Europe's low carbon industries: A health check

October 2014

Building a better working world

Contents

Foreword

The term “low-carbon industries” is used in this report to refer to the set of industries which manufacture and deploy technologies and solutions to enable reductions in man-made greenhouse gas emissions, and thus the transition to a low-carbon economy.

The development of these industries constitutes part of the solution for limiting the EU’s growing energy dependency and trade deficit, and for enhancing its industrial competitiveness. Low-carbon industries have the potential to yield significant economic growth and job opportunities for the EU and the rest of the world in the coming decades.

The present study seeks to investigate the extent to which this potential is being exploited in Europe, and to which political and policy drivers are contributing towards the growth of a selection of these industries at various stages of development. This “health check” is carried out by examining the criteria of market development and innovation, in comparison with steps taken and progress made in other major economic regions.

For each low-carbon industry covered in this report, the approach consists of examining data and trends which shed light on the following questions:

- Market trends and global players: What steps have the world’s main economic regions taken to develop the industry? Which regions are becoming its key players?
- Europe’s progress and positioning: What is Europe’s degree of progress in terms of market development and innovation, compared to other regions? In cases of relatively mature industries, which have globalized some of their production segments, how is Europe positioning itself within global markets?
- “Low-carbon investment leakage”: Is Europe making the necessary investments to develop the industry? Or could there be potential “investment leakage”, whereby the EU would be failing to mobilize the necessary investments for developing its low-carbon industries, while other economic regions would be making such investments?

Executive summary

This executive summary outlines the key findings of the study for each of the low-carbon industries within its scope, and synthesizes the arguments put forward in the reviewed body of literature.

The study addresses the EU's state of progress, in terms of innovation and market development, for a selection of low-carbon industries, and is not a full assessment of all low-carbon industries.
The technologies within its scope were selected so as to consider:

- mature renewable energy markets with high remaining potential (wind, solar PV);
- solutions for integrating and balancing a power system based on renewable energy (smart energy solutions, energy storage technologies);
- the main solutions known at present for the low-carbon transition of the transport sector (alternative vehicles, biofuels).

Skill requirements and potential shortages are also discussed as a cross-sector theme, to illustrate the challenges the EU could face on that key success factor.

Solar PV energy

Europe was the first economic power to deploy solar PV on a large commercial scale, and still accounts for 57% of global installed capacity. Over the last three years, other regions have entered the field; the PV industry employed 2.3 million people in 2013 worldwide, including 220,000 in the EU. However, while the rest of the world has embarked on a strong growth path, the number of annual installations in the EU has been declining since 2011, despite significant untapped market potential.

China and Taiwan have become leaders in the production of PV modules, with 70% of global production; their price competition is primarily responsible for Europe's declining market share in this particular segment. However, with 73% of the total value of the European PV market still created within Europe, there remains market potential in segments such as installation, operations and maintenance, and optimization services. In addition, with a strong manufacturing base on certain components of PV systems, Europe can even secure a perennial position within the PV manufacturing global value chain, and continue contributing towards innovation at global level.

Wind energy

Onshore wind energy has become a cost-competitive source of energy in many regions, and is set on a trend for worldwide deployment. The industry employed 834,000 people worldwide in 2013, including about 328,000 in Europe and 356,000 in China. Europe has played a pioneering role in terms of R&D and market development, and still accounts for 38% of cumulative installed capacity today. It is a major player in global manufacturing of wind turbines and components, with a trade surplus of €5.6 billion in 2010, mainly in wind turbine and component manufacturing. However European companies will face increasing competition with the rise of large Chinese manufacturers.

Similarly, Europe is leading innovation and market take-off for the offshore wind industry. This challenging industry would benefit from cooperation at the global scale for innovation and project financing. This is something that Europe could help to drive.

Such prospects could however be jeopardized by the recent significant fall of renewable energy investments in the EU, with a 58% decrease of investments between 2011 and 2013 in renewable energies (mainly solar PV and wind). Europe's policy framework may not be well-adapted for further growth of the renewable energy sector, with lack of certainty regarding long-term targets and support mechanisms, which could present a risk of "investment leakage". In the meantime China has sustained its investment efforts and is now the world's top investor in renewable energy.

Biofuels

Despite promising growth throughout the 2000s, the conventional biofuels market proved to be a "false start", hindered by feedstock price volatility and impact on food prices, as well as concerns about indirect land use change and resulting GHG emissions. The European Commission has set a 7% limit on the use of food-based biofuels in transport fuel, and is unfavorable to further supporting that industry after 2020.

The global biofuels industry nevertheless employed 1.5 million people worldwide in 2013, including 110,000 in the EU, mainly agricultural jobs found in feedstock production. That workforce could be maintained and even grown with the development of advanced biofuels, which appear to be a more promising and sustainable alternative to fossil fuels.

Although advanced biofuels are currently at the emerging stage, the EU and the US are gathering some of the necessary conditions for tapping into future market potential, with relatively supportive policy frameworks and first-mover status for R&D, demonstration and commercialization projects. Given the late criticisms towards first-generation biofuels for skewing commodity markets, worldwide cooperation will be necessary to structure a mature global value chain, for which future land availability remains uncertain at this stage.

Alternative vehicles

With the second largest vehicle market, the highest absolute automotive R&D spending, high net exports, and strong assets in lead-based battery manufacturing, including emission-saving microhybrid applications, the EU lies on solid foundations for developing its domestic alternative vehicle market (HEV, PHEV, BEV) and eventually seeing its companies tap into global market opportunities. There are however signs of “investment leakage”, with the EU’s potential not being fully exploited, and electric and hybrid vehicle domestic market development lagging behind Japan and the US. Alternative vehicles are a relatively mature market in Japan (4% of the vehicle fleet in 2012, over 3 million vehicles in use) and the US (over 1% of the fleet in 2013).

Japan’s market growth has been driven by long-term targets and support mechanisms set by the Government, which for instance announced in 2010 the “Next-Generation Vehicle Strategy”, aiming to increase the share of alternative vehicles in new vehicle sales to 20-50% by 2020.

Moreover, the EU is being outdistanced by Japan in terms of innovation as measured by patent applications. As for R&D spending in lithium-based batteries, Japanese car manufacturers appear to be leading the way, while China’s public funds recently injected into electric vehicle R&D place it among key players for the future.

While public policies and private investments are gathering the conditions for the global alternative vehicle market to triple by 2020, and to continue growing thereafter, it is uncertain that Europe would place among leaders of the automotive transition. Market take-up is however recent, and the automotive industry is one where first-mover advantage does not necessarily materialize. Despite a late start, the opportunity for Europe for finding its place in the global alternative vehicle industry remains open.

Smart energy solutions

Smart energy solutions are a rapidly growing market, with much future potential. This is related to the need for renewal and upgrade of existing power grids, mainly in Western countries, and the development of new capacities in emerging nations. Smart metering and the smart grid industries are currently of equivalent size, while the third pillar of the smart energy solutions, smart homes, is as yet largely unexplored.

In order to integrate Europe's electrical grids – which is a precondition for an increasingly renewables-based power system – each Member State will need to renovate and improve its existing infrastructure. Europe’s deployment of smart meters is in line with other economic regions, though its investments in grid applications are less extensive than those in the US and China. Regarding the global innovation effort, the EU’s contribution is likely to rely on its incumbent electrical equipment giants, though it is too early at this stage to identify which region is taking leadership.

Grid energy storage

Led by projects in Germany, France, Italy, and the UK, the EU is establishing the necessary conditions for becoming a key player on the international energy storage market. It can rely on a solid manufacturing base in lead-based batteries, technological leadership in hydrogen storage, and a need to balance an energy system with an increasing share of renewables. However, the EU would need to harmonize its policy framework, clarify its grid regulation, and create more integrated energy markets to enable the deployment of innovative and commercially available energy storage systems, such as decentralized energy storage for grid management (for peak shaving, renewable energy integration, frequency regulation…) and energy management in homes and buildings (for self-consumption time-shifts, smoothing of renewable energy feed-in, uninterruptible power supply…).

In the meantime, other major economies are investing in R&D and setting supportive policy frameworks and targets for market deployment. For instance, the US Department of Energy has a specific budget of USD200 million over 2011-2015 specifically dedicated to energy storage R&D projects. Japan, Korea and China produced 95% of all lithium batteries in 2011 for the consumer electronics market, though this does not necessarily guarantee future success in grid-scale batteries, which involve more advanced technologies.

Building up the required skillset

In the context of economic difficulties and unemployment in Europe, low-carbon industry represents an opportunity to create new jobs. However, there is a gap between supply and demand of new skills needed for the development of low-carbon technologies. The EU wind energy industry could face a shortage of 18,000 qualified staff by 2030. 50,000 electronic engineers would be needed in the EU automotive industry by 2030 for developing alternative vehicles. Construction skills necessary for green buildings could be lacking due to an aging workforce.

There are many opportunities for job creation in the low-carbon economy in Europe. In order to keep developing its low-carbon industries, the EU needs to implement major improvements to address predicted skill shortages, such as improving STEM skills (Science, Technology, Engineering and Mathematics), harmonizing Vocational Education and Training, and increasing the emphasis on O&M training.

Conclusion

This report examines a variety of low-carbon industry situations with different characteristics, development stages, policy frameworks, and market dynamics. The analysis yields the following conclusions:

- The low-carbon transition could represent a major socio-economic shift and yield significant market opportunities. The market forecasts reviewed in this report expect global market size for each of the industries to grow significantly, to reach up to USD100 billion per industry by the turn of the decade, provided key success factors are gathered for these industries requiring large capital investments.
- Successful take-off of low-carbon industries hinges on political direction and support. This key condition for success explains Europe's early-mover and leadership status in the solar PV and wind sectors, and the recent rise of the US and China. Another example is the maturing of the alternative vehicles sector in the US and Japan, while Europe has opted for diesel as its primary low-carbon vehicle technology, indicating a possible case of "investment leakage" in that sector.

  A similar situation could occur in other cases where the EU is placing as an R&D and early commercialization leader in emerging markets (advanced biofuels, offshore wind, grid energy storage), but where growth could be slowed down in the absence of a supportive policy framework.
- A predictable regulatory framework and adequate political support remain necessary for low-carbon industries even in a mature stage. Investment leakages due to political uncertainty have been observed in the cases of solar PV and wind energy, where concerns about future policy support in the EU and the US have delayed investment decisions since 2011, while China has sustained its investment efforts. Furthermore, the right policy direction is necessary to avoid potential shortages in skills required for securing the continued development of low-carbon industries.
- The game mostly remains open in low-carbon industries. The PV module experience shows that Europe can rapidly lose its competitive position to a new market entrant, but that opportunities remain if it manages to find its right place in the global value chain. In the wind energy sector, Europe has played a pioneering role, and is today a major player in global trading of wind turbines and components, but its companies will have to face increasing competition from Chinese manufacturers. Conversely, in emerging industries where Europe has been less active (e.g. alternative vehicles), opportunities remain open, and Europe can rely on solid industrial assets and know-how to contribute towards innovation and market development at global level – if it chooses to. In a context of "coopetition", opportunities will also arise for global cooperation schemes, as illustrated in the case of offshore wind, where joint ventures with Asian companies have financially supported large-scale projects in Europe.

The health check carried out in this study has shown that it is critical for the EU to provide long-term policy certainty and clear targets to set the right investment climate, if it is to seize the major market opportunities emerging in low-carbon industries. This would need to be complemented with an industrial strategy, stimulus packages and technological integration policies for low-carbon solutions where the EU has a strong role to play.

Introduction

The concept of low-carbon industry is often used in publications such as news articles or study reports, but does not have a commonly accepted definition. In the present report, the term is used to refer to the set of industries that manufacture and deploy technologies and solutions to enable reductions in man-made greenhouse gas emissions and the transition to a low-carbon economy.

The case for building strong low-carbon industries

The development of low-carbon industries constitutes part of the solution for limiting the EU's growing energy dependency and trade deficit, enhancing its industrial competitiveness, and reducing greenhouse gas emissions. Most of the transition to a low-carbon economy remains to be achieved. For instance, wind power, a relatively mature low-carbon industry, accounts for less than 3% of global electricity consumption, indicating that much growth potential could remain in the coming decades.

