Chapter 2
RES Scenario in the European Union

The evolution of energy consumption in Europe is going through a profound change in recent years: the incidence of traditional fuels is diminishing gradually in the face of an increase in renewable energy sources (RES). In 2013, the consumption of electricity from RES amounts to 14 % of the total with respect to 6 % in 1997. This chapter provides a quantitative analysis of RES in the EU and the prospect of development of RES under different scenarios. The analysis begins with a description of the technical characteristics of RES and the quantity produced by each source at world level. In Sect. 2.2, the distribution of the three major RES that are wind, solar and biomass throughout the EU context is analyzed. Section 2.3 provides an analysis of the development of RES in the coming years by different scenarios, both according to the 2014 edition of future scenarios of the International Energy Agency (IEA; 2014a) in the World Energy Outlook-2014 (WEO-2014) and the current EU climate and energy package. Conclusions are drawn in Sect.clus.

2.1 Power Generation from RES

In recent years, especially after repeated threats that affect the environment, RES have acquired significant positions in public opinion and among energy experts. This is because they have as main characteristic the renewability, i.e., the ability to provide energy without exhausting over time. In fact, RES are one of the engines of sustainable development because they do not affect the storage of energy resources and allow to produce cleaner energy. RES have a huge amount of advantages that affect political, economic, and ethical issues. Their use involves a reduction in greenhouse gas (GHG) emissions, greater security supply of primary energy sources, the stabilization of energy costs in the long run since RES have raw material costs in only a few cases (e.g., biomass), high conversion efficiency (thermal and electric) due to technological innovations. Next to the great advantage of producing cleaner energy, RES also show some drawbacks. The production of RES is intermittent in time due to variability in daily, seasonal, climatic conditions of the primary source and there are high investment costs. Systems of the various RES require very large

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land areas and these can have a little look natural both for the shape of the components and the visual impact.

The energy sources are grouped into two macro groups: sources relating directly or indirectly to solar radiation and sources relating to materials or phenomena that occur on earth independently of solar irradiation. Among the sources derived directly or indirectly from solar radiation there are the kinetic energy associated to the flow of the winds, the kinetic energy associated with ocean currents deep, biomass, photovoltaic (PV), energy connected to swell, and the chemical energy contained in fossil fuels.

Among the sources derived from materials or phenomena that occur on earth independently of solar radiation there is the energy contained in the bonds between intra-atomic particles and the kinetic energy related to the motion of the tides and the motion of the current surface ocean, geothermal energy.

The Directive 2001/77/EC (European Commission 2001, 2011) states that:

- RES, renewable nonfossil energy sources (wind, solar, geothermal, wave, tidal, hydropower, biomass, landfill gas, residual gas from sewage treatment, and biogas);
- biomass, means the biodegradable fraction of products, waste, and residues from agriculture (including vegetal and animal substances), forestry, and related industries, as well as the biodegradable fraction of industrial and municipal waste;
- electricity produced from RES, electricity produced by plants using only RES, as well as the share of electricity produced from RES in hybrid plants also using conventional energy sources, including renewable electricity used for filling storage systems, and excluding electricity produced as a result of storage systems;
- electricity consumption, the national electricity production, including autoproduction, plus imports, minus exports (gross national electricity consumption).

Features common to most RES that have direct implications in the power system are the variability, the location, modularity, uncertainty on the intensity of the source, and low operating costs since no fuel costs occur.

Here follows a brief and nontechnical description of the main sectors of intervention and investment in electricity generation plants fueled by RES, by the type of RES, particularly with regard to hydropower, geothermal, wind, solar PV, and biomass because of their greater industrial importance compared to other RES.

The development of current wind technology began with the oil crises that hit particularly industrial countries from 1973 onwards. Wind was considered as one of the most promising alternatives to fossil fuels for electricity production. At the beginning of the 1980s, current wind technology was already tested in the context of government programs in Denmark, Britain, Germany, Sweden, and the USA, several prototypes of wind turbines with power up to 4 MW. The progressive introduction of incentives in various countries, especially in Europe, helped to keep alive the demand. At the beginning of the 1990, European, American, and Japanese companies came to produce machines with power ratings up to 300 kW. In more recent years, machines have been placed in the market wind turbines with power ratings between 1.5 and 3 MW. Today, the wind farm built on land in Europe typically has a total power of tens of mega watt.

Offshore installations[1], as well as terrestrial ones in countries with wider availability of space, can be up to several 100 MW each.

