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PANORAMA

October 2015

A brighter picture for European photovoltaic energy?

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European photovoltaic (PV) energy developed rapidly starting in 2010, thanks to national and European subsidies promoting its establishment in the energy landscape. But the increase in production capacity rapidly pushed down prices in a context of increased competition from China and a downturn in European business conditions. The end of the subsidies, starting in 2011 also helped generate financial losses for companies in the sector. Employment associated with solar development has also decreased significantly. Today, European activity in this area is slowly regaining its 2008 level, while electricity generation capacities have increased during this time. Therefore, the profitability of the traditional players in the sector has remained penalised. While Europe was ahead in the race to a green economy, both through its commitments and through existing equipment, the rest of the world is now rapidly narrowing the gap.

But the slow-down in PV development in Europe seems temporary. While the transition to electricity generation that is more respectful of the environment cannot be made overnight, as it requires significant investment, COP21 (the climate summit to be held in Paris in December 2015) is a good occasion to accelerate the process. Diversification of the energy mix, and therefore including renewable energy, will hold a priority place at the summit. In the longer term, worldwide development of PV and storage technologies will rapidly make this type of energy profitable even without subsidies. Thus, energy independence within five years in Europe is not unattainable.

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STUDY

October 2015

A BRIGHTER PICTURE FOR EUROPEAN PHOTOVOLTAIC ENERGY?

BY OUR ECONOMISTS

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1 PHOTOVOLTAIC ENERGY IN EUROPE, A TURBULENT HISTORY

A flagship technology among renewable energy sources

PV solar panels (also called PV modules) produce electricity directly from solar energy. The PV cells composing each panel generate electric charges that produce direct current (DC) that can be transformed into alternating current (AC) through an inverter for integration into the network.

PV panels can easily be made modular and require little maintenance in comparison with other traditional technologies (nuclear, coal, gas, etc.). Moreover, the energy thus produced is renewable and clean, as direct emissions from solar panels are nil and indirect emissions are low *a priori* (1). But the energy created by PV facilities varies during the day, depending upon changes in the amount of sunshine. Therefore it is almost mandatory for PV facilities to be integrated into the network in a manner that can offset production decreases and thus ensure a balance.

There are three distinct generations of PV technologies:

- **Crystalline silicon cells**
  This technology is by far the most widely used (more than 93% of the demand for modules at the end of 2014). Crystalline silicon cells offer a high yield (from 15 to 19% for polycrystalline (pc-Si) cells and from 20 to 24% for monocrystalline (mc-Si) (2) cells and are produced from silicon, one of the most abundant materials on earth.

- **Thin film cells**
  These cells have a lower production cost, but a low yield (between 5 and 11% depending upon the materials used). This technology, which is less mature, only represented 6% of module exports in 2014.

- **"Third generation" cells**
  They include a variety of technologies that are not yet mature and in 2014 represented less than 1% of module exports.

(1) ADEME estimates that over its entire lifespan, a PV facility emits between 20 and 80 g of CO_2 per KWh on average versus an average of 86 g of CO_2 per KWh for France and 565 g of CO_2 per KWh globally.
(2) Renewable energy technologies: cost analysis series, IRENA, June 2012.

The expansion of the PV sector in Europe

The PV sector experienced a major expansion in Western Europe at the end of the 2000s. Thus, production of electricity from PV sources increased from 0.7 to 62.4 billion kWh between 2004 and 2012 in the countries studied (Germany, Spain, France, Italy, and the United Kingdom), making the European continent the global leader in PV, with 75% of worldwide production in 2012. This significant growth was driven primarily by Germany, Italy, and Spain, whose installations represented 80% of the installed base in Europe in 2012. The PV share of overall electricity generation in these countries reached 2.9% in 2013. However, electricity from PV represents only 5.3% of overall electricity consumption (versus 14.6% for hydro power and 12.8% for wind energy, the majority of electricity from renewable sources coming from biomass and renewable waste).

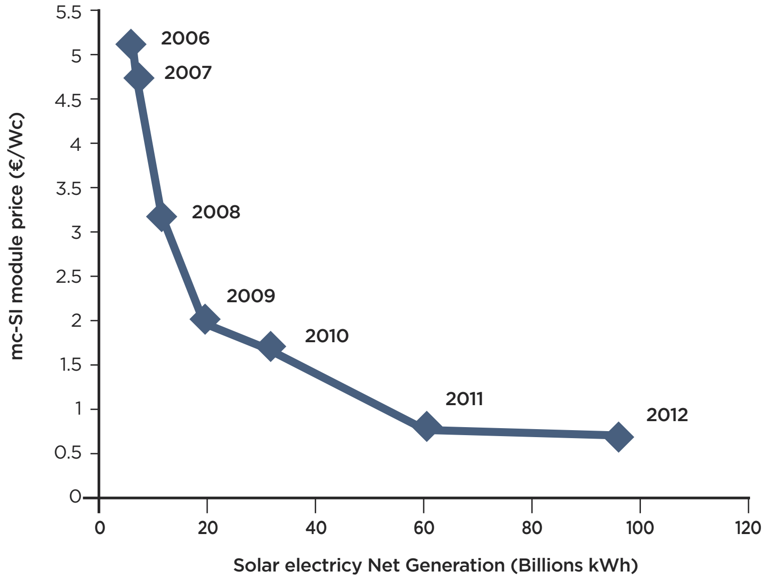
The strong growth in the installed PV base in Europe can be explained by public policies favourable to the development of solar energy. In this way, PV development was promoted by establishing purchase requirement systems. In several European countries including France, network managers were required to buy electricity produced from solar sources at preferential rates.

The development of the installed PV base in Europe can also be explained by the on-going decrease in prices. In fact, Prices for mc-Si modules decreased by approximately 80% between 2006 and 2012 related to the very significant increase in production capacity *(see chart 1)*.

However, the drop in module prices cannot be explained solely by economies of scale or a learning process. In fact, the arrival of Chinese competition on the market starting in 2005 led to a very significant increase in PV module production. The sector was then marked by a true price war between western and Chinese producers. The latter, accused of dumping supported significantly by government subsidies, inundated the European market, to the detriment of local players.