Moreover, low-carbon industries could yield significant economic growth and job opportunities for the EU and the rest of the world in the coming decades. Existing market projections indicate potentially strong growth trends for a range of low-carbon technologies. Green stimulus packages adopted in past years in key economic regions show that the world's other major economies intend to seize these market opportunities. For instance:

- The United States regained their leading position among G20 countries in 2011 in terms of investments in clean energies, with an amount of USD48.1 billion. This evolution reflects part of the effects of the American Recovery and Reinvestment Act (ARRA) signed in 2009 by Barack Obama.
- Japan, in response to the Fukushima accident, increased its clean energy investments by 75% in 2012, to USD16.3 billion. 97% of these investments relate to solar energy. An obligation through the Renewable Portfolio Standard (RPS) since 2003 requires electricity suppliers to include renewable energy in their electricity mix. Moreover, Japan's main car manufacturers are strongly investing in alternative vehicles and in the reduction of the transport sector's carbon emissions.
- China adopted in 2010 a policy measure to support the development of seven strategic industries including energy efficiency, environmental protection, clean energy, low-carbon transportation, and new materials. The 11th and 12th five-year plans (2006 – 2010 and 2011 – 2015) include measures to develop smart-grids, low-carbon transport, as well as biomass, wind, solar and geothermal energies. As part of China's economic stimulus plan following the global financial crisis, USD46 billion were allocated to clean energies. China's clean energy deployment is expected to accelerate significantly in the near future: the development plan of the National Energy Administration for emerging energy industries will require direct investments totalling 5 trillion Yuan (€600 billion) from 2011 to 2020.

The purpose of this study is to provide a "health-check" of low-carbon industry development in Europe, through the lenses of market development and innovation, in comparison with steps taken and progress made in other major economic regions. The review will allow conclusions to be drawn as to what extent Europe is contributing towards the global development of low-carbon industries, and their expected benefits. It will also examine the emerging concept of "low-carbon investment leakage" whereby the EU would be failing to mobilize the necessary investments for developing its low-carbon industries, while other economic regions would be making such investments.

Scope of this study

This study addresses the state of progress of innovation and market development for a selection of six low-carbon industries:

- Solar PV energy;
- Wind energy;
- Biofuels;
- Alternative vehicles;
- Smart energy solutions;
- Grid energy storage.

Skill requirements and potential shortages are also discussed as a cross-sector theme, to illustrate the challenges the EU could face on that key success factor.

This study is not a full assessment of all low-carbon industries. The technologies within its scope were selected for the following aims of the study:

- Analyzing mature renewable energy markets with high remaining potential; renewable energy technologies will be one of the major features of the low-carbon transition. Solar PV and wind are more advanced in their capacity build-up than other renewable technologies (solar heating/cooling, biogas, geothermal, concentrated solar power, marine power, etc.), which are out of this study's scope. In addition, much solar PV and wind energy potential remains to be exploited, as opposed to hydroelectricity which will be facing physical and natural constraints, and thus out of the scope of this study.
- Analyzing the state of progress of solutions for integrating and balancing a power system based on renewable energy: smart energy solutions and energy storage technologies could be necessary for handling the intermittency or variability of renewable energy technologies. These industries are entering the commercialization stage, with potentially significant investments undertaken over the next decades.
- Analyzing the main solutions known at present for the low-carbon transition of the transport sector: while much of the carbon emission savings potential will lie in enhanced efficiency of internal combustion engines, this study takes interest in the potentially shifting technological landscape of the global automotive industry, with low-carbon drivetrains and fuel technologies emerging out of their niche markets. Within the alternative vehicles sector, the report focuses on technologies that have entered commercialization and hold promising potential (hybrid-electric, plug-in hybrid-electric, electric vehicles). Natural gas vehicles, which will have limited prospects according to the reviewed literature, as well as hydrogen fuel cell vehicle which remain at R&D stage, are out of scope. Regarding new fuel technologies, both conventional and advanced biofuels are within scope to examine their respective prospects.

The report therefore focusses on some elements of the transition of the power sector to a renewables-based system, and the evolution of the transport sector. The following features of the low-carbon transition are out of scope:

- Breakthrough technologies and energy efficiency solutions intended for the buildings and the energy-intensive industry sectors (though the technologies addressed in this study will indirectly affect these sectors as part of a systemic transition);
- Solutions for other Greenhouse Gas emitting sectors (agriculture, forestry, waste management);
- Within the power sector itself, co-generation and district heating and cooling, energy services, and strengthening of the European transmission grid;
- Carbon capture and storage, which remains at early demonstration stage.

Specific policy recommendations which could result from the conclusions of this report are out of scope. However, the report points to cases where stimulus packages in a given region have spurred low-carbon industry growth. Conversely, the report will point to some cases in Europe where the lack of a supportive, stable and consistent policy framework could be slowing or hindering low-carbon industry growth.

Methodology

This study addresses industries that are in very different situations:

1. Relatively mature industries which have entered worldwide commercial deployment (solar PV, wind).
2. Maturing industries which have entered commercialization in certain parts of the world (alternative vehicles).
3. Industries at the R&D, pilot and demonstration phase or early commercialization stage (grid energy storage, smart energy solutions).

Biofuels are another specific case: after wide-scale commercialization of conventional biofuels, the industry's development came to a stall at the turn of the last decade in many regions, including Europe. Future development potential is borne by advanced biofuels, currently in-between demonstration and commercialization.

The industries studied in this report further differ in terms of their domestic market dynamics, trade dynamics and value chain interconnectedness, existing policy frameworks, key success factors, and possibility of measuring success in an objective manner.

Because of this diversity, the approach for studying each industry will vary. Though the topics of market development, future economic and employment potential, and innovation are systematically analyzed, the qualitative and quantitative parameters collected to support the conclusions will differ for each industry. Moreover, the conclusions themselves are not comparable from a sector to another. Priority has been given to the relevance of the evidence, rather than to a methodical and normalized approach.

Qualitative and quantitative data was collected through a literature review of publications from recognized institutions. Most of the collected data is historical and considered as accurate; conclusions are drawn on clear tendencies, and remain cautious otherwise.

The global value chain in low-carbon industries, just as in many other industries, is interwoven and complex. Similarly, cross-border cooperation for innovation and R&D may be strong in some cases. For instance, data such as patent applications can be misleading, as a patent filed in a given region may result from the effort of another region. The main limitation of this study is the absence of a bottom-up construction of the conclusions, which would entail a detailed analysis of company-level and/or segment-level data of the global value chain. In certain cases, conclusions may be drawn from data specific to a given segment of the value chain (e.g. PV module manufacturing, biofuels feedstock production). This report provides a general overview of each sector and not a detailed assessment of each sub-segment.

Rather, the approach consists, for each low-carbon industry, of examining macro-level information and trends which shed light on the following questions:

- What steps have the world's main economic regions taken to develop the industry? Which regions are becoming its key players?
- What is Europe's degree of progress in terms of market development and innovation, compared to other regions? In cases of relatively mature industries (solar PV, wind energy), which have globalized some of their production segments, how is Europe positioning itself within global markets?
- Is Europe making the necessary investments to develop the industry? Or could there be potential "low-carbon investment leakage", whereby the EU would be failing to mobilize the necessary investments for developing its low-carbon industries, while other economic regions would be making such investments?

It must be specified that when mentioning a country or region, this study refers to production and markets on that country or region's soil. It may be that the companies operating are non-European, and that part of the production may be exported, but opportunities are still created for European workers.

In some cases the study refers explicitly to companies from a country or region. In these cases the reference is to the opportunity for European companies working on European soil to export towards global markets.

1. Solar PV energy

Having been a pioneer in this area, the EU is no longer the main market where photovoltaic is being deployed on a wide scale.

After a period where demand for PV technology was limited to Europe, other markets have emerged over the years in other regions, including emerging markets. Installed capacity was only 2.6 GW in 2003, and increased to 15.8 GW in 2008 and 138.9 GW in 2013[1].

Solar energy still has a long way to go before becoming a significant component of the energy mix. In the EU, where the share of solar PV in the mix is by far the largest, solar energy represents 3% of electricity demand and 6% of peak demand. Markets worldwide have only tapped into a small part of their potential so far.

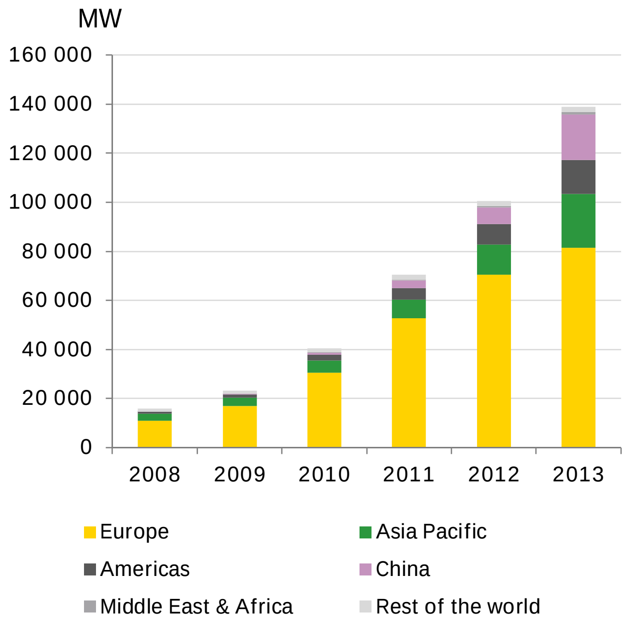
The European Union is the world's leading region in terms of cumulated installed capacity, with 57% of global cumulative capacity[2]. Over the past three years, the market has also taken off in Asia and the US.

The global PV market progressed in 2013, reaching a record of almost 40 GW installed in a year. The most striking evolution in the past two years is the rapid development of PV in Asia. China was a leading market in 2013, with 11.8 GW of additional installed capacity. Japan has also entered the field with 6.9 GW connected to the grid, followed by the US with 4.8 GW.

However, the European market has faced a drop in installations over the last two years. The EU's share went down from 75% of the world's installed capacity in 2011 to 59% in 2013.

Europe installed 11 GW during the year 2013, down from its record performance reached in 2011 (22.3 GW installed), which was driven mainly by Italy and Germany.

Evolution of global PV cumulative installed capacity 2008 – 2013



Source: EPIA, Global Market Outlook for Photovoltaics 2014-2018, 2014.

Probability scenarios projected by EPIA assume slow market growth in Europe and a growing market in other economies that have recently entered the field. In the most favorable scenario, the European market would install 13 GW in 2014 and increase to 17 GW in 2018. In parallel, in that favorable scenario, the global market could install 69 GW in 2018[1].

Similarly, Lux Research expects a 61.8 GW market in 2018, and a growth from about USD95 billion in 2013 to USD155 billion in 2018, mostly led by the US, China, Japan and India[3].

IRENA estimates that the global solar PV industry employed 1.4 million people in 2012, a workforce that increased to 2.3 million people worldwide in 2013, including:

- 1.6 million jobs in China (up from 0.3-0.5 million in 2011);
- 220,000 in the EU (including 56,000 in Germany, down from 110,000 in 2011);
- 143,000 jobs in the US (up from 119,000 in 2012)[4].

1 EPIA Global Market Outlook for PV 2014-2018
2 EPIA
3 Lux Research, Market size update 2013: Return to equilibrium, 2013
4 IRENA, Renewable Energy and Jobs, Annual Review 2014

PV development in Europe has recently declined because of a less favorable policy framework, and falling prices for Asian PV modules.

The main drivers for PV market development so far have been relying on:

- Ambitious targets for renewables set by the European Commission, through the Renewable Energy Directive that came into force in 2009 and set a target of 20% RE in final energy consumption, broken down into 28 national targets[5];
- Significant political support in the sector, in particular through feed-in tariffs in European markets and R&D support to innovative energy technologies;
- Uncertainties regarding the availability and cost of fossil fuels and governments trying to reduce their energy dependence and secure their supply;
- Rapidly decreasing cost of modules: the average price of polycrystalline silicon unit fell from €2 / Wp in 2009 to €0.60 / Wp in 2012.