Installations of wind power generation in use today can be divided into two categories:

- the wind farm power significantly related to the medium-voltage networks and especially the high voltage;
- the mini wind turbines, that is low power plant (not more than 100–200 kW) used for feeding of users not served by the network with the help of accumulation systems or for connection to low-voltage networks.

The key component of both types of system is the machine that converts wind energy into electricity, i.e., the wind turbine. In wind farms, a certain number of wind turbines are installed in patterns appropriate in an area with adequate wind conditions. The power of each unit today is tend to exceeding 1 MW. The mini wind turbines instead often include a single wind turbine whose power is 1 kW (or less) up to 100–200 kW.

The division of the cost of a wind farm in a typical land site is on average 70–80 % of the purchase and installation of the wind turbines and 20–30 % for the remainder, including the foundations of the wind turbines, the streets of access, internal roads, electricity infrastructure, installation work, the line connecting to the network, and the planning and authorization procedures. The incidence of these costs is naturally higher in hilly or mountainous areas.

Generally, the typical costs of plant lie in the range between 1300 and 2000 €/kW, with the highest values for relatively small plants in remote areas in complex terrain.

The offshore farms have a much higher installation cost compared to terrestrial ones, both for the higher prices of wind turbines designed for offshore use and for the higher costs of foundations underwater, installation in the sea, and electrical infrastructure connection to the mainland. For the most recent projects, estimates range from 2800 to almost 4000 €/kW; the ma higher costs of offshore should be offset by higher annual energy production.

In order to calculate the average cost of a wind power plant project, it is necessary to evaluate its annual net real manufacturability and it is appropriate to make assumptions regarding the useful life of the machines, usually 20 years, and the discount rate. For instance, for an average Italian wind farm of 20 MW with specific cost 1740 €/kW for a life of 20 years and a discount rate of 5 %, it is estimated an average cost of between 110 and 160 €/MWh. Of course, in other countries with easier terrain, open spaces, and strong and regular wind regimes (e.g., in the

[1] The offshore wind is the wind made in the sea. Thanks to the favorable conditions of wind at sea, offshore wind (with the same installed power) produces on average 30 % more energy than usual onshore.

north-central EU), the average cost of energy may be much lower, even in the order of 50–60 €/MWh.

The production of wind energy has mainly two controversial aspects. First, the average cost of wind power generation is still above the EU average revenues obtained from the sale of the wind power in the electricity market. It then explains how the wind power production still needs some incentives (it follows a detailed description of incentive mechanisms in Chap. 3).

Second, the development of RES, in particular wind energy, introduces elements of landscape transformation, thus an evolution of the ratio between the population and perception that they have of the landscape itself. The plants powered by RES are deeply rooted in the territory in which they are installed and from which they receive their raw material, making it more visible energy production and transforming the relationship with the natural environment. The presence of environmental impacts related to RES imposes the need for a shared scenario and an integrated approach to the comparison of the overall benefits and the changes induced locally.

The wind power capacity installed worldwide during 2012 is 44,184 MW, corresponding to a cumulative capacity of 281,052 MW worldwide (Table 2.1).

Wind continues to be used mainly by wind power plants of significant power, connected to high-voltage power grids and wind turbines mainly between 1 and 3 MW of power per unit on the mainland and between 2 and 6 MW offshore.

Concerning the PV technology, it allows to directly convert solar energy into electricity through the PV effect, that is the property of some semiconductor materials to generate electricity when struck by light radiation. The silicon element is widespread in nature, is the basic material for the PV cell, and is the elementary device that can produce about 1.5 W in direct current, normally insufficient for common uses. More cells are electrically connected and encapsulated in a structure to form the module-based component which is commercially available.

Several modules are connected in series and in parallel, forming sections of a plant whose power can reach thousands of kilowatt. Downstream of PV modules is placed the inverter that converts the direct current into alternating current generated by the cell, directly usable by users or with the possibility of being fed into the grid. The modules can be oriented towards the sun on fixed structures, or structures able to follow the movement in order to increase solar collection.

Each kilowatt peak[2] installed requires an area of about 8–10 m^2 net for crystalline silicon modules coplanar to the roofs of buildings; it is necessary instead of a broader space for modules arranged in several rows on a flat surface to reduce shading.

The main applications of PV systems are:

- Systems with storage system for isolated users from the network; such systems are independent type and they are indicated in the case of the absence of electrical connection (such as mountains, in agricultural areas not served by the network,

[2] The kilowatt peak is used to measure the maximum power delivered by a photovoltaic generator.

