulting	2.8%	11.5%
Wave & Tidal	4.1%	23.0%
Wind	3.7%	31.0%
Total	3.7%	19.4%

Table I0: Development of sub-sectors in the UK³⁵

The overview shows very strong growth in all renewable energy sub-sectors except for hydro-energy but also in the alternative fuel sector and in building technologies. On the other hand growth in air pollution, nuclear industry and Water supply and water treatment was slow. Overall employment in the green industry grew to just below one million in 2011. Within the UK, green industries are concentrated in the south east of England (30% of turnover), and fairly evenly distributed in the rest of the country.

As in other countries LCEGS sectors grew very steadily over the selected period and as GDP growth was very low in the UK in this period, the LCEGS sectors made a substantial contribution to support the struggling UK economy.

	2008	2009	2010	2011	2008-2011
LCEGS	4.3%	4.3%	4.7%	4.8%	19.4%
GDP	2.4%	-3.1%	4.8%	3.5%	7.6%

Table I1: Nominal growth rates in LCEGS and GDP for the UK, 2008-2011

³⁵ U.K. Department for Business, Innovation and Skills. *Low Carbon and Environmental Goods and Services – Report for 2011/12*. London: 2013.

5.2 Non-European countries

5.2.1 China

China has a coordinated clean energy policy, with a focus on manufacturing and installation. It is also focused on producing clean energy technologies for export. The 12th Five-Year Plan set specific goals for seven emerging industries; three of them are clean energy industries: vehicles; renewables; and clean energy technology.³⁶ The Chinese government's focus on these industries is to gain a strong market position globally and occupy the high-value-added portions of the value chain, specifically in manufacturing. In its response to the Great Recession, China engaged in the largest amount of direct governmental spending (over \$200 billion), with 1/3 of the 2009 stimulus total dedicated to clean economy spending – energy efficiency, rails, grid and water infrastructure.³⁷ As massive amounts of public and private investment have gone into the clean economy and data reliability remains an issue overall with Chinese economic data, it has not been possible to assess whether the Eco-Industries in China have fared better than the economy as a whole. As will be seen below, however, large-scale investment continues and has been growing in the clean economy.

With its focus on manufacturing, China is a world leader in clean economy production, but the results have not been as robust in terms of R&D investment and environmental results. For example, while China is the world leader in total installed renewable capacity and also produces half of the world's solar panels and wind turbines, it is also the world's largest consumer of coal and faces substantial air and water pollution issues.³⁸ In fact, China is already the world's leading emitter of greenhouse gas emissions and on current trends China's coal consumption may pass the consumption of the rest of the world combined.³⁹ In light of these significant environmental effects, China has established a set of policy objectives to improve the environmental performance of the economy and reduce natural resource pressures. China has set a carbon intensity target (17% reduction of carbon emissions per unit of GDP), an energy intensity target (16% reduction), and a 30% reduction of water use measured by industrial value added.⁴⁰ Further, "China wants to grow these sectors from 5 percent of its GDP in 2010 to 15 percent of its GDP by 2020."⁴¹ In the current,

³⁶ Gordon et al. "The Green Industrial Revolution and the United States," The Center for American Progress, December 2013. p. 6.

³⁷ *Green stimulus measures*, EC-IILS Joint Discussion Paper Series No. 15, 2011, p. 12.

³⁸ Muro et al. *Sizing the Clean Economy*. The Brookings Institution, 2011.

³⁹ See US Energy Information Administration <http://www.eia.gov/todayinenergy/detail.cfm?id=9751&src=email> and Adam Vaughn, "China burns half of coal consumption worldwide, figures show," The Guardian, 30 January 2013, <http://www.theguardian.com/environment/2013/jan/30/china-burns-half-coal-worldwide>.

⁴⁰ Gordon et al. "The Green Industrial Revolution and the United States," The Center for American Progress, December 2013. p. 10.

⁴¹ *Ibid.*, p. 9.