The reasons for the slow-down in European installations over the last two years vary between Member States. They include a combination of regulatory changes, feed-in tariff cuts, and difficulties selling excess electricity. PV remains a policy-driven business, where political decisions considerably influence market dynamics.

As was the case for Europe, emerging PV markets have developed through favorable policy frameworks. China has an ambitious plan of installing 50 GW by 2020, compared to 3 GW in 2012. In the US, solar PV is one of the main priorities of energy development and various projects have been undertaken to expand capacity. Japan aims to add 28 GW of new solar power production capacity by 2020 and 94% of renewable energy investments in 2011 concerned solar energy.

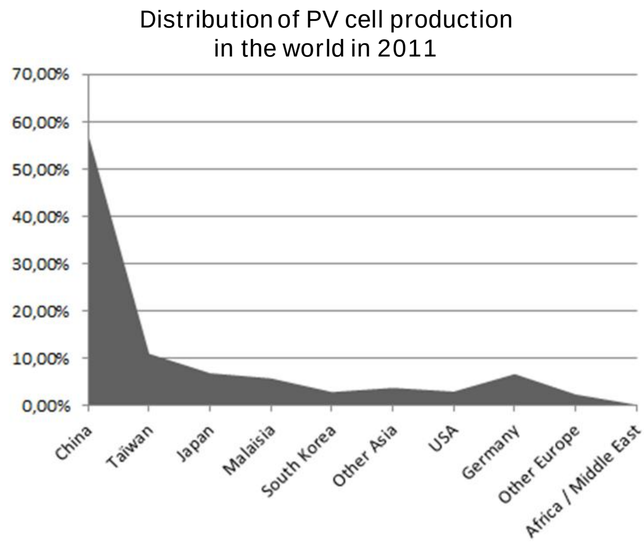
EU manufacturers further face difficulties because of strong price competition, posed mainly by Chinese and Taiwanese manufacturers. China and Taiwan together accounted for 70% of PV modules manufacturing in 2012[6].

The evolution of the PV market over the next five years will depend on the ability of European policymakers to maintain market conditions to an acceptable level. According to EPIA, two thirds of installed capacity over the period 2012-2017 will be undertaken by companies outside Europe.

Europe has lost ground in PV module manufacturing, but still represents an attractive market (optimization of production, Operation and Maintenance).

Based on analysis by EPIA, the value created by European PV activities is estimated at around €19.3 billion in 2012, *i.e*. 73% of the total value of the European PV market the same year[7].

While only 14% of the cells and modules are manufactured in Europe, the total value of European PV module manufacturing represented more than 51% of the value associated with the PV modules placed on the European market in 2012. That is partly because cell production and module assembly account for only 56% of the total PV module cost. This is also due to the presence of a strong European manufacturing base for polysilicon, PV equipment and PV materials.



Source: Le Journal du Photovoltaïque, 2012.

5 European Commission, Renewable Energy Directive 2009/28/EC, 2009
6 J. Popov, EU list of failings on low carbon grows, Financial Times, 25 November 2013
7 EPIA, Photovoltaics (PV) industry value chain analysis, 2013

Furthermore, modules represent a decreasing share of overall system costs. It appears that with over 80 GW of PV already installed in Europe, there will be a large market in the EU for optimization services and O&M activities, likely to create long-term employment in the solar PV sector.

The EU has taken action to tax solar panels from China. An investigation carried out by the EU in 2012 found that Chinese prices should be 88% higher and anti-dumping duty has been placed on Chinese solar products. This measure has received criticism in Europe by the PV sector itself, as it may penalize distribution and installation companies, which represent the majority of the European PV industry's activity. This underlines the fact that modules represents a limited share of the overall PV industry added value.

R&D activities and funding indicate that the US, Germany, Japan and Korea are leading the race for innovation.

With significant cost reductions of PV applications, solar energy is now being regarded as a common electricity supply option. Governments tend to identify the benefits of this technology's further development, and push for better integration with existing energy systems.

In 2012, the most significant countries in terms of R&D funding were the USA (USD262 million), Korea (USD118 million), Japan (USD130 million) and Germany (USD66 million)[8]. The EU, led by Germany, would have to remain active in technological innovation in order to stay among the leaders. Germany has an ambitious program and technological development should continue growing in the years to come, especially with its commitment to phase out nuclear power by 2022[9].

Europe was the first economic power to deploy solar PV on a large commercial scale, and other regions have entered the field over the last three years. However, while the rest of the world has embarked on a strong growth path, the number of annual installations in the EU has been declining since 2011, despite significant untapped market potential.

China has progressively emerged as a leader in the production of PV modules. Price competition from Chinese manufacturers is primarily responsible for Europe's declining market share in this particular segment. However, with 73% of the total value of the European PV market still created within Europe, there remains market potential in segments such as installation, O&M, and optimization services. In addition, with a strong manufacturing base on certain components of PV systems, Europe can even secure a perennial position within the PV manufacturing global value chain, and continue contributing towards innovation at global level.

8 IEA, Trends in Photovoltaic applications, 2013
9 David L. Chandler, Innovation in renewable-energy technologies is booming, MIT News Office, 10 October 2013

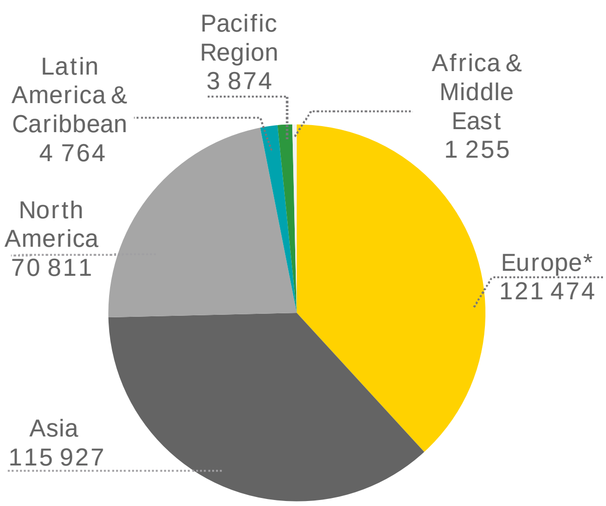
2. Wind energy

Europe is progressively challenged by Asia and the Americas in its leading market position.

According to GWEC, annual installed wind energy capacity has grown worldwide at a steady rate of around 30% per year over the last 10 years[1]. Onshore wind energy is increasingly competitive with newly built conventional power plants, in Europe but also every other continent, with prices as low as 50 USD/MWh[1]. Wind power represents 2.9% of global electricity consumption and generates a revenue of €50 billion for the sector.

At the end of 2013, six countries had over 10,000 MW of installed capacity: China (91,412 MW), the US (61,091 MW), Germany (34,250 MW), Spain (22,959 MW), India (20,150 MW) and the UK (10,531 MW). Other EU leaders include Italy, Spain, and Denmark as the historical pioneer. The EU accounted for 38% of global cumulative capacity in 2013.

Cumulative installed wind power capacity by region in 2013 (in MW)



** of which 117,289 MW in EU-28*
Source: GWEC.

China experienced the highest growth in 2013, with a newly installed 16,100 MW, *i.e.* nearly 46% of global newly installed capacity. China could build up to 1,000 GW of wind-power capacity in economically feasible onshore and offshore regions by 2050[2]. Germany ranked second with 9.1% of global newly installed capacity, and the UK ranked third with 5.3% of global newly installed capacity.

Global market growth in the wind sector is expected to be more than sustained in the coming years: total installed capacity could double from 300 GW in 2013 to 600 GW in 2018, with Brazil, Mexico and South Africa as some examples of significant market entrants[3].

To provide an indication of job potential, IRENA estimates that the global wind industry employed 834,000 people in 2013 including:

- 328,000 jobs in the EU (42% of which in Germany)
- 356,000 jobs in China
- 51,000 jobs in the US
- 48,000 in India
- 32,000 in Brazil[4]

Wind turbine and component manufacturing is the most intensely traded segment of the wind energy value chain. It represents 36.7% of added-value in the EU, compared to 20.5% for service providers and 42.8% for developers. Yet, turbine and component manufacturing represents 85% of the wind sector's exports[5].

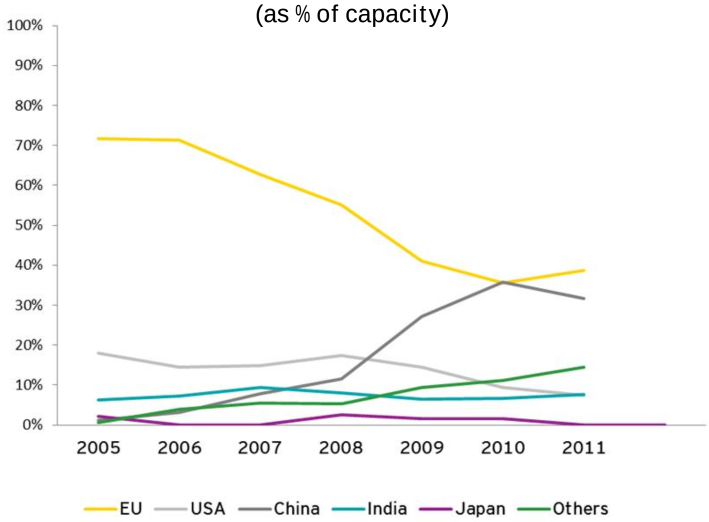
Driven by strong manufacturers in Denmark, Germany and Spain, the EU's wind energy sector exports were €8.8 billion in 2010, for a trade surplus of €5.6 billion, mainly driven by turbine and component manufacturing[5].

1 GWEC, Global Wind Report – Annual Market Update, 2014
2 Deutsche Bank Group, Scaling Wind and Solar Power in China – Building the Grid to Meet Targets, 2012
3 GWEC, Market Forecast for 2014-2018, 2013
4 IRENA, Renewable Energy and Jobs – Annual Review 2014
5 EWEA, Green growth – The impact of wind energy on jobs and the economy, 2012

Of the top fifteen wind turbine manufacturing companies, seven are Chinese, six are European, one is American and one is Indian. The global share of wind turbines supplied by large European equipment manufacturers has been decreasing in recent years relative to Asian competitors. EU manufacturers' share of global supply decreased from over 70% in 2005 to under 40% in 2011, while the share of Chinese manufacturers increased to above 30%. The share of American manufacturers (mainly General Electric wind) decreased from about 20% in 2008 to less than 10% of the global supply of wind turbines.

These relative shares seem to be in line with Europe and China's domestic market development. However, they indicate that, while still well-placed for exploiting further potential on global markets, European companies will face increasingly intense competition from Chinese manufacturers.

Share of wind turbine global supply by origin of manufacturers, 2005 – 2011
(as % of capacity)



Source: EWEA analysis on Make Consulting data

The EU is an innovation leader and first market entrant in the emerging field of offshore wind.

Offshore wind power remains more expensive than onshore wind, which will continue to be the leading wind technology in the coming years. According to the IEA, however, offshore capital costs are expected to decrease and would provide a growing share of the market, with one third of wind generation by 2050 in a scenario to limit global warming to 2°C. In the near term, offshore wind capacity is expected to increase from 5.4 GW in 2012 to 28 GW in 2018[6].

Offshore wind has entered the commercialization stage in Europe, though further R&D and deployment will be necessary to bring down costs, and progress needed on securing grid connections and financing. Most of the global market growth is currently led by the UK, Germany and Denmark. 14% of wind capacity installed in 2013 in the EU was offshore, while the market remains at the embryonic stage elsewhere. Europe could account for two-thirds of total installed offshore wind capacity in 2018, far ahead of China with 28%[6].

According to Bloomberg New Energy Finance, investment in wind energy R&D amounted to USD1.7 billion in 2013, the most strategic effort consisting of reducing the cost of offshore turbine foundations and developing new concepts for use in deeper water[7]. Europe seems to be able to maintain its historical leadership position in wind energy innovation. According to the MIT, Europe was staying ahead in the wind patenting race in 2013, with China moving into second place after Japan and leaving the US behind[8].

Innovation in the wind sector, however, will be a matter of global cooperation, for which Europe can be the engine. For instance, many Asian companies are investing in European technologies or creating joint-ventures with European companies, an effective lever for financing increasingly large projects. The European offshore wind energy industry would indeed need to mobilize €90-123 billion by 2020 to meet its deployment target of 40 GW cumulated capacity[9].