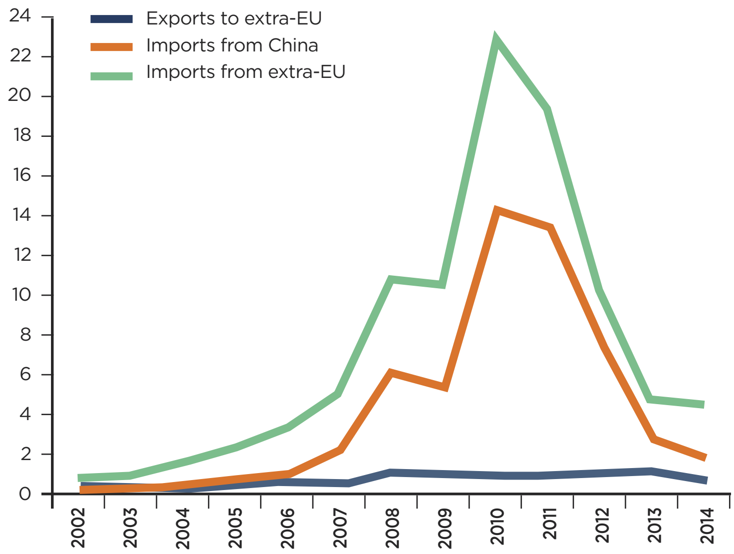
Despite Chinese competition and complaints from some players in the sector, the European Union adopted no tangible measures. This was despite the fact that the United States established a tax on imported Chinese modules in 2012. Therefore, dependence upon Chinese manufacturers in European countries increased. Thus, the EU posted a considerable trade deficit in terms of PV cells and modules between 2006 and 2011. During this period, imports of PV components, primarily from China (an average 75% of the total) exploded while exports remained low *(see chart 2)*.

Chart n° 1
Learning curve in the PV sector



Sources: EIA, ADEME

Chart n° 2
Trend in European foreign trade in PV components
(billions of euros)

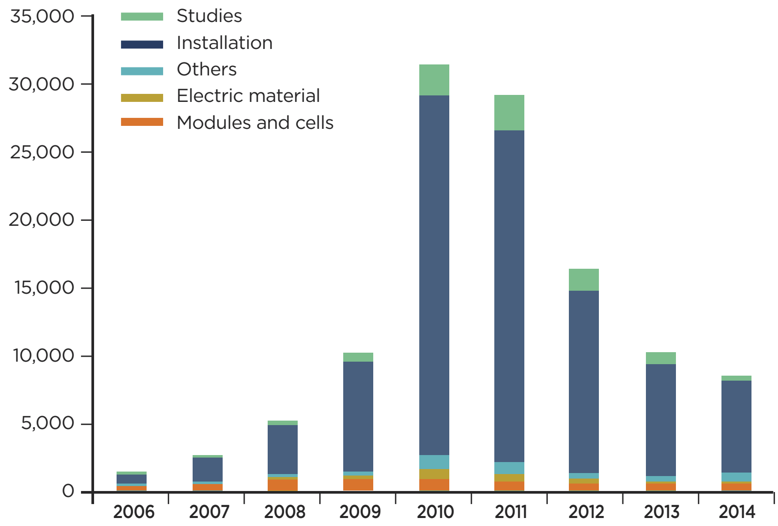


Source: Eurostat

Despite the difficulties of European panel producers, PV sector development still created jobs. For example, in France, where expansion of the sector has proven to be lower (four billion kWh in 2012), ADEME [3] estimates that the PV sector represented nearly 31,500 jobs at its activity peak in 2010. However, most of these jobs were in module installation and not production *(see chart 3)*.

Thus, PV panel installations dropped, to approximately 10 GWc in 2013 (*versus* 22 GWc in 2011). In France, the number of people employed in the sector decreased by 67% between 2010 and 2013 *(see chart 3)*. The decline of solar in Europe seems to have been as sudden as its start, and from many perspectives, the development of the sector resembled a speculative bubble.

Chart n° 3
Trend in PV sector jobs in France



Sources: ADEME, In Numeri

In fact, rate subsidies were what first allowed the sector to take off in Europe *(see chart 4)*. By ensuring exceptional profitability levels, measures supporting PV development fed the expansion of the sector.

However, the increase in the number of speculative projects, in a context of decreasing module prices, led European authorities to reduce these support measures, causing the bubble to burst. Therefore, European companies, already affected by successive crises, saw their profits drop.

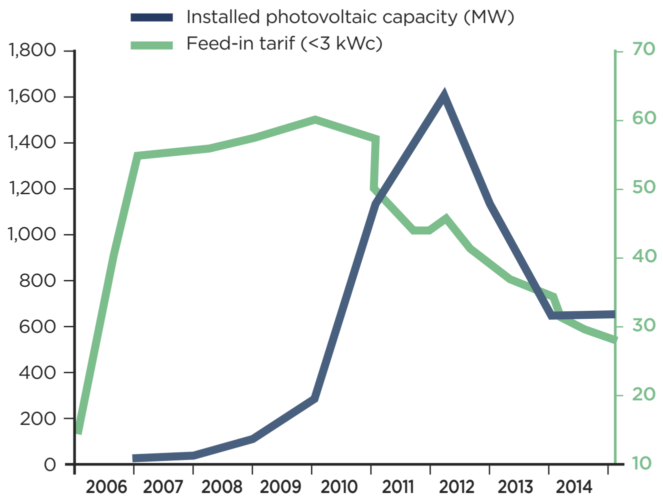
Thus, insolvencies in the PV sector in Europe increased significantly. In 2012, many European manufacturers declared bankruptcy, being unable to rival their Chinese competitors, as did German companies (Solon SE, taken over by Microsol) and Q Cells (taken over by the Korean company Hanwha) or French companies (Auversun, Solarezo, and Tenesol, bought by the American company Sun Power). Other companies, such as Schott and the Bosch group stopped all PV activity. *Chart 5* shows us the insolvency trend in France with a significant peak between 2011 and 2102.

The end of subsidies marked the end of the solar bubble

The expansion of the PV sector experienced an abrupt end at the turn of the last decade.

The decrease in subsidies also affected Chinese players, who found themselves in an excess capacity situation. Thus PV component imports collapsed between 2012 and 2014 *(see. chart 2, page 3)*.

Chart n° 4
Rate subsidies and installed capacity in France



Sources: ADEME, MEDDE

Graphique n°5
Business insolvency trend in the PV sector in France
(Index 100=2010)

Sources: INSEE, Coface

(3) Markets and jobs related to energy efficiency and renewable energy, ADEME, November 2014.