Table 2.1 Global wind capacity (MW). (Source: EurObserv'er, 2014 and ENEA 2014)

	Cumulative capacity (2011)	Cumulative capacity (2012)	Installed capacity in 2012
Europe	96,732.8	109,176.1	12,690.0
USA	46,919.0	60,007.0	13,124.0
Canada	5265.0	6200.0	935.0
China	62,364.0	75,564.0	13,200.0
India	16,084.0	18,421.0	2337.0
Japan	2536.0	2614.0	88.0
Other Asian countries	1086.0	1211.0	125.0
Africa and Middle East	1033.0	1135.0	102.0
Latin America	2280.0	3505.0	1225.0
Pacific Region	2865.0	3219.0	358.0
Total	*237,160.8*	*281,052.0*	*44,184.0*

etc.). The stand-alone PV systems are the best solution to address the lack of electricity network. This technology can be very useful in developing countries that have problems of energy supply to hospitals, schools, and kindergartens, and also in remote areas (in the mountains or countryside) not served by the national grid.

- PV plants connected to the grid: they have the feature to work on an interchange with the local power grid. In particular, during daylight hours, the user consumes the electricity produced by his solar system, and when there is no light or it is not sufficient, or if the user requires more energy than the plant can provide, the electricity network will ensure the supply of the electricity needed. On the other hand, in the case, the plant produces more energy than required by the user, such energy can be fed into the network. Solar installations connected to the grid thus represent an additional source, because they provide a contribution for a different amount depending on the size of the plant, the building's overall electricity balance that uses them. There are also power stations connected to the network in the medium or high voltage.
- "Anti-blackout" PV systems: they are hybrid systems which provide electricity during power cuts by taking energy from the battery (as in systems for isolated users), while working as normal systems to connect to the network when there is electricity.

Of all the energy that hits the solar cell in the form of light radiation, only a portion is converted into electric energy available at its terminals. The conversion efficiency of commercial silicon cells is generally between 13 and 20 %, while laboratory cells have reached values of 32.5 %.

A PV system produces electricity for 20–25 years, with few maintenance requirements and a good resistance to atmospheric agents. Disposal at the end of life does not have any particular problems: a PV module is in fact more than 90 % recyclable.

The most significant cost item for the construction of a solar system is certainly made up of the purchase cost of PV modules that affect the total to 40–60 % (depending on power). The PV modules are the most long-lived component of a plant, as designed and manufactured to produce electricity for more than 50 years (some researchers claim that they can work for over 100 years). The design and installation together range from 30 % for smaller plants to about 15 % for the major power plants. The remaining cost items are almost always below 10 %. In particular, the inverter is at most 10 % of the total cost of the system for a power range of 20–100 kWp, which declined gradually to 7 % in the case of plants from 3 kWp. The support structures of the modules instead vary from 5 to 8 % for traditional structures depending on the size of the system.

In 2012 there have been installed 31.4 GW worldwide, an increase of 14 % compared to 2011 and in 2013 the PV has grown more than 13 %. The EU accounts for the predominant share of the global PV market, with 55 % of all new capacity in 2012 and about 70 % of the world's cumulative PV capacity with more than 70 GW of cumulative installed capacity in 2012. China is the second largest producer of PV with cumulative capacity amounts to 8.3 GW in 2012, followed by the USA

Table 2.2 Global photovoltaic cumulative installed capacity (MW). (Source: EurObserv'er and ENEA 2013)

	Cumulative capacity (2011)	Cumulative capacity (2012)	Installed capacity in 2012
Europe	52,884.0	70,043.0	17,159.0
Asia Pacific	7628.0	12,397.0	4769.0
Americas	4959.0	8717.0	3758.0
China	3300.0	8300.0	5000.0
Middle East and Africa	192.0	601.0	409.0
Rest of the world	2098.0	2098.0	0.0
Total	*71,061.0*	*102,156.0*	*31,095.0*

(7.8 GW) and Japan (6.9 GW). Some countries that have a huge potential, as Africa, the Middle East, South East Asia and Latin America, are beginning to appear on PV market.

At the global level, nine of the top ten markets for PV in 2012 have installed at least 1 GW of PV systems (Table 2.2).

Concerning the hydroelectric technology, hydroelectric power plant converts the hydraulic energy of a watercourse, natural or artificial, into electrical energy. In general, the functional scheme includes the work of the barrage, a dam, or a crossbar, which intercepts the course of water creating a reservoir which may be a tank, or basin, where it is kept in an almost constant level of water.