6 IEA, Technology Roadmap, Wind Energy, 2013 edition
7 BNEF, Global trends in renewable energy investment, 2014
8 David L. Chandler, Innovation in renewable-energy technologies is booming, MIT News Office, 10 October 2013
9 EWEA, Where's the money coming from? Financing offshore wind farms, 2013

The European framework has been favorable to the development of wind energy, but may not be sufficient for further development.

Policy plays a major role in mobilizing and incentivizing investments in clean energy. The following figures provide an indication of recent policy effects on investments in both solar PV and wind, which make up the bulk of renewable energy investment:

- EU: USD48 billion invested in 2013 in renewable energy, a decrease of 58% since peak year 2011;
- US: USD36 billion invested in 2013, a decrease of 33% since 2011;
- In contrast, China: USD56 billion invested in 2013, an increase of 8% since 2011[10].

The main EU legislation pushing for renewable energy remains the Renewable Energy (RE) Directive. In January 2014, the EC proposed a climate and energy package with targets for 2030, according to which the EU should reduce greenhouse gas emissions by 40% compared to 1990 levels, and reach 27% renewable energy penetration.

Recent investment trends however show the potentially negative impact of the current regulatory and political uncertainty across Europe, including with regards to the question of grid and infrastructure requirements. Though market growth was sustained overall, unstable legislative frameworks undermined investments. Formerly large wind energy markets such as Spain, Italy and France have seen their rate of installations decrease significantly in 2013, by 84%, 65% and 24% respectively[11].

In contrast, RE legislation was recently re-adapted in the UK and is still evolving in Germany. In the UK, a Contract for Difference (CfD) system was introduced and approved under the 2013 Energy Act. In April 2014, eight renewable energy projects were awarded CfD, amongst which five offshore wind farms. In Germany, the government approved in April 2014 draft reforms of Germany's Renewable Energies Act (EEG). The scheme foresees an annual 2.5 GW cap for onshore wind, only including net additions from repowering projects. The offshore wind target is set at 6.5 GW in 2020 and 15 GW by 2030. A buffer of 2.2 GW in grid connection approvals by 2020 is also expected.

In 2011, the US regained its leading position among G-20 countries in terms of RE investments (USD53 billion). This evolution is mainly due to the American Recovery and Reinvestment Act (ARRA) of 2009, which provides political and financial support for green industries. However, concerns about future policy support have delayed investment decisions since 2011.

In China, the policy framework and Renewable Energy Law, launched in 2003 and frequently revised since then, provides support for development concessions, feed-in tariffs, public-led investigation of available wind resources, and planning and targets for large-scale integration of wind energy in the power system.

Onshore wind energy has become a cost-competitive source of energy in many regions, and is set on a trend for worldwide deployment. Europe has played a pioneering role in terms of R&D and market development. It is a major player in global manufacturing of wind turbines and components, though its companies will face increasing competition from Chinese manufacturers. Similarly, Europe is leading innovation and market take-off for the offshore wind industry. This challenging industry would benefit from cooperation at the global scale for innovation and project financing.

Such prospects could however be jeopardized by the recent significant fall of renewable energy investments in the EU, with a policy framework that may not be well-adapted for further growth of the renewable energy sector, and could present a risk of "investment leakage". In the meantime China has sustained its investment efforts and is now the world's top investor in renewable energy.

10 BNEF, Global trends in renewable energy investment, 2014
11 EWEA, Wind In Power – 2013 European Statistics, 2014

3. Biofuels

The term biofuels refers to liquid, solid or gaseous fuels produced from biomass (organic matter derived from plants, animals or biodegradable waste). Biofuels are mostly used as additives or supplements to traditional fuels (diesel, gasoline, kerosene or gas).

They can be classified into two main categories:

- Conventional (or first-generation) biofuels, produced primarily from food crops such as grains, sugar cane and vegetable oils;
- Advanced (or second-generation) biofuels, produced from feedstock that are not food crops (lignocellulosic biomass, wood crops, agricultural residues or waste).

The US and South America are the regions that have the most heavily invested in the conventional biofuels market.

The global biofuels market is mainly dominated by the ethanol industry, where the United States and Brazil account for 80% of production[1]. This domination can be explained by competitive prices of raw materials, the level of historical or current political support, and the commercialization of flex-fuel vehicles. China is the third largest producer, but its production for the period 2011-2015 is expected to remain stable, in the absence of higher targets.

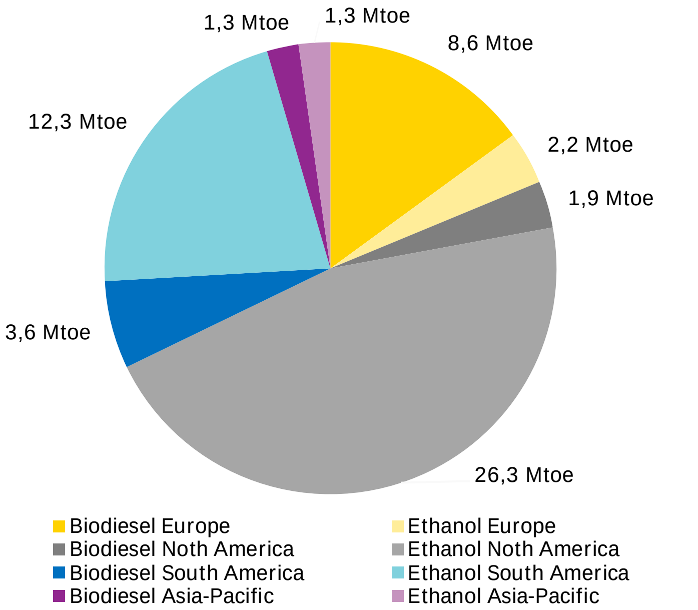
Europe has strongly positioned itself on the biodiesel segment of the conventional biofuels market.

Biofuels consumption reached 13.6 Mtoe in 2013 in the EU, accounting for 4.7% of total fuel consumption for transport[2]. Biodiesel is the most consumed biofuel in Europe, with 79% of total consumption against 20% for bioethanol. In 2010, the EU accounted for 55% of global biodiesel production. Germany and France were the first producers in the world, ahead of the United States and Argentina[3]. This was significantly driven by targets adopted by the EU in 2009 for reducing transport emissions in its landmark climate and energy goals for 2020.

EU Member States were required to source 10% of transport energy from renewable sources, mainly biofuels, by 2020. However, over recent years, first generation biofuels have been widely criticized for GHG emissions from indirect land use change and for skewing commodity markets by using up land that could be used for growing food, with a potential increase of the price of some crops by up to 36% by 2020[4].

Partly due to this, 2011 was a difficult year for the European biodiesel industry, with a decline in production of 8% according to the European Biodiesel Board. The rate of capacity utilization fell below 40% for the first time, resulting in four plants closing down in Spain. The industry was particularly affected by the sustainability criteria for biofuels under the Renewable Energy Directive 2009/28/CE (relating especially to greenhouse gas savings and agro-environmental practices) and the increase in imports of Argentinian and Indonesian biodiesel, which reached 2.6 million tons in 2011, rising by 30% in one year. The bioethanol industry suffered less with a growth of about 3% according to initial estimations – a growth below the increase in consumption due to higher imports of North American bioethanol.

Production of biodiesel and ethanol in 2010, in Mtoe



Source: USDA Foreign Agricultural Service, Argentina Biofuels Annual, 2011

1 IFPEN, Biofuels update: growth in national and international markets, 2012
2 EurObserv'ER, Biofuels Barometer, 2014
3 USDA Foreign Agricultural Service, Argentina Biofuels Annual, 2011
4 Oxfam International, The hunger gains, 2012

Development perspectives for the conventional biofuels market will remain limited, as opposed to the advanced biofuels market.

As a response to concerns over the secondary effects of biofuels, EU energy ministers agreed on May 28th 2014 to a 7% incorporation cap on food-based biofuels for use in transport. Furthermore, according to the 2030 framework for climate and energy policies, the European Commission is no longer favorable to the definition of new targets beyond 2020. Food-based biofuels should thus no longer receive public support after 2020.

Recent developments at the global level confirm that future growth of conventional biofuels will remain limited. Following a peak production capacity investment in 2007 of USD28 billion, the last five years have seen a strong decline to USD2.8 billion in 2012, not only due to the controversy on the impact of biofuels on food price increases, but also due to actual rises in agricultural commodity prices[5].

On the other hand, though uncertainties remain at this stage on future availability and cost of feedstock, advanced biofuels could have a strong role to play in the future transport energy mix. As part of its BLUE Map Scenario for stabilizing atmospheric greenhouse gases at 450 ppm, the IEA forecasts that 27% of world transport fuel could be provided by biofuels in 2050, 90% of which would originate from advanced biofuel production[6]. Pike Research estimates that the global biofuels market could double from USD83 billion in 2011 to USD185 billion in 2021[7]. This is of course provided that policy, and especially economic hurdles, closely related to physical and natural constraints, are overcome.

To provide an indication of job potential, for now mostly agricultural jobs found in feedstock production for conventional biofuels, IRENA estimates that the global biofuels industry employed 1.5 million people in 2013 including:

- 820,000 jobs in Brazil;
- 236,000 jobs in the US;
- 26,000 in Germany, and 85,000 in the rest of the EU[8].

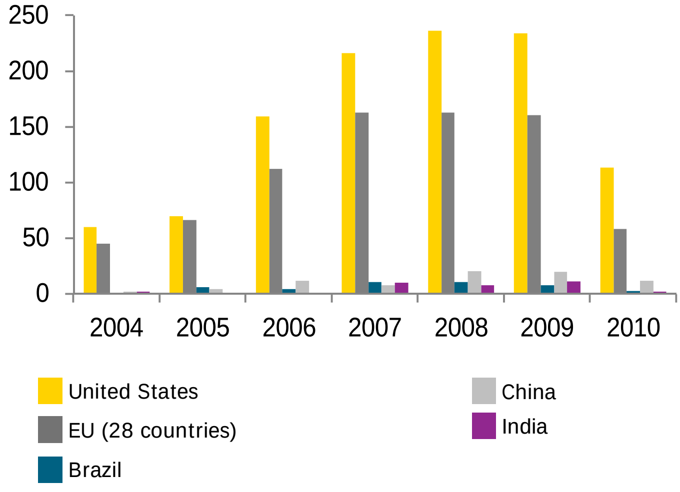
Advanced biofuels remain at pilot and demonstration phase, but Europe, along with the US, is well positioned to tap into future market potential.

Despite a strategy of backing away from conventional biofuels, the European Commission acknowledges that policy development should focus on further development of second and third generation biofuels and other alternatives, as part of a more holistic and integrated approach[9]. Europe and the United States are among the few to have put in place supportive policy measures, with financial support for production facilities, and a sustainability certification scheme in the case of Europe.

Compared to the conventional biofuels "boom" of the mid 2000's, R&D and investment figures for advanced biofuels are too low at present, and trends too recent, to draw definitive conclusions on emerging leaders. However, Europe and the US are, for the time being, taking the lead for innovation in advanced biofuels.

Firstly, as shown in the graph below, throughout the 2000s, the US and the EU were filing the most patents relating to biofuels. Though innovation was mostly driven by conventional biofuels (explaining the drop in the late 2010s), research communities in those regions have built an asset for further innovation in the domain.

Number of biofuels patent applications by region



Source: OECD Patent Database

5 IEA, Tracking Clean Energy Progress, 2013
6 IEA, Technology Roadmap – Biofuels for Transport, 2011
7 Pike Research, Biofuels Markets and Technologies, 2012
8 IRENA, Renewable Energy and Jobs – Annual Review 2014
9 European Commission , A policy framework for climate and energy in the period from 2020 to 2030, 2014

Secondly, since the early 2010s, Europe and the US were the main regions accounting for the considerable deployment of demonstration and pilot plants, thereby progressively entering into commercialization stage[10]. On the back of a supportive policy framework, European companies increased their investments. In Denmark, Novozymes has become a leader in developing enzymes to break down waste. In Italy, Biochemtex has built a €150 million biorefinery. In the UK, Solena Fuels in partnership with British Airways has committed to building the world's first facility to convert landfill waste into jet fuel. In Finland, UPM developed a renewable wood-based diesel, made from a pulp production residue called crude tall oil. The annual production of UPM BioVerno in Lappeenranta will cover nearly a quarter of Finland's 20% renewable energy target for transport in 2020.