Strong domination by Chinese companies on the PV market

Today, Chinese manufacturers, led by Trina Solar, Yingli Green Energy, Jink Solar, and JA Solar, largely dominate the PV market. The market share of European companies has considerably decreased, while Japanese (Kyocera) and Taiwanese companies (Gintech, NeoSolar and Motech Industries) have maintained their presence on the market. Moreover, the PV sector seems concentrated: 13 companies represented approximately 60% of module exports in 2014. Europe, long ahead in developing PV, has now been overtaken by Asia, where nearly 60% of facilities were located in 2014.

2 CHALLENGES ARE CONSTRAINING PHOTOVOLTAIC DEVELOPMENT IN THE SHORT TERM

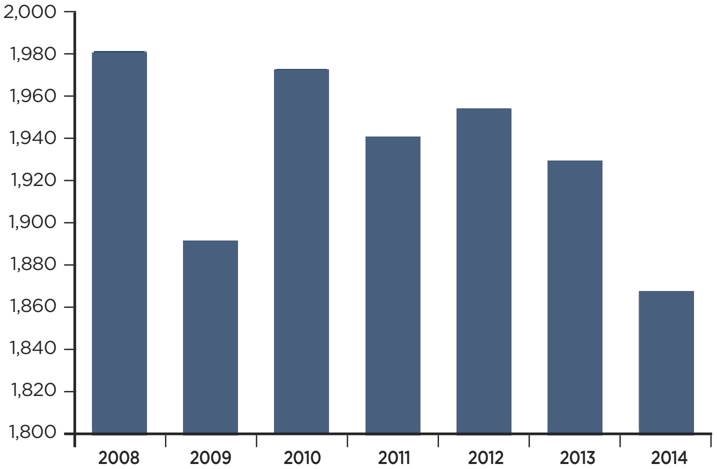
PV is a technology of choice in the European energy mix, and its position is not compromised a priori in the medium term. Nonetheless, renewable energy in general, and PV in particular, face strong challenges that will hinder their progression in the short term. First, the question of excess electricity production capacity seems worrisome. How can PV be integrated into a weakened sector?

The difficult question of excess capacity in Europe

European electricity consumption has decreased since the peak in 2008 *(see chart 6)*. The five countries studied are no exception to this rule. Economic difficulties explain this phenomenon in a large measure. The abrupt drop in electricity consumption observed in 2009 was due to lower industrial activity. The industrial production index then decreased by more than 25% in Europe. Thus, with the exception of Germany, all the countries studied saw a decrease in the industrial share of GDP between 2008 and 2014, according to the World Bank: -5.9 p% in Spain, –2.3 p% in France, –2.7 p% in Italy, and 2.3 p% in the United Kingdom.

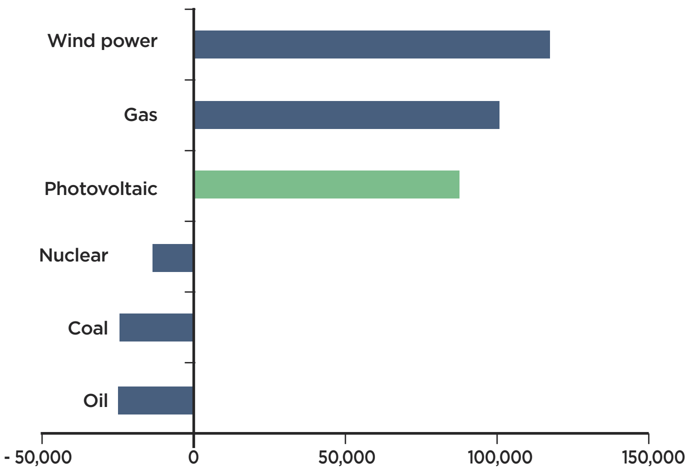
In parallel, electricity production capacity has continued to grow. Thus, according to the EWEA, the professional federation of European wind power industrials, between 2000 and 2014, the net capacity (counting plant openings and closings) grew by 350 GW, or 63% additional capacity *(see chart 7)* [4]. This increase was driven by the expansion of renewable energy, with PV ranking behind wind and gas. The weak decrease in fossil fuels was linked to the years from 2003-2008, which were a period of growth in consumption leading to investments in additional power plants.

Chart n° 6
Electricity consumption between 2008 and 2014 in Europe, in TW/h



Sources: ENTSOE, Coface

Chart n°7
Net electric facility capacity between 2000 and 2014, in GW



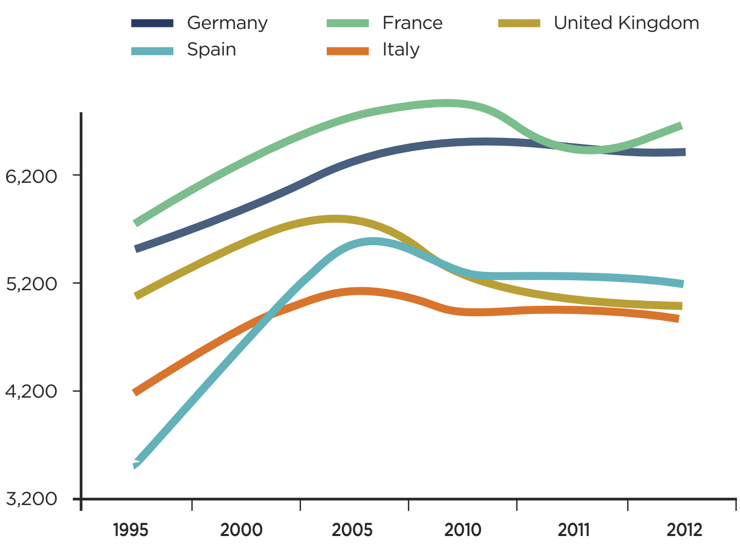
Source: EWEA

(4) Wind in power 2014, 2014, European statistics, EWEA, February 2015.

This situation of excess capacity exerted downward pressure on bulk energy prices. In fact, the Platts PEP reference price is currently close to 45 MW/h, while it exceeded 50 MW/h between 2010 and 2012. Energy producers saw their sale price drop while they had to bear high fixed costs. The same is true for the marginal cost of fossil fuel power plants, which is higher than that of renewable energy, as the latter is nil or very low [5]. Thus, according to the merit order effect, producers of electricity from renewable sources have priority access to the network for selling their production. Therefore, they make more conventional producers bear the cost of supplementing them during intermittent periods, incurring higher additional costs because of this. This support, or backup, is provided through the use of power plants that burn gas, which can thus be started with greater flexibility. Additionally, according to Fabien Roques, citing IHS CERA in a document by France Stratégie, the profitability of capital invested (ROCE) by the top ten European power producers was 7% in 2012, versus 12.3% in 2007 [6].