Through the works of water supply, canals, and tunnels, water is then piped into tanks and cargos and through penstocks, it flows in turbines via the inlet valves (safety) and regulatory bodies of the range (distributors) according to energy demand. The water, which puts into action the turbines, then flows out of the discharge channel through which it is returned to the river. The alternator is directly connected to the turbine and is mounted in an arrangement with a vertical axis or horizontal axis. It is essentially a rotating electrical machine capable of transforming mechanical energy into electrical energy by the turbine. The electricity thus obtained must be transformed in order to be transmitted over long distances.

Therefore, before being conveyed in transmission lines, electrical energy passes through the transformer that lowers the intensity of the current produced by the alternator; however, by raising the voltage to thousands of volts. Arrived at the place of use, before being used, the energy passes back into a transformer that this time raises the intensity of current and lowers the voltage so as to make it suitable for domestic use.

The power of a hydraulic system depends on two factors that are the jump (height difference between the height at which the water resource is available flared and the level at which the same shall be refunded after the passage through the turbine) and the rate of flow (the mass of water flowing through the machine expressed per unit of time).

There are also mini hydroelectric plants which are hydroelectric plants with a capacity less than 100 kW. The micro-stations fall into one broader category, called micro-hydraulic by United Nations Industrial Development Organization[3] (UNIDO), a term that indicates hydropower plants with a capacity below 10 MW.

The micro-hydraulics plants are classified as:

- Pico-hydropower plants, $P < 5$ kW;
- Micro-hydropower plants, $P < 100$ kW;
- Mini-hydropower plants, $P < 1000$ kW;
- Small-hydropower plants, $P < 10{,}000$ kW.

Both in the case of large and micro plants, the generation of electricity by hydroelectric presents environmental benefits of not polluting the environment with substances discharged into the air, as it happens in the case of traditional methods of generation by thermoelectric.

The micro- hydropower plants mainly solve the problems associated with large systems: from more parts, large dams are under indictment for the damage they might cause to natural ecosystems as the variation in the quantity and the quality of water resulting from the construction of dams can have potential impact on fish fauna along with any changes in the riparian vegetation.

In many cases, moreover, the micro-hydropower stations have positive effects on adjustment and retention of floodwaters of the streams, especially in mountainous areas where they often cause instability and degradation of the soil.

Approximately 20% of the electricity produced in the world today comes from hydro. Hydropower in fact contributes to a significant share of the world demand for primary energy: to a greater extent than 6% worldwide, but with values much higher for some regions (e.g. 27% in the case of Central and South America) or for individual countries. Global capacity in 2012 amounts to 990 GW, with China accounting for 23% with 231 installed capacity, Europe for 15% (148 GW installed capacity), Brazil 8.5% (82 GW installed capacity), USA 7.9% (76 GW installed capacity), Canada 7.8% (75 GW installed capacity) and Russia 4.6% (50 GW installed capacity). Globally, hydropower has generated at around 3700 TWh of electricity during 2012 (Table 2.3).

The biomass energy is applied to more than one material, virgin or residual agricultural, or industrial processes, which may occur in different physical conditions.

Depending on the type of biomass and the most appropriate technology for implementing the energy enhancement, there are many different plant solutions.

The plants that are most widely are:

- Conventional, with combustion of solid biomass
- Gas turbine fueled by synthesis gas, obtained from biomass gasification
- Combined cycle, with steam turbine and gas turbine

[3] UNIDO is the specialized agency of the United Nations that promotes industrial development for poverty reduction, inclusive globalization, and environmental sustainability.

Table 2.3 Hydropower capacity in 2012. (Source: World Energy Council 2013)

	Installed capacity (MW)	Actual generation (GWh)
China	231,000.0	714,000.0
Europe	148,500.0	
Brazil	82,458.0	428,571.0
USA	77,500.0	268,000.0
Canada	75,104.0	348,110.0
Russian Federation	49,700.0	180,000.0
Rest of the world	325,738.0	828,437.0
Global total	*990,000.0*	*2,767,118.0*

- Thermoelectric hybrids, that use both biomass and conventional sources
- Powered by liquid biomass (vegetable oils, biodiesel), consisting of engines coupled to generators

Biomass is the most sophisticated form of accumulation of solar energy which through photosynthesis converts light energy into chemical energy stored in organic molecules. For this reason, it is an RES as the CO_2 produced during combustion is reabsorbed by plants through photosynthesis.