Similarly, a major challenge for the advanced biofuels industry will consist of securing feedstock and reducing its costs in order to become eventually competitive with fossil fuels. According to the IEA, more precise mapping of underutilized land resources and global trading will become increasingly important in lifting economic and natural barriers. For instance, in the case of Europe, where land availability is a limiting factor for the Western part, the IEA identifies Eastern Europe and Ukraine as strong potential feedstock suppliers, with 40 Mha of underutilized land which could become available for advanced biofuel feedstock production[6]. Such feedstock production schemes and trade routes yet have to develop and structure themselves in order for advanced biofuels to play a significant and sustainable role in the future global energy mix.

World markets will remain interwoven and the global value chain for advanced biofuels has yet to structure itself.

The main cost factor for conventional biofuels is feedstock (45%-70% of total production costs). For advanced biofuels the main factor is capital costs (35%-50%), but feedstock remains a significant share of the cost chain (25%-40%)[11].

Biofuel feedstock was intensely traded under the conventional biofuel regime. For instance, 14% of global biodiesel production, for which the EU is a strong net importer, was traded on world markets in 2010[12].

Global trade in biofuels is however volatile and can be strongly affected by climatic hazards (and their impacts on availability and prices of agricultural resources), policy developments for biofuels, and new market entrants. For instance, due to the weakness of the US dollar and the appreciation of the Brazilian real, American ethanol has been recognized as increasingly competitive and the exports have grown significantly since 2010. Brazil, a large consumer which experienced a difficult harvest, became a net importer in 2011 for the first time. International trade in biodiesel was close in volume to world trade in bioethanol and involved important flows from Argentina and Asia (Indonesia, Malaysia) to Europe, which greatly destabilized the European biodiesel industry (plant closures, receiverships)[13].

Despite promising growth throughout the 2 000s, the conventional biofuels market proved to be a "false start", hindered by feedstock price volatility and impact on food prices, as well as concerns about indirect land use change and resulting GHG emissions. Advanced biofuels appear to be a more promising and sustainable alternative to fossil fuels.

Although advanced biofuels are currently at the emerging stage, the EU and the US are gathering some of the necessary conditions for tapping into future market potential, with relatively supportive policy frameworks and first-mover status for R&D, demonstration and commercialization projects. Given the late criticisms towards first-generation biofuels for skewing commodity markets, worldwide cooperation will be necessary to structure a mature global value chain, for which future land availability remains uncertain at this stage.

10 IEA, Sustainable production of second-generation biofuels, 2010
11 IEA, Transport, Energy and CO2 – Moving towards mobility, 2009
12 Ecofys, International biodiesel markets, 2011
13 US DOE, Department of Energy Recovery Act Investment in Biomass Technologies, 2012

4. Alternative vehicles

Alternative vehicles have not yet entered wide-scale commercialization stage in the EU, in contrast with Japan and the US.

The EU automotive industry is a key component of its economy, with 12 million jobs, 16.2 million vehicles produced in 2012 (19% of global vehicle production, second to China with 23%)[1], and net exports of €70 billion in 2011[2]. Recent trends, however, show that the US and Japan are maturing their domestic alternative vehicle markets (HEV, PHEV, BEV), and gaining industrial know-how.

Though cars are mostly manufactured in the regions where they are sold (only 11% of passenger cars sold in 2011 worldwide were traded between North America, Europe and Southeast Asia[3]), the risk for Europe would be to miss the domestic market opportunity, and grow dependent on foreign innovation and import of automobile parts, batteries in particular.

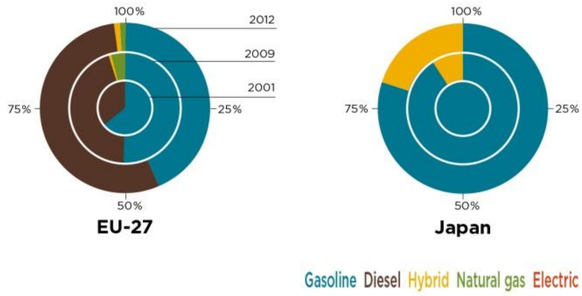
Japan's recent policy initiatives include the "New National Energy Strategy" (2006), aimed at improving vehicle energy efficiency by 30% by 2030, the "Next-Generation Automobile Fuel Initiative" (2007), which established sales targets for alternative vehicles, and the "Next-Generation Vehicle Strategy" (2010) which aimed at increasing the share of alternative vehicles in new vehicle sales to 20-50% by 2020. Alternative vehicles in use in Japan reached 4% of the vehicle fleet in 2012 (mostly HEV and PHEV), with over 3 million vehicles in use[4].

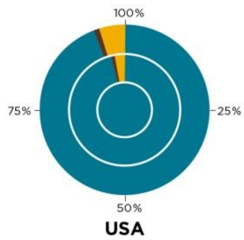
Similarly, in the US, the alternative vehicle market is largely dominated by hybrid vehicles. Incentives include tax breaks up to USD 7,500 for the purchase of electric vehicles. Public investments have been deployed, including USD2,4 billion in grants to lithium-ion battery makers, and USD3.1 billion in loans to auto companies. Electric and hybrid vehicles grabbed 2% of sales in 2007, a share that increased to 5% in 2O12. The US share of alternative vehicles in the total fleet went over 1% in 2013[5], above levels observed in Europe.

With the exception of the Netherlands (4.5% market share in 2013), alternative vehicles in the EU remain a niche market, with a little over 1% of registrations in 2013[6]. Sales have recently shown a strong growth, partly due to public stimulus packages (e.g. the UK's Plug-in Car Grant, France's Bonus-Malus system). The trend is however at the emerging stage, and hybrid and electric cars cover a marginal share of the total EU car fleet. In the case of Germany, which is illustrative because of the prominence of its automotive industry, registrations of hybrid and electric vehicles have steadily increased since 2006, with over 24,000 cumulated sales in 2012 (+65% compared to 2011). The total German car market in 2012 was 3,082,504 new passenger vehicle registrations, giving hybrid and electric vehicles a cumulated market share of 0.1%[7]. The EU's state of progress relative to Japan and the US could indicate a case of "investment leakage".

Europe, nevertheless, has advantages that could enable a stronger position in the alternative vehicles market. Besides the strong incumbency of its automotive industry, the transition to low-carbon vehicles would be facilitated by a strong manufacturing base for emission-saving microhybrid applications, as well as lead-based batteries, with over 25,000 workers[8], and to a lesser extent sodium-nickel chloride batteries.

Passenger car market shares by technology





Source: ICCT, European Vehicle Market Statistics, 2013

1 OICA, 2012
2 Eurostat
3 OECD, Capacity needs in the automobile industry on the short to medium run, 2013
4 JAMA, Report on Environmental Protection Efforts, 2013
5 Based on data from ETDA and State Clean Energy Index
6 ICCT, European Vehicle Market Statistics, 2013
7 Calculations based on data released by KBA, 2013
8 Eurobat, A review of battery technologies for automotive applications, 2014

The global alternative vehicle market is expected to yield increasing opportunities in the coming years.

Vehicle fuel efficiency is pursued worldwide as part of a strategy to mitigate climate change and fossil fuel dependency. In addition to Europe, Japan, India, and China have set targets of less than 5 liters of fuel per 100 km by 2020. The US have also set an ambitious objective (6.6 liters per 100km) compared to current levels (9.4 liters per 100km)[9]. Improvements will mostly rely on conventional vehicle fuel efficiency in the short term. But part of meeting the target is also expected to come from alternative vehicles, especially in relatively mature markets which intend to further invest in this field.

As a result, a number of institutions expect a strong growth of the alternative vehicle market, though estimates for this emerging market vary:

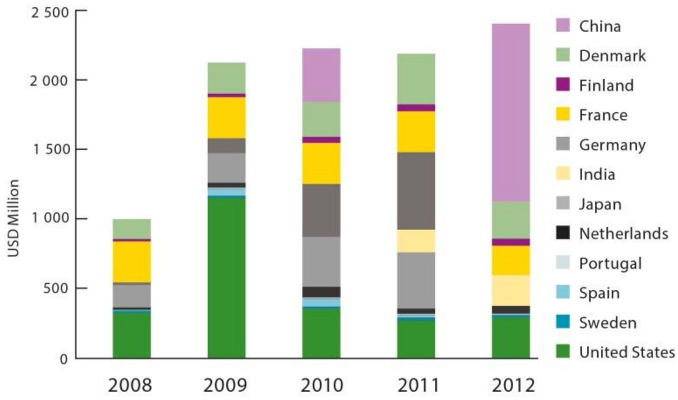
- According to IDTechEx, the global market for hybrid and pure electric vehicles would reach USD334 billion by 2023, from a current value of USD69 billion[10].
- The Electric Vehicle Initiative (EVI), grouping together the countries which account for 90% of the global EV stock, has set a target of 20 million plug-in hybrid electric vehicles, battery electric vehicles and fuel-cell electric vehicles on the road by 2020, compared to 180,000 at the end of 2012. Despite a current fleet size smaller than Japan and the US, the EU's share of the 2020 global EV fleet would be 30%, comparable to the US[11].
- According to Navigant Research, world sales of HEV, PHEV and BEV could reach 6.6 million annual units (7% of total light-duty vehicle sales) by 2020, a three-fold increase compared to 2013. Japan and the US would be the largest markets for HEV sales (about 1 million sales in 2020). Asia-Pacific is projected to be the largest market for plug-in electric vehicles, with 1.6 million PHEV and BEV sales combined in 2020[12].

Europe's historical position as an innovation leader is being challenged in the alternative vehicle transition.

Europe accounted for half of the €80 billion spent globally on automotive R&D in 2012 (Japan 27%, the US 16%). The share dedicated to alternative vehicles is unknown, as companies do not disclose information on budget splits. Data available from the JRC indicates that in 2008, EU corporate R&D spending on electric vehicles totaled about €1.5 billion[13]. Japan appears to be undertaking more significant investments, with a focus on lithium-based batteries. As an indication, for Toyota alone, R&D investments on hybrid technology amounted to USD7 billion over 2014[14]. Japan and the US are indeed able to recover their alternative vehicle R&D costs from a wider market than the EU, which has opted so far for diesel as its primary low-carbon technology.

Joint research between the IEA and EVI sheds further light on public funding of R&D. As illustrated below, while France, Germany, and Denmark have led the way until 2011, their position is challenged by China's recent significant investments.