At first glance, this is a disadvantage for conventional electricity producers and should thus benefit players in the PV sector. Nonetheless, this places important constraints on the stability of the European electricity system, as other sources of electricity are not only competitors but also complementary in the system, and therefore necessary for supply. In fact, intermittence, a phenomenon inherent (to date) in renewable energy, requires gas powered electric power plants as a backup. They are more flexible than other means of generation, as their cost is lower upon stoppage than those operating with other fuels.

Chart n° 8
Per capita end electricity consumption, in kWh



Source: Eurostat

These uncertainties are pushing the leaders of the countries studied to limit the development of PV and renewable energy in general. In fact, according to the 2014 EurObserv'er indicator, Germany, France, and the United Kingdom only increased their capacity by 5,322 MWc in 2014 (or +12%), thus sparing the already installed base to amortise costs associated with past investments.

Excess capacity also caused by the energy transition

Excess capacity does not come solely from the economic crisis, but also from a European policy of energy savings measures. In fact, this policy, encouraged by the European Commission, seeks to limit CO_2 emissions and thus to reduce environmental impact. By 2020, Member States must reduce their energy consumption by 20% in relation to forecast demand for this year. This means closing ("decommissioning") nearly 400 power plants.

In fact, a policy promoting energy savings affects several areas, in particular housing and offices, household appliances, real-time management of user electricity consumption, and energy efficiency in industrial processes, with energy intensity down by 19% between 2001 and 2011. Still according to the European Commission, the 2020 objective should be achieved thanks to the pace of progress in implementing the measures.

Thus, per capita electricity consumption in the five countries we are following *(see chart 8)* stagnated or even decreased between 1995 and 2012, according to Eurostat data. France was the only exception in 2012, but the trend should reverse in coming years, as these measures were ratified at the European level.

Therefore, the "traditional" European energy producers will have difficulties in relation to these attempts at "decarbonising" the economy, which consist of giving priority to renewable energies, and in turn reducing profitability (for traditional producers).

"Decarbonisation", like the effects of the "great recession", is pushing the downstream sector into great uncertainty and weakening the players. Undertaking a radical transformation of electricity production requires the players in the sector (including public authorities) to invest in a sustained and extended manner. Thus, Eurelectric estimates that achieving the Commission objectives through 2050 will require spending nearly 1,995 billion euros in electricity generation (prices held constant at 2014-euro) and 1,710 billion euros in transmission/distribution (in networks).

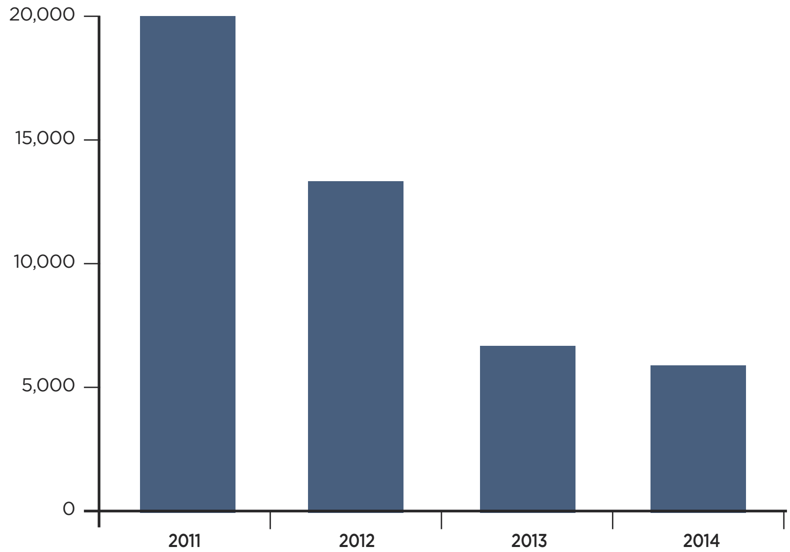
(5) Cost of producing an additional unit of electricity.
(6) The Crisis in the European Electricity System. Diagnosis and possible ways forward, *Commissariat général à la stratégie et à la prospective* (General Commission for Strategy and Forecasting), January 2014

Yet, the financial capacity of the energy producers will not allow them to handle such financial needs. The wholesale price of electricity is too low to be an incentive for them, and the low profitability of their European operations puts the boot in. Additionally, several of these players are starting to develop outside Europe, as well as in energy services, to capture the growth lost in their traditional activities. Investment is no longer attractive there. One of the major risks highlighted is the electricity shortage in coming years. The effects on entire sections of the economy will be significant. Western European industrials pay less for their electricity to be able to remain competitive, but also to prevent them from outsourcing production.

Additionally, how can they count on public finance, while for some States, the public debt to GDP ratio is dangerously approaching (or exceeding) the 100% threshold (except for Germany)? The margins for manoeuvring seem limited. PV is a technology being given life by the desire of public decision makers to limit environmental damage and to promote a more balanced energy mix. It was only able to develop in spectacular fashion during the period in which the question of public deficits and debts was not as important as it is now.

Indirectly, the profitability of the players in the PV sector will be affected. Public decision makers have already started the process of slowing PV development. In 2014, our five countries only installed 5,700 MWc, versus 19,800 MWc in 2011, according to EurObserv'er *(see chart 9)*, or a 71% drop. Managing the integration of renewable energy and PV clearly seems problematic for public decision makers, thus requiring them to limit development to reduce the impact on "traditional" electricity producers. Another reason is the increase in the retail price of electricity, as unlike the wholesale price, it includes taxes and subsidies granted for generation, and has tended to increase in recent years *(see part 3, page 8)*.