13th Five-Year Plan, China's government dictates that 15% of the country's electricity should come from renewables by 2020, up from 8% in 2012.⁴²

China's global leadership in Eco-Industries

- China regained the lead in global new renewable capacity investment in 2012 (retaking 1st place from the US). Renewables investment reached \$66.6 billion in 2012, up from \$54.7 in 2011 and \$25.0 billion in 2008.⁴³ In 2012, it installed the most hydro power and solar water heating units globally, was second in new wind capacity; and third in solar pv installation and ethanol production.⁴⁴
- China's added wind power generation in 2012 exceeded added generation from coal; wind power production exceeded nuclear production.⁴⁵ China also received 25% of global investment in solar energy - \$31.2 billion – 37% of global wind investment, and 47% of global investment in all other renewables. China added 23 GW of clean energy generation in 2012.⁴⁶
- China has the world's largest amount of total renewable and non-hydro renewable capacity, 125 GW as of 2012.⁴⁷ Though 80% of this is hydro. China also produces about half of world solar pv and wind power hardware.⁴⁸ China, with Europe, leads the world in solar water heating installation; China has the most installed geothermal for direct use as heat and wind capacity in the world too.⁴⁹

Despite China's world leadership in renewables production and installation, this is embedded in an economy still heavily dependent on coal and an energy-system that has not made a full transition to low-carbon fuels. Moreover, the country's focus on economic growth and manufacturing in recent decades has resulted in tremendous strain on environmental resources and human health. Other sectors of Eco-Industries should also receive the Chinese government's attention and dealing with these effects while ensuring growth will be one of the main challenges of future Chinese leadership.

Despite these caveats, the Chinese government has set an ambitious target for the share of Eco-Industries in the overall economy (15% of GDP by 2020). The EU Commission has proposed a target for industrial activity to make up 20% of GDP by 2020, increasing from 16% currently; however, this target is not binding and does not specify the proportion that Eco-Industries should comprise. Further, as Eco-Industries in China consist primarily of manufacturing activities and combined with its various resource efficiency targets for the manufacturing sectors (i.e. decreased water use per industrial value added), China's focus

⁴² Ibid., p. 10.

⁴³ REN21. *Renewables 2013 Global Status Report*. (Paris: REN21 Secretariat), 2013, pp. 58-59.

⁴⁴ Ibid., p. 17.

⁴⁵ Ibid., p. 13.

⁴⁶ Pew Charitable Trusts. *Who's Winning the Clean Energy Race 2012*. 2012. p. 7.

⁴⁷ Ibid., p. 36.

⁴⁸ Muro et al. "Sizing the Clean Economy." The Brookings Institution, 2011.

⁴⁹ REN21. *Renewables 2013 Global Status Report*. (Paris: REN21 Secretariat), 2013, pp. 16-17.

on Eco-Industries and their success rivals that of the EU's. In several respects (the specific economy-wide target and the water-use reduction), it appears to exceed EU ambition; the EU, for example, has no water-use target for industrial value added. Joined with China's success in dominating the manufacture and installation of a number of renewable energy sectors, China is rightly seen as a focused and real competitor to the EU across Eco-Industries; current policy indicates that China may be placing even more weight on the importance of Eco-Industries than the EU.

The LCEGS statistics that underpin the analysis presented in this study, however, do not underpin the development in Chinese Eco-Industries that other sources suggest. In nominal terms, there has been a slow but steady growth in the study period 2008 – 2011, averaging about 2% per year. Yet these growth rates pale in comparison to nominal GDP, which increased by almost 80% over the same period. This means that the LCEGS has become less important in proportion to the rest of the economy, and may have actually shrunk in real terms. However, an in-depth discussion of this phenomenon would require a much closer look at the underlying data and the way it was collected and processed, which was not feasible in the frame of this exercise.

	2008	2009	2010	2011	2008 - 2011
LCEGS	1.8%	1.8%	2.0%	2.1%	8.0%
GDP	18.1%	8.6%	17.8%	17.8%	78.0%

Table 12: Nominal growth rates in LCEGS and GDP for China, 2008-2011

5.2.2 Mexico

Mexico is a member of the OECD and one of the world's largest economies, but it is also one of the poorest members of the group as well. It is a major producer of oil and natural gas, and its energy economy is strongly dependent on the burning of fossil fuels. Despite a series of policy measures (laid out below) to promote the clean economy and Eco-Industries, the 12 December 2013 decision by the Mexican legislature to end PEMEX's monopoly on oil and gas investment could distract political and economic attention from further development of these industries, not unlike shale oil and gas development in the US, industry.⁵⁰

Mexico has made strides in its environmental performance over the previous decade. The OECD estimates that the costs to the economy from environmental degradation fell from 10% of GDP in 2000 to 7% of GDP in 2010.⁵¹ With a suite of policies and investments over the last several years – before, during, and after the Great Recession – Mexico has improved its environmentally-important infrastructure. Mexico's 2009 stimulus package⁵² in response to

⁵⁰ Ministry of Environment and Natural Resources, www.semarnat.gob.mx

⁵¹ OECD, *Environmental Performance Reviews, Mexico 2013*. 2013.