Public R&D Spending in the Electric Vehicles Initiative



Note: missing countries indicate incomplete data

Source: EVI – IEA, Global EV Outlook, 2013

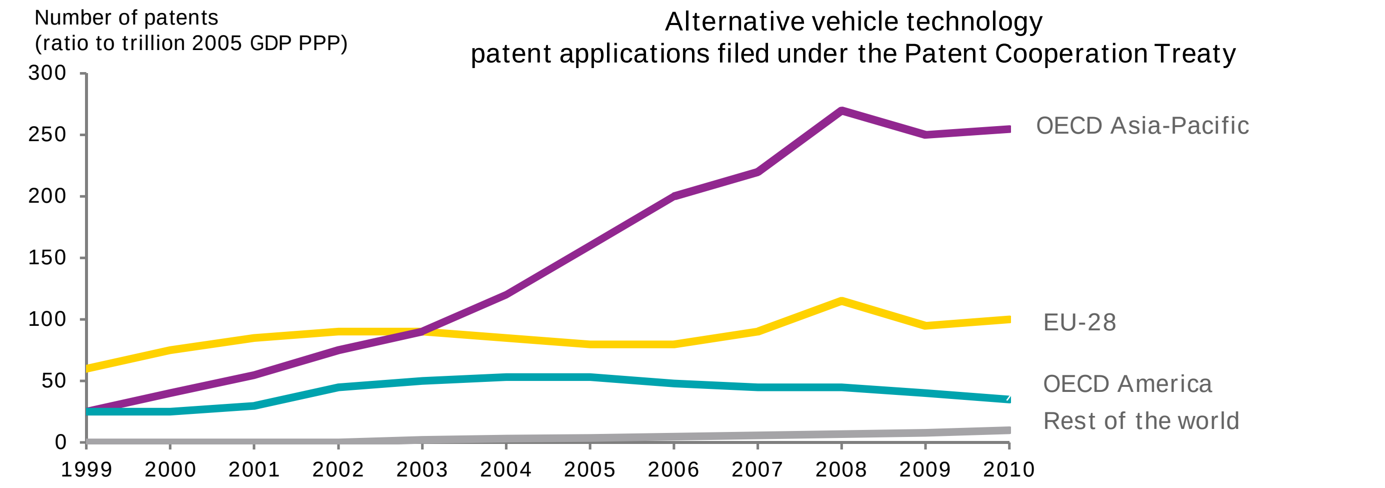
9 Climate Strategies, Staying with the leaders, Europe's path to a successful low-carbon economy, 2014
10 IDTechEx, Electric Vehicle Forecasts, 2014-2024, 2013
11 EVI – IEA, Global EV Outlook, 2013
12 Navigant Research, 2013-2020 Electric Vehicle Market Forecast, 2013
13 European Commission – JRC, Mapping Innovation in the European Transport Sector, 2011
14 BBC News, Toyota: Investment in 'green' paying dividends, 2013

Similarly, recent trends on patent registration show that Europe is among innovation leaders, but increasingly falling behind OECD Asia-Pacific. Key patenting domains include fuel cells, fuel efficient vehicle designs, hybrid propulsion, electric powertrain propulsion, and ICE propulsion. Though efforts are concentrated on improving ICE (about half of vehicle-related patents in 2012[15]), Japan appears to be taking the lead in electric and hybrid propulsion, with half of the patents filed worldwide in these domains in 2012.

Joint research between alternative vehicles and Information and Communications Technology (ICT) is a key success factor when it comes to intellectual property in alternative vehicles.

According to the European Commission, Japan is also leading the way in that field with 45% of high-value EV-ICT patent applications between 1998 and 2008. Europe accounted for 28% of EV-ICT applications in the same period, versus 16% for the US[16].

Despite Japan's apparent first-mover advantage, both in terms of domestic market development and innovation, the alternative vehicle race remains open, as many factors other than fuel efficiency standards and battery technology will be influencing the sector. Market shares for alternative vehicles are still relatively low at this stage, giving an opportunity for late movers to catch up.



Source: OECD Patent Database

Note: Sum over five technology areas: fuel cells, fuel efficiency-improving vehicle designs, technologies for hybrid propulsion, technologies for propulsion using electric powertrains and technologies for propulsion using internal combustion engines.

With the second largest vehicle market, the highest absolute automotive R&D spending, high net exports, and strong assets in lead-based battery manufacturing, including emission-saving microhybrid applications, the EU lies on solid foundations for developing its domestic alternative vehicle market (HEV, PHEV, BEV) and eventually seeing its companies tap into global market opportunities. There are however signs of "investment leakage", with the EU's potential not being fully exploited, and electric and hybrid vehicle domestic market development lagging behind Japan and the US. Moreover, the EU is being outdistanced by Japan in terms of innovation as measured by patent applications. As for R&D spending in lithium-based batteries, Japanese car manufacturers appear to be leading the way, while China's public funds recently injected into electric vehicle R&D place it among key players for the future.

While public policies and private investments are gathering the conditions for the global alternative vehicle market to triple by 2020, and to continue growing thereafter, it is uncertain that Europe would place among leaders of the automotive transition. Market take-up is however recent, and the automotive industry is one where first-mover advantage does not necessarily materialize. Despite a late start, the opportunity for Europe for finding its place in the global alternative vehicle industry remains open.

15 OECD Patent Database
16 European Commission, Impact of ICT R&D on the large-scale deployment of the electric vehicle, 2012


MON40

5. Smart energy solutions

The term “smart energy solutions” refers to the set of technologies aiming to optimize the production, distribution and consumption of electricity at every level of the grid. Their contribution would allow saving energy by smoothing consumption peaks and reducing needs for costly peak production capacity, thereby securing the network and reducing its costs. Smart energy solutions can be split between three main business segments[1]:

- Grid applications: applications that automate the grid to make its infrastructure more efficient and flexible;
- Advanced metering infrastructure / smart meters: digital electronic devices that record consumption of electric energy and communicate the information back to the utility company for monitoring and billing purposes. These meters support two-way communication between the meter on the customer premises and the utility and between the meter and the home-area network (HAN);
- Customer applications: the level of functionality can vary from a simple in-home display (IHD) that shows energy consumption to a fully automated home with smart appliances and a centralized energy-management system. Even the basic functionality option would receive usage and pricing information and data readouts through a home-area network (HAN), enabling customers to adjust energy consumption and suit their price sensitivity and usage patterns.

The focus of this chapter is grid applications and smart metering, whose markets are maturing, with some available historical data.

The world’s major economies have engaged in a smart energy deployment strategy, as observed in recent smart metering deployment trends.

As stated by SETIS – European Commission in October 2013, smart energy solutions should be a crucial part of the European SET-Plan which defines European energy technology strategy. Through better demand management and peak demand reduction, smart grid technologies could potentially save up to €5 billion a year for the EU by 2030[2]. The potential has been identified by other major economic regions, which have also adopted a strategy of smart energy solution deployment.

As a result, the stock of installed smart meters worldwide has been growing, from 46 million in 2008, to 285 million in 2012. It is projected that 500 million new units would be added by 2020. The largest national smart meter stocks would then be China (400 million units), followed by the US and Canada (150 million units), and Japan (60 million units). The UK, France, Germany, and Italy would have 32 to 35 million units each, while India would have around 18 million units[3].

For the next 5 to 15 years, analysts agree on the leading role of the Asia-Pacific region in global deployment of smart metering, as well as the very important potential for Europe (with up to 20% projected growth in installed smart meters)[3]. The US is starting, alone mostly, a major second phase, which is information integration in which the wealth of collected data coming from the power grid is used to improve grid management, like outage reduction, customer segmentation, and theft detection[4].

These challenges open a window of opportunities for the smart energy sector for the next decades: the rollout of a smart grid in the US could reduce electricity consumption by 10% to 15% and create up to 280,000 jobs[5]. Hope is that such a rollout would reduce electricity transport losses by at least 2% (from an average estimate of 10% to 8% or less)[6].

1 McKinsey, The smart grid opportunity for solutions providers, 2010
2 Booz & Co, Benefits of an Integrated European Energy Market, 2013
3 Accenture, Realizing the Full Potential of Smart Metering, 2013
4 Bloomberg New energy finance, February 2014
5 KEMA, Smart Grid Jobs Report, January 2009
6 Purdue University, GE Digital Energy, Smart Grid, 2013

As part of smart grid investments, grid applications are a growing industry with shifting key players.

The global smart grid industry amounted to approximately USD10 billion worldwide in 2009[7]. Three years later, in 2012, smart grid investments amounted, for the three leaders, to USD4.3 billion in the US, USD3.2 billion in China, and USD1.4 billion in the EU[8], for a global total of USD14.2 billion in investment and USD33b in revenue[9].

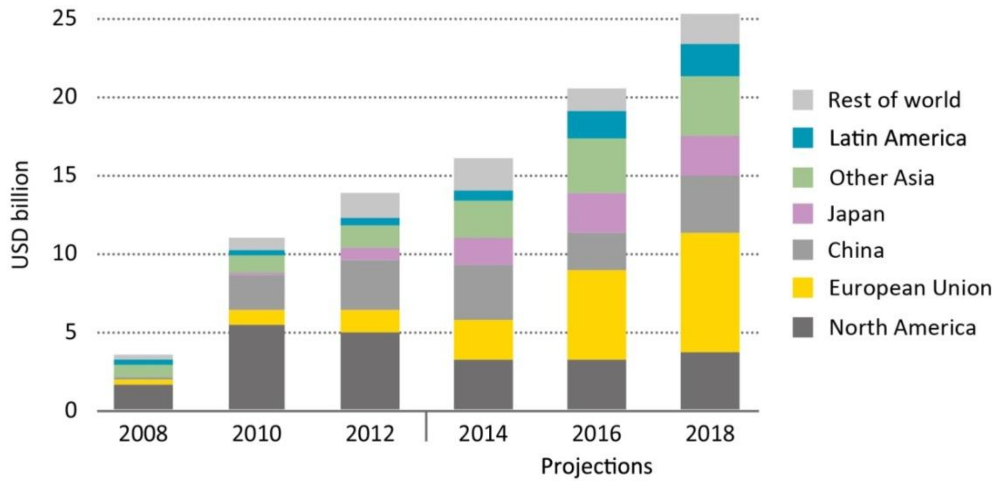
In 2013, China spent more in this market (USD4.3 billion) than the US (USD3.6 billion) for the first time, partly due to the US slow-down. Smart metering represents half of the current global smart energy investments, with grid applications making up the rest (e.g. distribution automation and other integrated demonstration projects)[10].

Investment is expected to rise in the medium term, to over USD25 billion, as other countries and regions such as the European Union, Japan and other parts of Asia increase expenditure.

In other regions, however, including China and the US, future growth in expenditure is less certain, as government stimulus funding is running out. Governments, regulators and the private sector are awaiting results from demonstration projects and smart meter targets before committing to additional amounts. According to the IEA, investments remain below the milestone of its 2DS scenario, which aims to limit global warming to 2°C levels, although available data is limited. Cumulative investment requirements are considerable, but the benefits of deployment are likely to outweigh investment cost, as smart grids enable financial savings in generation, transmission and distribution, retail operations, and the overall system[11].

It has been estimated that the projected costs to renovate and automate the American electrical grid range from USD200 billion and USD2 trillion over the next 20 years, while Europe would have to invest €750[12] to €2,200[13] billion in the next 30 to 40 years (split between upgrading the grid and building or renovating production capacities).

Global smart grid investment



Source: IEA, Tracking Clean Energy Progress, 2013

7 Pike Research, Smart Grid Technologies, 2009
8 J. Popov, EU list of failings on low carbon grows, Financial Times, 25 November 2013
9 Navigant Research, June 2013
10 Bloomberg New energy finance, February 2014
11 IEA, Tracking Clean Energy Progress, 2013
12 ETP-Smart grids, SRA for Europe's electricity networks of the Future, 2007
13 European Technology Platform, 2012

Two major changes are happening simultaneously:

- Countries that are already largely equipped, e.g. Italy, Sweden or the US, are shifting their industry focus from hardware (manufacturing and installing smart meters) to software (providing the associated services).
- Countries that are not equipped yet, e.g. Germany, India, or China, are shifting their requirements from packaged solutions to custom-built solutions.

The world's electrical equipment giants have launched the race for smart grid innovation, without clear leaders at this stage.

The establishment of standards and protocols may well be the key factor of the future smart energy solution successes. However, once technologies and norms are regionally or internationally defined, it would be too late for Europe to position itself as a leader.

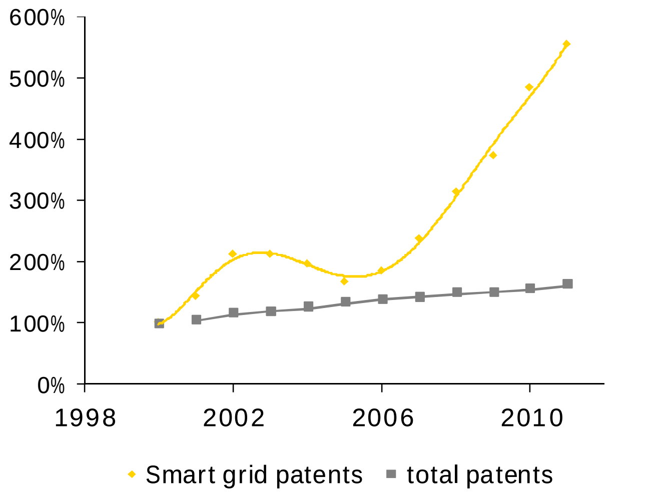
In Asia, South-Korea has strong ambitions and aims at becoming the worldwide leader in smart-grid technology and service exports[14], while Singapore Experimental Power Grid Centre (EPGC) wants to develop the country as a "living laboratory for smart grid solutions"[15].