Chart n° 9
Installed PV capacity in the five Western European countries, in MWc



Source: EurObserv'er

European electricity integration: a requirement for PV

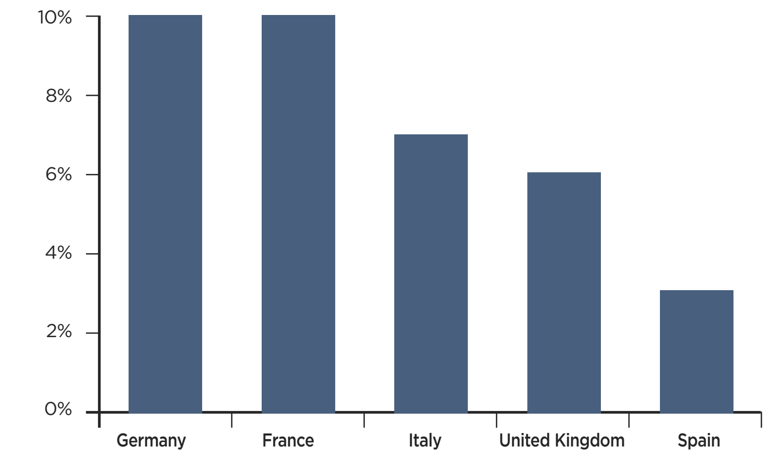
Developing interconnections (electricity exchanges for consumption purposes) between European countries is an indispensable condition for developing renewable energies, and thus for PV. In fact, a country with surplus electricity production might export part of the surplus to neighbouring countries suffering from a supply/demand imbalance. Thus, Spain could sell some of its electricity to France, thanks to the new interconnecting line between Roussillon and Catalonia (even though, in this case, wind is the main means of generation involved). Other interconnections will be put into place and others should "surface" within a few years, such as the Savoy-Piedmont line between France and Italy (2019) or the Cotentin-Cornwall line between France and the United Kingdom (2023).

This phenomenon should reduce the electricity autarchy of European countries, and thus allow development of a more varied mode of generation. European electric integration must be able to provide a response to intermittent PV generation, by establishing a sort of "continuous" adjustment of supply and demand at the European level. For example, half of the electricity consumed by Denmark is supplied by its Scandinavian neighbours, in particular through wind power.

The cost of developing interconnections in Western Europe is high, and the French electricity network operator (RTE) estimates it at nearly 150 billion euros. A total for which financing will be delicate a priori even though all these projects will help create savings assessed at between 450 and 750 billion euros. With such investments, Europe could achieve its energy independence objectives (in relation to fossil fuels), develop a sustainable means of electricity generation, and maintain price-competitiveness. The total amount of investments planned in this area by the European Commission is approximately 200 billion euros through 2020. These infrastructures must be financed through the CEF (Connecting Europe Facility) funds, which are dedicated to the interoperability of digital infrastructures, the ESIF (European Structural & Investment Funds) for local action, especially to support job creation, and the EFSI (European Fund for Strategic Investment) for development.

However, in 2002, the European Union's objective was for its Member States to achieve at least 10% interconnection (in terms of annual consumption).

Chart n° 10
Interconnection percentage



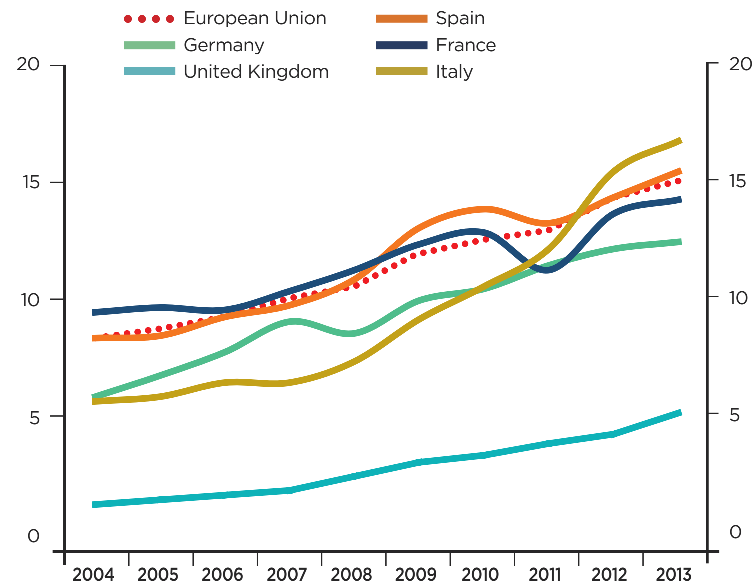
Source: ENTSOE

As of the end of 2014, data published by ENTSOE (a consortium of electricity transmission operators) showed that only Germany and France, out of the five countries that we are studying, had achieved this objective *(see chart 10)*. Because of this, Spain must invest heavily in coming years, despite reticence by the population who does not want to see electricity transmission lines run near their homes. Thus, if the infrastructures are developed, electricity coming from Spanish PV farms could be sold to French customers. Yet, in the short term, this delay is slowing the establishment of an integrated electricity market throughout Western Europe. It is also slowing the development of the PV sector, as interconnection, coupled with the implementation of smart grids [7], can help limit the impact of variability in intermittent generation on the network, and thus of its cost on "traditional" generation methods. However, the question of excess capacity remains unresolved as interconnection can help smooth rates among generating countries. In theory, it should lead to greater efficiency in the electricity generation system, but the presence of widespread excess capacity can erase the positive aspects of European electricity integration, as it will not help absorb this capacity.

3 BRIGHTER MEDIUM-TERM PROSPECTS

Despite current obstacles, PV has medium-term development opportunities. First, the global transition to green energy policy has been under way for nearly a decade, and holding COP21 in Paris should accelerate the trend. The French representatives want to find a way to finance the "Green Climate Fund" created in 2009 in Copenhagen to help emerging countries make the energy transition. The World Bank has been promoting a new objective: a carbon-free world by the end of this century [8]. Then, the cost of electricity generation by traditional channels has tended to increase, while invoices for installation and commissioning solar panels have followed an opposite trajectory. As a result, many European households are seeking own use. Lastly, advanced technologies such as energy storage forecast greater flexibility for using solar energy.

Chart n° 11
Trend in the share of renewable energy in final electricity consumption



Source: Eurostat

Decision makers face the challenge of a rapid energy transition

During the coming decades, renewable energy will continue to play an increasing role in the European energy mix. Between 2004 and 2013, the share of renewable electricity consumed almost doubled within the EU *(see chart 11)*. It was 15% in 2013, versus 8.3% in 2004. Additionally, the share of PV in the renewable energy mix has also shown a growth trend. The installed electric capacity from PV solar energy increased tenfold between 2008 and 2013 according to Eurostat, from 7.3 to 71.2 MW.