⁵² "National Agreement in Favour of Family, Economy and Employment." Ministry of Environment and Natural Resources. Mexico, D.F.: 2009

the Great Recession, was \$ 7.7 billion, \$ 0.8 billion was allocated to environmental themes, including \$ 0.75 billion to promoting energy efficient buildings.⁵³ Changes to energy and water subsidies would reduce environmental pressures and improve the economic situation of the poor.⁵⁴ Granular policy changes in the electricity, oil and gas, and transportation sectors would be necessary to realize substantial installation of renewables, reduce energy use in the transportation sector, and reduce emissions.⁵⁵

The development of Eco-Industries in Mexico is still an undertaking in its early stages; the high level of expenditures is explainable in part due to catching up with investment in terms of items like wastewater treatment and water access.⁵⁶ In addition to its green stimulus investments, Mexico's government has taken important policy steps in addressing growing environmental challenges in the last few years. The government enacted the Special Program for Climate Change 2009-2012 (PECC). This program lays out a long-term vision for combating climate change while establishing the sectoral level interventions that will result in emission reductions.⁵⁷ The country introduced an Appliances Replacement Program to help households replace appliances with new energy-efficient models. In January 2012, The Ministry of Environment and Natural Resources (SEMARNAT) and UNEP signed a Memorandum of Understanding (MOU) to facilitate Mexico's transition towards a green economy and low carbon development. In February 2012, the World Bank along with UNEP, OECD and the GGGI launched a new international knowledge-sharing platform in Mexico – the Green Growth Knowledge Platform (GGKP) to enhance and expand efforts to identify and address major knowledge gaps in green growth theory and practice, and to help countries design and implement policies to move towards a green economy.⁵⁸

	2008	2009	2010	2011	2008-2011
LCEGS	5.8%	5.9%	6.5%	6.6%	27.2%
GDP	7.5%	-1.3%	9.4%	9.0%	26.6%

Table 13: Nominal growth rates in LCEGS and GDP for Mexico, 2008-2011

The LCEGS growth from 2007 to 2012 shows that Mexico has by far the highest growth rate overall, of over 25%; this compares favourably to the US (just above 5%), China (8%) and Germany (just above 13%) – see Table 2. However, this is mostly a statistical artifact of

⁵³ Robins et al. "A Global Green Recovery? Yes, but in 2010." August 2009; and "Green stimulus measures," EC-IILS Joint Discussion Paper Series No. 15, 2011, p. 12.

⁵⁴ Ibid.

⁵⁵ "Low-carbon development for Mexico," Energy Sector Management Assistance Program, Low Carbon Growth Country Studies Program, Briefing Note 003/10, 2010, pp. 1-4.

⁵⁶ OECD, *Environmental Performance Reviews, Mexico 2013*. 2013.

⁵⁷ World Bank. Program Information Documentation (PID) Appraisal Stage. Report No. AB5003. 2009.

⁵⁸ UNDESA. *A guidebook to the Green Economy*. <http://sustainabledevelopment.un.org/content/documents/GE%20Guidebook.pdf>

Mexico's starting position in terms of environmental and clean economy investments (low). Large investments, for Mexico, in these areas have produced sizable growth, but Mexico remains a small-scale player in Eco-Industry markets as yet. Mexico stands out because Mexico has just started making public investments in environmentally related infrastructure and in promoting renewable energy sources in the 2000s which exceed other economic investments as measured by the GDP. Over the past decade, environmental sustainability has been given a higher profile in Mexico's policy agenda. For example in 2010 Mexico's hydropower achieved the largest absolute increase in renewable energy investment in Latin America. The annual Global Growth Rate shows a relatively high percentage of a 6,6 % increase in LCEGS Sales in Mexico for 2011/12, which is an explanation for the rather low level of economic maturity. The more mature economies show lower annual growth trends, but from a higher economic base.

Mexican global leadership in Eco-Industries

- Mexico is not a global leader in any Eco-Industries, with the possible exception of geothermal power production, where it ranks 4th globally in installed capacity.⁵⁹
- Mexico derived 6.9% of its primary energy and 16% of its electricity from all renewable sources in 2012.⁶⁰

To improve its position in Eco-Industries, Mexico must continue its policy focus on green initiatives, reform its electricity and transportation systems, encourage renewable energy installation, and develop specific measures to support the development of whole value chains for certain Eco-Industries.