The US have also recognized the strategic aspect of R&D and patenting for smart energy solutions. In particular, the US Department of Energy Office of Electricity Delivery & Energy Reliability set up an ambitious Smart Grid Research & Development Multi-Year Program Plan (MYPP), 2010-2014.

The key feature of the current and expected trends is a constant acceleration in patenting. There was a 500% growth in patent filing between 2002 and 2012[16]. Moreover, the innovation race appears to remain open, with the largest companies (such as Siemens in Europe) accounting for only 8% of all the filings.

A study by TechIPm identified 318 smart grid patents held as of October 2009 by eight key industry participants including Siemens, ABB, General Electric, Hitachi, and Samsung[17]. While it is too early at this stage to predict whether European giants will gain an edge over their US and Asian counterparts, it appears that the global race will see all three regions compete for innovation.

Worldwide trends in smart grid patenting (sum of 6,500 patent families related to smart grids)



Source: European Patent Office, 2013

Smart energy solutions are a rapidly growing market, with much potential remaining ahead, thanks to the need for renewal and upgrade of existing power grids, mainly in Western countries, and the development of new capacities in emerging nations.

Smart metering and the smart grid industries are currently of equivalent size, while the third pillar of the smart energy solutions, smart homes, is largely unexplored yet.

In order to integrate Europe's electrical grids – which is a precondition for an increasingly renewables-based power system – each Member State will need to renovate and improve its existing infrastructure. Europe's deployment of smart meters is in line with other economic regions, though its investments in grid applications seem to be less extensive than those in the US and China. Regarding the global innovation effort, the EU's contribution is likely to rely on its incumbent electrical equipment giants, though it is too early at this stage to identify which region is taking leadership.

14 Power insider magazine, South Korea look to increase efforts on smart grid technology patents, March 2013
15 Renewable Energy Focus, Smart grid R&D project in Singapore, 2010
16 European Patent Office, Expert interview, EPO coordinator Gerard Owens and patent examiner Giulio Ceccarini on the future of smart electrical grids, 2012
17 American University Washington College of Law, Standards Patents and the National Smart Grid, 2012


MON40

6. Grid energy storage

Energy storage technology could eventually become a key feature of the low-carbon transition, enabling the flexibility of a renewables-based power system. Energy storage solutions find applications at every level of the power grid, with the following classification proposed by Eurobat:

- Generation: arbitrage, capacity, firming, curtailment reductions;
- Transmission: frequency and voltage control, investment deferral, curtailment reduction, black starting;
- Distribution: voltage control, capacity support, curtailment reduction;
- Customer: peak shaving, time of use cost management, off-grid supply.

Grid energy storage remains at the R&D stage but may hold promising market prospects

The energy storage market has historically been dominated by Pumped-Storage Hydroelectricity (PSH), currently representing 99% of global storage capacity[1], mainly for demand levelling at transmission level. Energy storage is currently limited in the EU energy system, with 5% of total installed capacity, mainly in mountainous areas[2].

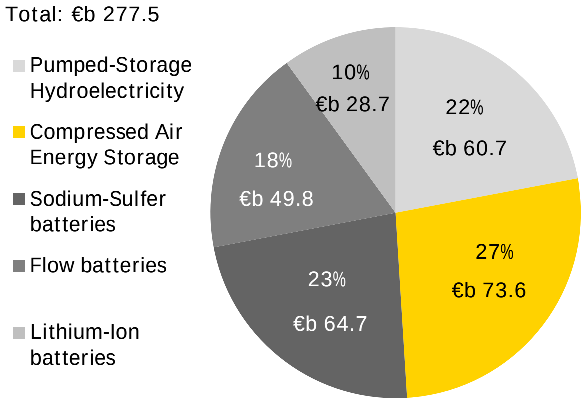
Coming decades could however see the rise of technologies currently at the emerging stage (e.g. sodium, lead, lithium, and nickel-based batteries, as per Eurobat's technology split), applied at distribution and customer level, to enable a decentralized and interconnected power system.

A BCG study estimates a global cumulated market potential, all grid applications combined, of €227 billion between 2010 and 2030, half of which would be accounted for by batteries[3].

Pike Research forecasts even more promising market opportunities for energy storage on the grid, starting from a low base in 2012 to USD30 billion by 2022, with total capacity reaching 56 GW[4]. Lux Research anticipates that global demand for grid-scale energy storage would reach USD113.5 billion by 2017, with a production of 185 GWh[5].

Over the period 2011-2021, half of the new storage capacity would be dedicated towards balancing intermittent renewable energy sources, 31% towards peak shaving, 12% for price arbitrage, and 7% for transmission and distribution investment deferral[6].

Energy storage market over 2010-2030 by technology



Source: BCG, Revisiting Energy Storage, 2011

The world's key economic players are undertaking R&D investments in this emerging field.

The US implemented numerous R&D projects through the "Department of Energy" (DoE) and the "US Advanced Battery Consortium" (USABC). The DoE targets to cut energy storage cost by 30% before 2015. In order to meet this objective, it has a specific budget of USD200 million over the period 2011-2015 for energy storage R&D projects. Moreover, ARRA law ("American Recovery and Reinvestment Act") boosted R&D and production of energy storage technologies. In 2013, the STORAGE Act made available USD1.5 billion in tax credits for energy storage projects in coming years, without privileging a particular technology. The US is expected to account for more than 40% of added storage capacity by 2023 according to a 2014 IHS report.

1 ENEA Consulting, Le stockage d'énergie – enjeux, solutions techniques et opportunités de valorisation, 2012
2 DG ENER working paper, The future role and challenges of energy storage, 2013
3 Applications within the scope of the study are price arbitrage, energy balancing, black-start services, conventional generation stabilization, off-grid storage, T&D deferral, industrial peak shaving, and residential storage
4 Pike study research, Energy storage on the grid, 2012
5 Lux Research, Grid Storage under the Microscope, 2012
6 Pike study research, Energy storage tracker 2Q12, 2012

Japan, since 1980, has implemented research programs on energy storage led by NEDO ("New Energy and Industrial Technology Development Organization"). The country has the highest penetration rate of PSH systems, and is the market leader for lithium-based batteries. This advantage on small-scale batteries could turn into a competitive advantage on grid-scale applications lithium-based batteries for decentralized and off-grid storage applications. Moreover, Japan is massively investing in recycling technologies of scarce elements, in order to be less dependent on China. Public subsidies strongly support the sector: in March 2014, the government opened a USD100 million program for stationary energy storage systems[7]. Through its various support schemes, the government's ambition is for Japanese companies to capture 50% of the global storage battery market by 2020[8].

Similarly, China wants to establish its technological and commercial leadership on the market, with numerous R&D initiatives, especially on vehicle energy storage, with technologies that can be adapted for stationary applications. Besides its investment capacity and its low production costs, China benefits from the majority of scarce resources, such as rare earth elements. China yearly investment in grid-scale energy storage is evaluated at USD500 million[9].

In 2011 about 95% of all lithium batteries (mostly found in consumer electronics) were produced in Japan, Korea and China. China also has the highest number of well educated, young electrochemists (about 100 times more than the EU)[10].

Despite progress made in other major economies, the energy storage race remains open and the EU would have to position itself in the global energy storage industry in the coming years.

Regarding Asian competition, the bridge between consumer electronics applications and grid storage is not so direct, as the technologies for the latter are more complex. There hence remains a window of opportunity for the EU to develop its own grid storage industry, with its advantages being a strong energy grid, major global players in power electronics, a solid manufacturing base in lead-based batteries, as well as well-positioned companies in all battery technologies.

The opportunity lies in two high-value segments:

- Battery manufacturing, which is rather prone to international trade, where the EU runs the risk of eventually depending on foreign imports;
- Integration equipment, which would typically be manufactured close to the customer.

The EU created The European Association for Storage of Energy (EASE) platform in September 2011, which contributes in broadcasting information and good practices among EU countries on energy storage. Some European countries have changed their legal framework to allow energy storage installations to benefit from preferential price rates to access the network. However, the European Commission's January 2013 Working Paper "The future role and challenges of Energy Storage" calls for stronger focus on storage in EU energy and climate policies. The existing regulatory framework would have to be adjusted in order to enable, among others, a level-playing field between energy storage and other sources of energy generation; medium-term predictability of investments and financial conditions (e.g. taxes); modulation of grid tariffs to take into account the fact that energy storage systems use the grid off-peak periods; technological neutrality between different storage solutions.

EASE and Eurobat similarly consider that a lack of strategic thinking in energy storage research has to be compensated, but that the EU enjoys a significant advantage due to a strong R&D network[11].

In Germany, alliances between government and industry encourage R&D projects. In particular, the "Lithium Ion Battery LIB 2015" innovation alliance has gathered €360 million of R&D investments from industry and €60 million from the government.

7 PV Tech, Japan launches subsidies for lithium-ion battery storage, 2014
8 METI, Information on storage technology and markets prospect in Japan
9 Industry Tap, China's Grid-Scale Energy Storage Investments Reach $500 Million Per Year, 2013
10 European Commission, DG ENER Working Paper, The future role and challenges of energy storage, 2013
11 Joint EASE/EERA recommendations for a European Energy Storage Technology Development Roadmap towards 2030, 2013

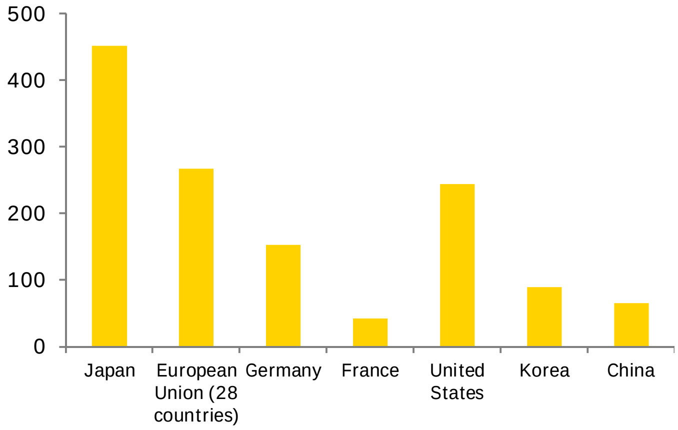
In France, political support towards energy storage development is increasing. With almost no remaining potential in PSH, other stationary storage technologies are being supported. The Ministry of Industry hence calls for a strong positioning of French industry leaders, while a Call for Interest was released this year to subsidize storage projects, as part of an investment of USD1.5 billion in demonstrations and technology projects for low-carbon energy technologies.

Italy is taking steps forward in energy storage, with a challenge of securing a grid with 17.6 GW of installed photovoltaic capacity. The transmission grid operator Terna is leading eight pilot projects totaling over 60 MW; close to 100 MW are in the pipeline for additional projects. The company has invested €31 million in 2013 in energy storage projects, to be increased to €120 million in 2014[12]. Energy storage equipment providers both from Europe and Asia-Pacific are active on the Italian market.

In the UK, energy storage technologies will also be critical in balancing supply and demand and reducing pressure on the local electricity grid. The necessity is reflected for instance in the increase of "constraint payments" made to wind energy operators having to switch off their generators for "wrong time electricity generation". The Scottish Government has stated its ambition of reaching 100% of electricity consumption from renewable sources by 2020, which would require energy storage capacity to increase from 745 MW to 3,086 MW[13]. Despite these needs, the Institution of Mechanical Engineers has warned that no official roadmap is set for the deployment of energy storage, while public investment and incentive schemes remain insufficient.

The strong competition faced by Europe from the US and Asia-Pacific is also reflected in the patent race. The energy storage sector has a strong potential for innovation. According to OECD statistics on energy storage, the number of patent applications has grown four-fold between 1999 and 2009. As the graph below illustrates, Japan is the country with the highest number of patent applications between 2008 and 2011. The US and the EU are also in good position, with Germany contributing over 50% of the total number of patents in the EU. China is catching up according to most recent figures after a late start.