(7) Also called "intelligent networks", they make it possible to balance supply and demand through the use of big data.
(8) Decarbonizing development: planning ahead for a future with zero emissions, May 2015, World Bank

COP21: Awareness by all advanced economies...

For several years, many leaders have seized upon the issue of the energy transition. In 2007, the position of former Vice President of the United States, Al Gore earned him and the IPCC [9] the Nobel Peace Prize for "his efforts to establish and spread better understanding of climate change caused by humans and to establish the bases for measurement necessary to counter such change". This environmental cause is at the core of public debate. In speaking about climate change affecting Alaska in September 2015, President Obama declared, "This is no longer some far-off problem. It is happening here. It is happening now". The United States now seems to be turning toward a necessary energy transition and has committed to reducing greenhouse gas emissions from 28 to 26% in relation to 2005 emissions levels. The potential election of a Republican president in 2016 should not hamper this transition in the sense that except for a few coal producing States, American public opinion believes in the change.

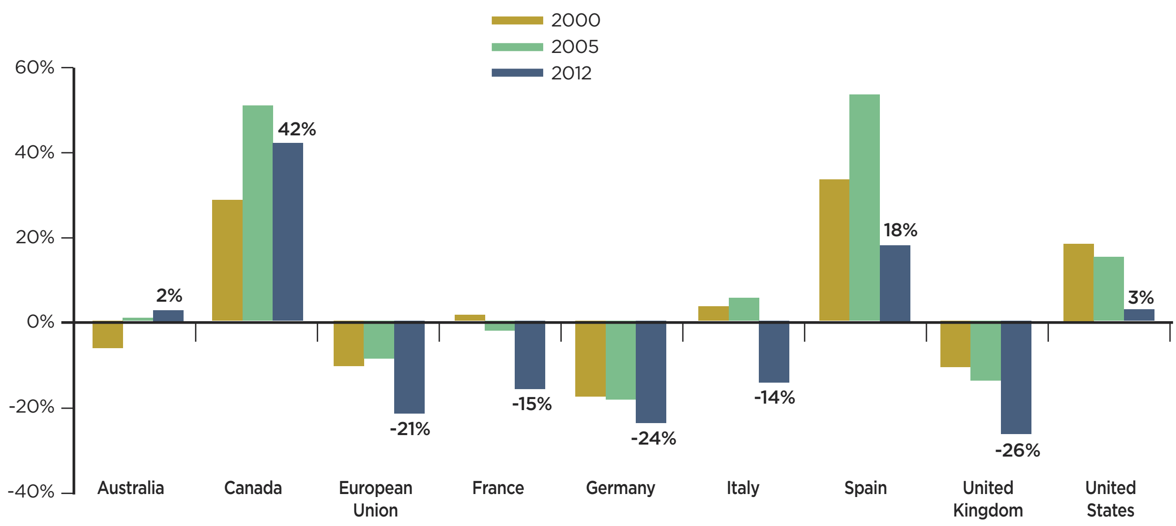
COP21 could lead to renewable energy consumption and generation objectives. While it is not always clear that they will all be achieved, targets can help define trajectories. Europe, the third largest greenhouse gas emitter in the world, is ahead in terms of reducing its emissions *(see chart 12)*. In October 2014, the EU member states adopted several objectives for 2030:

- To generate at least 27% renewable energy at the European level in consumption, or an increase of 10% in relation to 2013;
- To reduce greenhouse gas emissions by at least 40% in relation to 1990 (Europe contributes 9% of global emissions);
- To increase European electricity network interconnection by 15% to limit the dependency of peripheral countries on energy sources from outside the EU, in particular from Russian gas.

... and a subsidy for financing emerging economies

The major challenge for COP21 is to set universal greenhouse gas emission objectives, in particular for emerging countries such as China and India. In Copenhagen in 2009, such an agreement could not be reached, as these two great powers believed that the majority of emission reduction efforts should be made by advanced countries, which are largely responsible for the current degree of pollution as their economic development processes started well before those of the emerging countries. Yet in June 2015 in Paris, Chinese Prime Minister Li Keqiang gave a speech setting some environmental objectives. China, which represents 25% of global greenhouse gas emissions, is committing to lower its carbon intensity (CO_2 emission per unit of GDP) from 65 to 60% in relation to 2005 and to increase the share of non-fossil fuels in primary energy consumption to 20% before 2030. Lastly, China will reduce its overall emissions by 2030 at the latest. This declaration echoed the climate agreement signed between China and the United States in November 2014.

Chart n° 12
Trend in greenhouse gas emissions in relation to 1990



Source: UN

(9) Intergovernmental Panel on Climate Change.

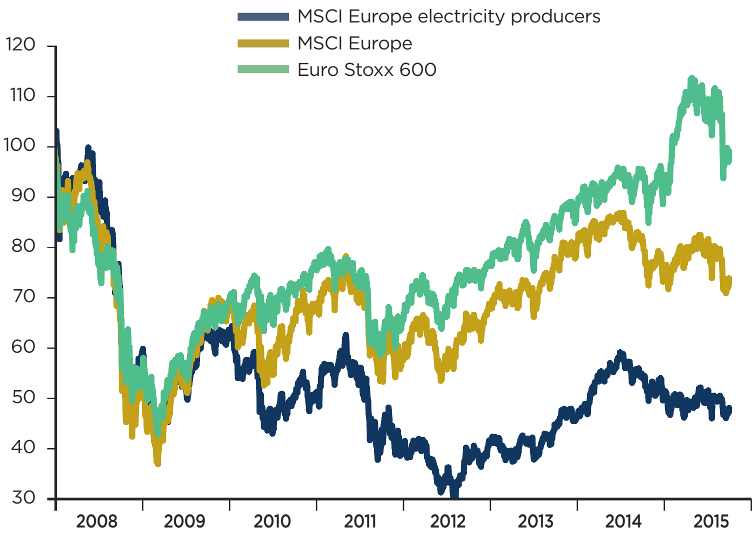
Among other emerging countries, Russia has also committed to reducing its greenhouse gas emissions by 25% to 30% by 2030 in relation to 1990. Brazil plans to reduce its greenhouse gas emissions by 37% by 2025 and by 43% by 2030 in relation to 2005. Additionally, it also wants renewable energy to make up 45% of its energy mix by 2030. At the time this study was written, a contribution from India was still awaited. Many emerging countries such as Colombia, Mexico, Kenya, and Algeria have objectives for reducing their emissions, subject to financial and technological assistance from advanced countries. In fact, at the Copenhagen conference in 2009, developed countries committed to provide 100 billion dollars per year by 2020 to finance environmental projects in emerging countries. This financing will come from public and private players. In April 2015, the World Bank emphasised that financial assistance is still well below the desired numbers. In 2013, out of 331 billion dollars mobilised for climate change, only 34 billion went to developing countries. The organisers have made the mobilisation of 100 billion dollars one of the main objectives of COP21, as it would help the countries of the south to address the environmental issue.