5.2.3 US

The development of Eco-Industries in the USA in the mid-2000s was driven primarily by private business interests in the sub-sectors and State-level (in contrast to federal-level) policies (e.g. renewable energy portfolio standards). Further, the US has extensive fossil fuel resources (oil, coal, and natural gas) and has a nuclear fleet that meets roughly 20% of electricity demand. Approximately coinciding with the years covered by this study (namely 2008/2009 through today), the introduction of hydraulic fracturing and horizontal drilling techniques have increased domestic oil and natural gas production in the US. Two exceptions to this situation in the mid-2000s were the 2005 and 2007 Energy Policy Acts, which created significant demand for biofuels and alternative fuels.

With the advent of the Obama Administration, and in part as a reaction to the Great Recession, federal-level public policy has directed additional public and private investment to Eco-Industries in the USA. Pointed investments in renewable energy, transportation, energy efficiency technologies, as well as a variety of other Eco-Industries, were one of the largest recipients of funds under the American Recovery and Reinvestment Act 2009 (the so-called "stimulus" or ARRA). The Act dedicated \$90 billion of federal investment in renewables,

⁵⁹ REN21. *Renewables 2013 Global Status Report*. (Paris: REN21 Secretariat), 2013, pp. 17.

⁶⁰ Ibid, p. 104-106.

transportation, etc., which spurred comparable levels of private follow-on investment.⁶¹ The ARRA investments, in part, led to the US leading the world in clean energy investment in 2011.⁶² US had \$48 billion in clean energy investment in 2011, but only \$35.6 billion in 2012, as the stimulus investments were rolled back. US is a leader in venture capital investment as well.⁶³ Installed capacity for non-hydro renewable energy doubled between 2009 and 2012. Electricity production from non-hydro renewable energy was 3.7% in 2009 and is predicted to reach 6.1% in 2013.⁶⁴ Further, the Obama Administration negotiated an agreement with the State of California and auto manufacturers to dramatically improve fuel economy of passenger vehicles and light duty vehicles over the next few decades. By 2025, fleet-wide (excluding heavy-duty trucks) fuel efficiency is to reach 54.4 miles per gallon (163 g per mile), which would more than double fuel efficiency from today's level.⁶⁵

The US lacks widely-accepted definitions of Eco-Industries and jobs in the clean energy sector. The Bureau of Labor Statistics cites that there were 3.4 million jobs in the clean energy sector in 2011; private sector employment made up 2.5 million of those jobs, which were only 2.3% of total employment.⁶⁶ Eco-Industry employment was higher proportionally in manufacturing (4.3% of total jobs), construction (8.9%), utilities (12.9%), and transportation (5.9%). These proportions could partially explain the slightly higher amount of GDP attributable to LCEGS (roughly 3.6%) cited above in Figure 1. A separate Brookings Institution report cites 2.7 million jobs in the clean economy.⁶⁷ The Brookings report was a comprehensive look, down to the county level, of performance in the clean economy from 2003 to 2010. The report found that the clean economy sector grew at a slower annual rate (3.4%) than the economy as a whole (4.2%) from 2003 to 2010. However, declines in performance in established clean economy sectors (housing, etc.) during the Great Recession coincided with robust growth in new clean economy sectors (especially renewables and smart grids).⁶⁸ Importantly for a consideration of the role of Eco-Industries terms of overall economic performance, the Brookings study found useful secondary effects from clean economy activity. The clean economy in the US was found to entail a larger share of manufacturing activity than the economy as a whole and it exported twice the value per job, on average, than the standard US job.⁶⁹ When considering the EU's industry target of

⁶¹ Gordon et al. "The Green Industrial Revolution and the United States," The Center for American Progress, December 2013. p. 13.

⁶² Pew Charitable Trusts. *Who's Winning the Clean Energy Race 2012*. 2012.

⁶³ Ibid.

⁶⁴ EIA. "Short-Term Energy Outlook," Figure 25. 2013.

⁶⁵ EPA. "EPA and NHTSA Set Standards to Reduce Greenhouse Gases and Improve Fuel Economy for Model Years 2017-2025 Cars and Light Trucks," August 2012.

⁶⁶ Bureau of Labor Statistics, "Employment in Green Goods and Services—2011" (2013), available at <http://www.bls.gov/news.release/pdf/ggqcew.pdf>.