Average yearly number of patent applications under the PCT over 2008-2011 under "energy storage" [14]



Source: OECD Patent Database

Led by projects in Germany, France, Italy and the UK, the EU is establishing the necessary conditions for becoming a key player on the international energy storage market. It can rely on a solid manufacturing base in lead-based batteries, technological leadership in hydrogen storage, and a need to balance an energy system with an increasing share of renewables. However, the EU would need to harmonize its policy framework to enable the development of innovative energy storage systems.

In the mean time, other major economies are investing in R&D and setting supportive policy frameworks and targets for market deployment. Asia is already dominating the battery market in consumer electronics, though this does not necessarily guarantee future success in grid-scale batteries, which involve more advanced technologies. There remains a window of opportunity in the next few years for Europe to contribute to the global battery industry. In addition, the energy storage sector also holds market potential in integration equipment; though this segment should remain sheltered from foreign competition, its development would equally necessitate a supportive political framework.

12 Energy Storage Report, Energy storage takes a hold in Italy, 2014

13 Institution of Mechanical Engineers, Energy Storage: the missing link in the UK's energy commitments, 2014

14 The PCT classification under "energy storage" includes batteries, ultracapacitors, flywheels, methods for charging and discharging circuits, and arrangements for balancing the load in a network by storage of energy. It does not include hydrogen (production, distribution and storage), and fuel cells.

Skills and education

Skill shortages could hamper further development of some low-carbon industries in the EU.

The transition to a low-carbon economy has a significant impact on the demand for new skills. Identifying and anticipating skills needed for the low-carbon economy is essential for Europe's success in the international competition and must precede training decisions so that skills acquired are relevant in a changing labor market[1]. Uncertainty surrounding the future scale and composition of these low-carbon industries presents a major challenge for their development. Demand and supply of skills will be conditioned by the specific nature of low-carbon sectors and technologies, and their role in the low-carbon transition[2].

Skill requirements for several low-carbon industries have already been identified.

A report by EWEA outlines the fact that there is currently a shortage of 7,000 qualified personnel in the European wind energy sector each year[3]. The EU Wind Technology Platform estimates that without an increase of the rate of graduation from courses relevant to the industry, there could be a gap of 18 000 qualified staff in the European wind energy workforce in 2030[4]. By that year, O&M will become the greatest source of new jobs and demand for trained staff.

A study by IRENA has further found economy-wide concern about the low number of graduates from schools and universities opting for Science, Technology, Engineering and Mathematics (STEM) courses, whose skills are most needed in the renewable energy sector[5]. Skill shortages are likely to be greatest in the operations and maintenance (O&M) segment of the renewable energy value chain, particularly for wind energy.

According to a 2011 ILO report on the construction sector, there are clear deficiencies in the supply of skills and training for green buildings. These regard needs both in conception and construction. As for skills in designing and conceiving green buildings, emerging countries are more likely to have the appropriate skillset than developed countries, whose personnel is aging, with uncertain replacement prospects. Given the quick pace of change in the sector, adaptability to change and environmental awareness are necessary. Although jobs are likely to be performed by workers who already work in the building sector, these jobs will be redefined in terms of skills, training and certification requirements[6].

The automotive industry is also evolving and Europe already benefits from advanced technical skills. Engineering skill levels in Europe are comparable to countries with a developed automotive sector such as Japan and South Korea. On average, Chinese engineers do not currently hold the same skill level. However, the shift to electric vehicles requires a different skillset, with a partial shift from mechanical engineering to electronic and mechatronic engineering. An additional 193,000 engineers would be needed globally in the electronics element of the automotive industry by 2030, among which 50,000 in Europe[7].

Regarding smart grids, the significantly higher levels of investment in China and the US will inject new skills and knowledge into their workforces and could further erode the competitiveness of EU labor[8].

1 European Commission and International Labour Office, Anticipating skill needs for the low carbon economy? Difficult, but not impossible, 2011
2 CEDEFOP – European Centre for the Development of Vocational Training, Skills for a low-carbon Europe: The role of VET in a sustainable energy scenario, 2013
3 EWEA, Worker wanted: the EU wind energy sector skills gap, 2013
4 European Wind Energy TP, March 2013 newsletter
5 IRENA, Renewable Energy and Jobs – Annual Review 2014
6 ECORYS commissioned by DG Environment, Environment and Labour Force Skills, 2008
7 European Commission report, Impact of ICT R&D on electric vehicles deployment, 2012
8 J. Popov, EU list of failings on low carbon grows, Financial Times, 25 November 2013

Major actions would need to be taken to ensure that Europe has the skills necessary to support the development of its low-carbon industries.

A set of improvements would have to be implemented to address the predicted shortage of skilled workers in most low-carbon industries[2]:

- Improve core STEM skills in industry
- Introduce industry experience into training and education
- Expand the cohort of graduate level renewable energy generalists
- Harmonize VET (Vocational Education and Training) at EU level
- Increase the emphasis on O&M training

In the context of economic difficulties and unemployment in Europe, low-carbon industry represents an opportunity to create new jobs. However, there is a gap between supply and demand of new skills needed for the development of low-carbon technologies. In order to keep developing its low-carbon industries, the EU needs to implement major improvements to address predicted skill shortages, such as improving STEM (Science, Technology, Engineering, and Mathematics) skills, harmonizing VET (Vocational Education and Training) and increasing the emphasis on O&M training.

Conclusion

This report examines a variety of low-carbon industry situations. The selected industries intrinsically differ in their market structure and dynamics. They also present diverse cases in terms of policy frameworks, economic regions which are active in innovation and market development, and Europe's position within the industry. The analysis however yields the following conclusions.

The low-carbon transition could yield significant market opportunities and socio-economic benefits.

Along with other high-tech industries, low-carbon industries will be among the main economic game changers in the coming decades. Wind power, solar PV and biofuels already show a sizeable workforce in the EU, with a total of 650,000 jobs, while market potential remains mostly untapped.

The market forecasts reviewed as part of the report (Pike Research, Navigant Research, IDTechEx, Lux Research) expect global market size for each of the industries to top USD100 billion around the turn of the decade, provided key success factors are gathered for these industries, especially regarding their important capital investment needs.

Successful take-off of low-carbon industries hinges on political direction and support.

This key condition for success partly explains Europe's early-mover and leadership status in the solar PV and wind sectors. The EU accounted for over 40% of global renewable energy investments until 2011, driven by political support such as feed-in tariffs and national targets. The recent rise of the US and China are similarly explained by strong political direction. China's government set in 2011 an objective of 250 GW of cumulative wind and solar energy capacity by 2020; in 2013 the country installed one fourth of solar PV capacity and half of wind energy capacity deployed globally.

Another example is the fact that the EU has opted for diesel engines as part of its low-carbon vehicle strategy, as opposed to Japan and the US which have engaged in the alternative drivetrain transition. Such outcomes are largely the result of policy choices. The EU's delayed start in alternative vehicles indicates a possible case of "investment leakage" in that sector.

A similar situation could occur in other cases where the EU is placing as an R&D and early commercialization leader in new markets (advanced biofuels, offshore wind, grid energy storage), but where the absence of supportive policies (long-term target certainties, stimulus policies and incentives, market development through public investments, technological and market integration policies) could prevent its industrial assets and know-how from materializing into wide-scale industrialization.

A predictable regulatory framework and adequate political support remain necessary for low-carbon industries even in a mature stage.

Investment leakages due to political uncertainty have been observed in the cases of solar PV and wind energy, where concerns about future policy support in the EU and the US have delayed investment decisions since 2011. Renewable energy investments in the EU and the US respectively decreased by 58% and 33% between 2011 and 2013. On the other hand, China's investments, which benefited from a more stable framework, increased by 8% between 2011 and 2013.

Furthermore, the right policy direction is necessary to avoid potential shortages in skills required for securing the continued development of low-carbon industries. Some EU low-carbon industries (wind energy, alternative vehicles, green buildings) have already been identified as presenting such a risk.

Policy stimulus packages and favorable regulatory frameworks that were put in place in several countries to facilitate the development of specific low-carbon industries have proven to be efficient in strengthening the competitiveness of the concerned countries. For instance, packages which have boosted investments in renewable energy include the American Recovery and Reinvestment Act in the US (2011), Japan's Renewable Portfolio Standard (2003) and Excess Electricity Purchasing Scheme for Photovoltaic Electricity (2009), and China's successive five-year plans (2006-2010 and 2011-2015).

The game mostly remains open in low-carbon industries.

The PV module experience shows that an incumbent can rapidly lose its position to a new market entrant. Although Europe was a first-mover in innovation and wide-scale deployment of solar PV, the world's key economic regions have heavily invested in these fields since the late 2000s. The EU has thereby lost much of its domestic PV module manufacturing base to Asia. However, opportunities remain in the domestic markets for PV-related services, and on global markets for other segments of PV manufacturing. Europe's PV industry employs 220,000 people and still creates 73% of the total value of the European PV market.

The opportunity for European onshore wind industry has been demonstrated by Europe's high net exports (€5.6 billion in 2010) and employment (270,000 people in 2013). Similarly for offshore wind, Europe is positioning itself as a leader in innovation and market take-off, in this segment which could represent one third of wind energy generation by 2050 according to the IEA's projections.

Conversely, in industries where Europe has been less active, the window of opportunity is far from being closed:

- Regarding biofuels, after backing away from the conventional biofuels race, the EU, along with the US, is leading the R&D and demonstration effort in advanced biofuels, and is well positioned to tap into future market potential.
- Alternative vehicles remain a niche market in Europe, in contrast to Japan and the US. Domestic market development however remains in the early stage in these countries. Europe can rely on solid industrial foundations for contributing towards innovation and market development in the future transport landscape.
- The European energy storage market is still in an emerging phase and the race is open on all segments. Europe is already well positioned on lead-based batteries (with a workforce of 25,000 workers) and integration equipment.
- Regarding the smart grids sector, while it seems that Europe's investments are less extensive than those mobilized in the US and China, the industry remains in its early stages, and future success would start with development of the domestic market.

In a context of "coopetition", opportunities will also arise for global cooperation schemes, as illustrated in the case of offshore wind, where joint ventures with Asian companies have financially supported large-scale projects in Europe. In the case of advanced biofuels, feedstock production and supply will necessitate coordination at global level.

Worldwide low-carbon industrial development requires each region to find its suitable role in the global effort. Europe's advantage would for instance lie in innovation, skills, and capital formation rather than labor costs and price competition. This study has shown Europe's assets and potential role in respective low-carbon industries, and the opportunities at hand.

Finally, the six low-carbon industries examined in this report have been addressed separately, which, ideally, should not be the case. The low-carbon transition may indeed imply systemic economic change, with a thorough transformation of the infrastructure which has prevailed throughout the twentieth century.

In that sense, the low-carbon transition should rather be conceived and materialized at system-level, with stronger linkages between the contributing economic sectors. The future scheme could, for instance, see the building and transport sector exchange electricity through a flexible power system fed from renewables. Rather than an accumulation of investments and projects functioning in silos, the transition could be facilitated by stronger cross-industry synergies and territorial transformation plans.

The health check carried out in this study has shown that it is critical for the EU to provide long-term policy certainty and clear targets to set the right investment climate, if it is to seize the major market opportunities emerging in low-carbon industries. This would need to be complemented with an industrial strategy, stimulus packages and technological integration policies for low-carbon solutions where the EU has a strong role to play.

EY | Assurance | Tax | Transactions | Advisory

About EY

EY is a global leader in assurance, tax, transaction and advisory services. The insights and quality services we deliver help build trust and confidence in the capital markets and in economies the world over. We develop outstanding leaders who team to deliver on our promises to all of our stakeholders. In so doing, we play a critical role in building a better working world for our people, for our clients and for our communities.

EY refers to the global organization and may refer to one or more of the member firms of Ernst & Young Global Limited, each of which is a separate legal entity. Ernst & Young Global Limited, a UK company limited by guarantee, does not provide services to clients. For more information about our organization, please visit ey.com.

Photo: EY
Studio EY France – 1410SG180

SCORE France : n° 14-054

ey.com

Your contacts

Alexis Gazzo
+33 (0) 1 46 93 63 98
alexis.gazzo@fr.ey.com

Cyrus Farhangi
+33 (0) 1 46 93 58 33
cyrus.farhangi@fr.ey.com