Cost trend in favour of PV

The most widespread resources for generating electricity around the world are thermal power plants that use fossil fuels (oil, gas, coal), which are thus highly polluting. The increasing rarity of raw materials from traditional extraction techniques, and the implementation of carbon taxes [10] in many economies are leading to an increase in electricity production costs. In France in 2016, the carbon tax will be 22 euros per ton of CO_2 emitted versus 14.5 euros in 2015. Additionally, representatives set themselves the objectives of 56 euros per ton by 2020 and 100 euros in 2030. The carbon market is still just beginning; a study by the International Energy Agency (IEA) mentioned that around the world, energy markets have covered 11% of greenhouse gas emissions, at an average price of seven dollars per ton of CO_2.

Additionally, gas and oil extraction is becoming increasingly difficult. First, regulations have changed following the Macondo (Deep Water Horizon) catastrophe in the Gulf of Mexico in 2010, leading to additional fees for equipment installation and monitoring. Then in March 2015, Vallourec [11] mentioned the growing complexity of *offshore* projects located at increasing depths and further from coasts. Investments associated with deep water drilling cannot be profitable with a price per barrel of Brent that Coface forecasts at $56 for 2016, or with a $90 price, which the IEA anticipates for 2020. This forecast is still 22% below the June 2014 price.

Chart n° 13
The weakened electricity sector



Sources: MSCI, Stoxx

Increasing trend in the retail price of electricity in Europe

Major European electric companies suffered greatly during the financial crisis of 2008, causing a significant drop in their market capitalisation. The MSCI index of equities prices for listed companies in this sector lost 79% of its value between January 2008 and September 2012. While the index has corrected since then, it remains well below its pre-crisis level, contrary to overall European market capitalisation *(see chart 13)*, which reached a historic peak in May 2015. Therefore the difference is unique to the weakening of the condition of the European electricity sector.

Wholesale electricity prices collapsed in Europe as the sector has a structural excess capacity [12]. Despite this drop, retail prices in Europe increased by 32% between 2007 and 2014 due to costs incurred for modernisation and upkeep on thermal power plants, as well as due to subsidies granted to renewable energy sectors. Additionally within the EU, there are significant disparities between States *(see chart 14, page 11)*. Denmark and Germany have the highest prices due to significant taxes, in particular to promote renewable energy, while Bulgaria is the country with the most attractive costs. Network inter-

(10) INSEE Definition: carbon tax is a tax added to the sale price of products or services based on the quantity of greenhouse gas, such as carbon dioxide gas (CO_2), emitted during use.
(11) Vallourec, March 2015, Oil and Gas activity.
(12) Wholesale market: market upon which competing electricity generators sell the energy they produce to Suppliers.

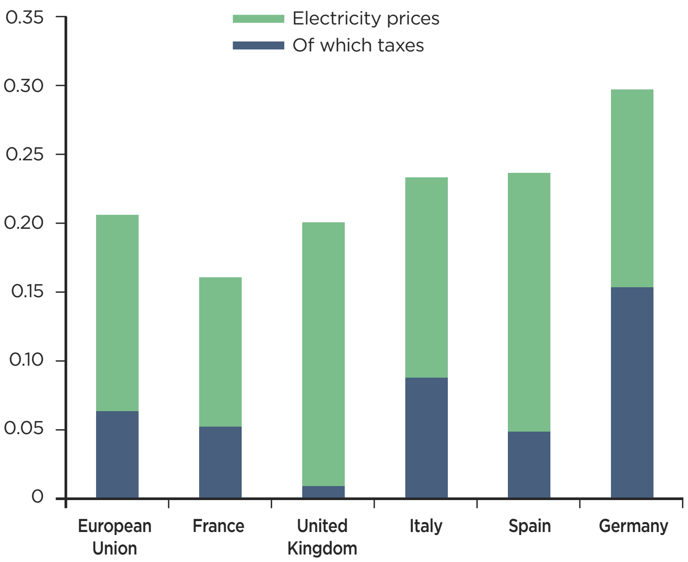
connection, associated with the opening of national markets to competition, should lead to a harmonisation of pre-tax electricity prices in Europe. French distributors, who offer some of the least expensive electricity in Europe, will see their prices increase noticeably. Conversely, German distributors should benefit from inter-connection to lower their rates. Since the Nome law of 2010 [13], regulated prices in France must converge with market prices. In July 2015, a 2.5% increase in electricity prices was adopted and implemented starting in the following month. This is the sixth increase since 2010 (average increase of 2.8%). French consumers (including self-generators) pay a tax to promote renewable energy, the *contribution au service public de l'électricité* (CSPE - contribution to the electric utility). In 2015, 35% of the revenue from this tax went to PV development, according to the Energy regulatory commission.

A study by the IEA and l'OCDE [14] on the impact of renewable energy on German thermal power plants concluded that the increase in generation of electricity from green sources up to the objectives set for 2025 will have negative consequences for current thermal power plants (primarily coal-fired). Capacity will increase and thermal power plant profitability will tend to decrease. Revenue for the oldest power plants (1975 to 1985) will no longer be sufficient to cover modernisation and maintenance costs. The assumptions made by the authors are an increase in solar and wind energy generation from 49.9 GW in 2011 to 115.5 GW in 2025 while the capacity of traditional power plants will remain stable. Thus, the IEA anticipates a decrease in installed capacity generated from fossil fuels in coming years. Electricity generated from gas, oil, or coal is 375 GW in 2015 and will be 326 GW in 2030 (-13%). At the same time, its share will decrease from 37.2% to 31.5%.