⁶⁷ Muro et al. *Sizing the Clean Economy*. The Brookings Institution, 2011.

⁶⁸ Ibid, p. 4

⁶⁹ Ibid, p. 4.

20% of GDP by 2020, carving out additional space for Eco-Industries under that target could have positive implications for trade and value-added production.

- The US remains a world-leader in overall R&D investment. It was responsible for 37.8% of global R&D spending in 2010, 36.9% in 2011, and 36.0% in 2012.⁷⁰ In energy patents, the US was second only to Japan in energy patents overall, and in terms of patents in four key clean energy categories (solar, wind, geothermal, and fuel cells), the US patent rate, adjusting for country size, is relatively strong in fuel cells and the expected rate for the others.⁷¹
- While the US will not likely meet its nominal goal of 1 million electric vehicles sold by 2015, several plug-in hybrid and full electric vehicles are available. GM offers the Chevrolet Volt, which was developed and launched during the Great Recession, and the US also is home to Tesla Motors, an all electric vehicles company that did not exist in the mid-2000s. Its Model S sells well in the US and internationally. Tesla is also developing its own charging infrastructure.
- The US is the global leader in bio-power and geothermal power capacity, as well as geothermal heat capacity. It is second globally in total renewable and total non-hydro-renewable capacity, third in hydropower, second in concentrated solar thermal power, third in solar pv capacity, second in wind power capacity, and second in geothermal direct heat use. It also leads the world in biodiesel and ethanol production.⁷²
- The US has a number of companies working on advanced battery technology, including one of the world leaders – Johnson Controls.⁷³

Despite positive trends, global leadership in several areas, and robust R&D spending, the overarching political situation portends to be a brake on full-throttle US engagement in Eco-Industries. The ARRA was a time-limited investment that has not been renewed or followed with comprehensive policies or planning. As a Center for American Progress report put it “the current Congress seems especially hostile to any transformation of our energy system toward lower-carbon alternatives.”⁷⁴ For example, budget cuts forced the Bureau of Labor Statistics to stop tracking the clean economy after doing so for a few years after developing a methodology under ARRA. The President’s Climate Action Plan should help stimulate some investment, especially if the regulations for new and existing power plants are robust. However, the States have a significant role to play too, and interest in the clean economy at the State level is uneven with high interest in California and other states and little in others. Private investment and interest in the clean economy remains robust, but that is driven also by policies in other countries and has also fallen off from highs in previous years. Lastly, the

⁷⁰ Batelle. *2012 Global R&D Funding Forecast*. 2012. p. 3.

⁷¹ World Intellectual Property Organization. *World Intellectual Property Indicators 2013*. 2013, p. 72.

⁷² REN21. *Renewables 2013 Global Status Report*. (Paris: REN21 Secretariat), 2013, p. 17.

⁷³ EV Obsession. “EV Lithium-Ion Battery List Topped By LG Chem, Johnson Controls, & AESC.” July 2013.

⁷⁴ Gordon et al. “The Green Industrial Revolution and the United States,” The Center for American Progress, December 2013. p. 14.

marked expansion of oil and gas production through hydraulic fracturing has shifted national attention from the clean economy; without policy drivers, this situation is unlikely to change in the coming years.

Table 14 below charts the performance of the US LCEGS sector and GDP through the recessions. The American economy shows comparatively smaller annual growth in LCEGS, thanks to its higher economic base and the aforementioned factors.

	2008	2009	2010	2011	2008-2011
LCEGS	0.8%	-0.5%	2.5%	2.5%	3.8%
GDP	1.7%	-2.1%	3.7%	5.3%	7.3%

Table 14: Nominal growth rates in LCEGS and GDP for US, 2008-2011

6 Conclusions and recommendations

Eco-Industries are the focus of industrial policy and policy promotion across the eight countries reviewed in this study. The means and extent of promotion differs between them, and predictably the role and size of Eco-Industries differ as well. In addition to policy differences, the size of Eco-Industries in each country and recent growth is a function both of policy promotion and the particular stage of economic development in each country. While China, Germany, the UK, the US, and Italy have more robust traditional Eco-Industry sectors and their recent growth is primarily in emerging Eco-Industry technologies (e.g. renewables), growth in Eco-Industries in Poland and Mexico, for example, is still weighted toward more established Eco-Industries (like water management). Portugal is somewhere between these two groups.

Despite these differences, our study confirms that Eco-Industries make up comparable shares of total economic activity. Further, emerging Eco-Industries are in fields exhibiting high levels of R&D and patenting behaviour, which can serve as an indication that Eco-Industries are among the more innovative sectors of the economy. As many countries explore options for promoting new and emerging industries with high innovation and value-added potential; Eco-Industries are a natural area of attention.

Eco-Industries have provided some stability and delivered impetus for growth during turbulent economic times in all of Europe. For every year in each of the five EU countries considered, annual growth in LCEGS has been higher than the respective GDP growth, i.e. the LCEGS sector has outperformed the wider economy. This was particularly notable during the economic downturn of 2008/9, when Eco-Industries remind relatively stable within stagnating or even contracting economies. It should be noted, though, that this counter-cyclical dynamic of Eco-Industries, is also partly due public spending: as government expenditures grew in the early years of the financial crisis, not least through stimulus spending, Eco-Industries have benefitted.

The most effective Eco-Industry interventions have been found to provide strong investor certainty (e.g. the use of feed-in tariffs in Europe); unsurprisingly, nearly 40% of total growth in Eco-Industries was in the renewable energy sectors. From the European perspective, policies to promote Eco-Industries have mostly been a success: since 2008, European Eco-Industries were able, on balance, to defend their global market share in a growing global market, and despite increased competition. This is, of course, not true for each and every subsector and technology, as witnessed by the fate of much of Europe's solar PV manufacturing industry. Yet, in light the fact that the EU economy as a whole has lost ground to its competitors since 2008, the stable performance of Eco-Industries is a positive sign.

Even with these results, European countries should not necessarily aim to capture all parts of the value chain for relevant Eco-Industries. International market dynamics make it increasingly unlikely that a country could do this without incurring unnecessarily high costs. Solar PV manufacturing is just one example of this. While Chinese competitors supplanted the earlier market dominance of German manufacturers of PV modules, the vast majority of value-added and particularly employment effects are still retained in Germany. This is because, even though equipment can be exported and imported, much of the value added of Eco-Industries is locally bound as installation and maintenance of appliances have to be provided locally. This means that the economic effects of Eco-Industries can be substantial,

even if there is no large domestic industry for the manufacture of equipment. But it also means that the local business climate, and propensity to invest, is an important factor for the growth in Eco-Industries.

In the contest to promote Eco-Industries, the EU currently faces a more focused, long-term public sector challenge from China than from the United States – at least in terms of nationally-directed attention to Eco-Industries. The US Congress remains highly sceptical of directly supporting Eco-Industries, and the current Administration has only limited means to promote them after the exhaustion of stimulus funds. Chinese governmental attention, on the other hand, warrants particular attention from EU policymakers. For example, the Chinese government has set a specific target for the share of Eco-Industries in the overall economy (15% of GDP by 2020). While the EU Commission is considering manufacturing targets overall, some attention could be given to the share of Eco-Industries as a sub-category. Moreover, China has meshed this target with its various resource efficiency targets for the manufacturing sectors (i.e. decreased water use per industrial value added). As the EU seeks to remain competitive in Eco-Industries over time, it may choose to consider incorporating similar goals into its economic and industry policies.

Yet, in terms of innovativeness of Eco-Industries, using the patenting activity as a proxy, the race is currently still being fought between the US and Europe. European Eco-Industries are very well positioned for technologies such as waste management and electric vehicles – and, to a lesser degree, energy storage – where they leads innovation activity with an increasing margin. For a number of technologies, such as air and water pollution abatement, wind energy and insulation, the EU is currently still the technological leader, but the gap is closing. Finally, for solar PV and in particular for biofuels, the EU is neither the technological leader, nor do the growth rates suggest that the EU is catching up. China, by contrast, does not yet account for a majority of patents in any of the technologies considered. Yet, if Chinese companies manage to maintain the current rapid growth in patenting activity, this is bound to change eventually for technologies such as water pollution abatement, insulation or solar PV.

Lastly, it is important to consider the role of Eco-Industries terms of overall economic performance. A recent US think tank study found useful secondary effects from clean economy activity. The clean economy in the US was found to entail a larger share of manufacturing activity than the economy as a whole and it exported twice the value per job, on average, than the standard US job. This is likely to be the case in the EU as well. Thus, when considering the EU's target of a 20% share of industry in GDP by 2020, industrial policies and the wider economic framework should be designed such that Eco-Industries form a substantial part of this target.

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