The cost of commissioning a solar panel is decreasing

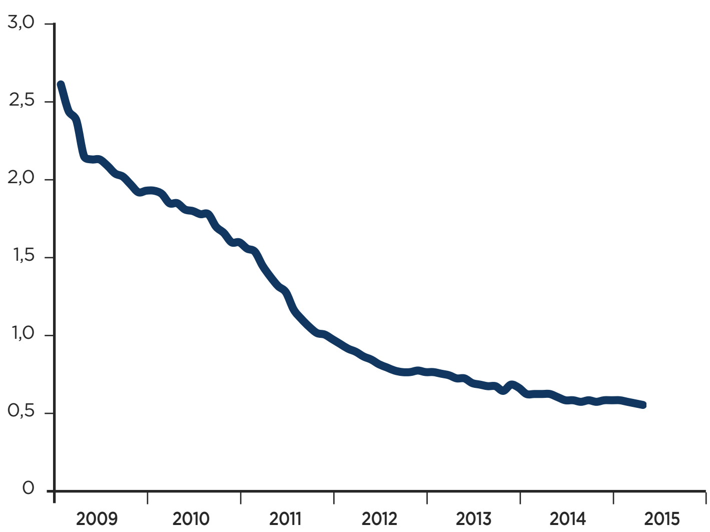
In the price of a PV facility connected to the network, solar panels represent 60% of the invoice, the inverter 15%, and the mounting components and installation 25% [16]. Crystalline technologies *(see section one, page 2)* are the most widely used for building solar panels. Yet, this technology is becoming less expensive *(see chart 15)*. While the installation cost is fixed, inverter and panel costs are decreasing. Together with the increase in electricity prices, this scissors effect is profitable for the sector as it accentuates the profitability of solar investment. *In 2015, Bloomberg new energy finance* (BNEF) published a study that found that solar will become the most competitive green energy source by 2030. Wind power currently holds this position. According to BNEF, solar will represent 35% of energy sources installed worldwide until 2040. The conclusions of the report for Europe lead to the development of small-scale PV, which should reach 22% of the electric bouquet in 2040, versus 6% today.

Chart n° 14
Price per kilowatt-hour sold to households in euros [15]



Source: Eurostat

Chart n°15
Cost of crystalline module, in €/Wc



Source: pvXchange

(13) Opening of the electricity market to competition.
(14) Thermal power plant economics and variable renewable energies, 2014, OECD – IEA.
(15) For consumption of 2,500 to 5,000 KWH.
(16) An inverter helps standardise the PV electricity produced. It transforms the direct current produced by PV facilities into alternating current that can then be put back into the electricity transmission network.

Trend in storage resources available to the sector

The development of PV was made possible thanks to industrial enthusiasm for the technologies of the future. Many research and development centres around the world are working to roll out non-polluting vehicles and energy independent homes. Own use represents an ultimate goal already achieved in many countries.

Additionally, solar energy has a major fault that is being overcome by technological advances: intermittent generation. The development of storage tools can help overcome the decrease in electricity generation at night and during winter. This market should grow rapidly as suggested by many announcements made in 2015.

In April 2015, American luxury electric auto manufacturer Tesla unveiled a battery designed to change "all energy infrastructures worldwide", according to Elon Musk, founder of Tesla and SpaceX. In 2014, Tesla built the largest lithium-ion battery plant in the world in the United States (Nevada). Five billion dollars were invested together with Japanese electronics manufacturer Panasonic. The batteries, with a seven kilowatt-hour (KWh) capacity for a daily cycle or ten KWh for a weekly cycle, will be marketed in 2016 in Europe for a price of $3,500. Germany represents Tesla's advanced target market, as it is one of the world leaders in numbers of solar panels deployed. Additionally, Elon Musk is also presenting this battery as a substitute for the network, which is sometimes non-existent in emerging countries. The American company, Sungevity, a residential PV installer in the United States, and the German company Sonnebatterie, the European leader in on-site storage, announced that they will work together to create a battery to compete with Tesla's.

In 2015 in France, EDF awarded a prize to Energiestro for the creation of a solar storage flywheel. This invention is much less expensive than traditional batteries, both in terms of purchase price and maintenance. According to its founder, André Gennesseaux, storage will decrease to one or two cents per kilowatt-hour versus ten cents for batteries. This product is expected to go on the market in 2017.

Self-supply, an attainable objective

According to a European Commission report from July 2015 on own use of renewable energy, households and companies will shift from being passive consumers to being "prosumers" (producers and consumers) thanks to a decrease in costs and the development of storage tools [17].

The report mentions that many European countries, in particular those in Southern Europe have achieved network parity, which is to say the cost of PV generation is similar to the retail price of electricity including all taxes. With such parity, it becomes attractive for consumers to generate their own electricity. In Italy and Germany, shops already have an interest in installing solar panels (without storage), as their electricity requirements correspond to daylight hours. The cost of generation, estimated at 95 euros per 100 MWh, is lower than commercial rates. In France, a study conducted by the AT Kearny Firm and the European Photovoltaic Industry Association (EPIA) expects that all segments of the market will achieve parity in 2020.

However, there are some obstacles that remain to the rapid development of own use. In fact, many European States have taken the decision to make "prosumers" pay for their access to the network; for example, through a tax depending upon the size of their PV installations. This is the case in the Netherlands, Germany, Belgium, Italy, Spain, and Portugal.

(17) Best practices on renewable energy self-consumption, 2015, European Commission

4 CONCLUSION

Despite the coming challenges, the trend is clearly toward increasing production of renewable energy in Europe in the coming years. COP21 could lead to universal agreements on climate change. While Europe is ahead of its partners, the adjustment that the latter have undertaken will help set higher objectives. Therefore, the "decarbonisation" of the European economy is still in progress.

PV is making a comeback after having been successively stunned by the crises that have struck Western Europe since 2008. Bankruptcies and changes of policy direction have significantly affected the sector, with a less fragmented sector than it was in 2008, and an irreversible loss of *leadership* for European panel production companies. Additionally, it must overcome short-term obstacles to its development. The obvious excess capacity must be reduced, and the slowed development of an integrated European electricity generation sector also opposes its development.

Nonetheless, these obstacles should be removed in the medium-term. Then, the cost of PV will come down as it is adopted, and increasingly large economies of scale will appear. In some countries the cost of PV is equivalent to other generation methods where it is connected to the network, which allows it to partially free itself from public assistance. The acceleration of its development process will also depend upon on-going technological advances, such as those in storage, which will help shift to decentralised energy generation methods closer to consumption sites.

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