Currently, biomass meets about 15 % of primary energy use in the world, with 55 million TJ/year (1230 Mtoe/year). The use of this source shows, however, a high degree of heterogeneity between countries. Developing countries, on the whole, on average, derive 38 % of its energy from biomass, with 48 million TJ/year (1074 Mtoe/year), but in many of them the resource meets up to 90 % of energy needs total, by the combustion of wood, straw and animal waste. In industrialized countries instead biomass contributes for 3 % of the primary energy use by 7 million TJ/yr (156 Mtoe/year).

A widespread use of biomass can result in significant impacts at economic, environmental, and employment levels, as they can ensure enhancement of agro-industrial residues, new opportunities for the development of marginal areas and/or reduction in agricultural surpluses with the replacement of traditional crops with energy crops, very low contribution to the increase in the rate of CO2 in the atmosphere. In order to diversify RES, the use of biomass is an important potential energy reservoir, which could help to reduce vulnerability in the supply of energy resources and restrict the import of electricity for many countries. Biofuel production that is any fuel derived from biomass is shown in Table 2.4.

Geothermal energy uses the earth's internal heat generated in part during the formation of the planet and in part by the decay of radioactive isotopes in the mantle (volcanoes, hot springs, fumaroles, and geysers are indications of the heat that is stored in the Earth's crust). A geothermal power plant consists of an area where it was detected in the presence of hot fluids, with depths ranging from 60 to 3000 m from where the vapor presents at high temperatures (150–250 °C) is extracted by drilling and then piped into insulated carbon steel pipes, which carry the steam to the central.

Table 2.4 Biofuel global production, 2012 (billion liters). (Source: REN21 2013)

	Fuel ethanol	Biodiesel	Total	Comparison with volumes produced in 2011
USA	50.4	3.6	54	−2.4
Brazil	21.6	2.7	24.3	0.6
Germany	0.8	2.7	3.5	−0.5
Argentina	0.2	2.8	3	0.1
France	1	1.9	2.9	0.2
China	2.1	0.2	2.3	No change
Canada	1.8	0.1	1.9	0.2
Thailand	0.7	0.9	1.6	0.5
Indonesia	0.1	1.5	1.6	0.2
Spain	0.4	0.5	0.9	−0.3
Belgium	0.4	0.4	0.8	No change
The Netherlands	0.2	0.5	0.7	−0.1
Colombia	0.4	0.3	0.7	No change
Austria	0.2	0.4	0.6	No change
India	0.5	>0.0	0.5	0.1
EU-27	4.2	9.1	13.3	−0.7
World total	*83.1*	*22.5*	*105.6*	*1*

The energy possessed by the vapor, expanded in a turbine coupled to a generator, is first transformed into mechanical energy and then into electrical energy. The exhausted steam is conveyed into the condenser, where it is converted to water at high temperature, which passes into the cooling tower, where it is cooled and injected underground. It is of fundamental importance to ensure the renewability of the geothermal system, replacing the fluid removed from use, both to prevent landslides and in order not to deplete the geothermal fields. This can occur naturally through the rain, while in other cases it is necessary to artificially recharge through injection wells.

The conversion of geothermal energy into electricity is obtainable with different technologies depending on the temperature and pressure of the hydrothermal system available:

- Dry-steam systems that consist in majority by dry steam which is located at high pressures and temperatures accompanied by other gases or soluble substances. The steam can be used directly for the production of electricity conveying it to a turbine.
- Systems to wet steam: it is constituted by hot water at a temperature higher than its boiling point and high pressure; when pressure is reduced in the column of the well the water vaporizes and comes to the surface in the form of a mixture composed of water and steam. The steam can be used for the production of electricity, while the hot water can be used in desalination plants to produce freshwater. The temperature in this type of system is between 180 and 370 °C.
- Hot-water systems: they contain water at a temperature below 100 °C can be used in most cases for direct uses such as home heating, greenhouses, and industrial plants.

The use of geothermal energy can be divided into some areas: as uses at high enthalpy with fluids that reach temperatures higher than 150 °C; it concerns the production of electric energy and some industrial uses and uses at medium- and low-enthalpy fluids that reach temperatures of 150–100 °C in the first case and less than 100 °C in the second; and it concerns the direct uses as domestic, agricultural, and industrial ones.

The overall yield of the production of electricity from geothermal steam is 10–17 %, about three times lower than that of traditional sources, this is due to the lower temperature of the steam (250 °C), both for the different chemical composition of the same, which determines a loss of energy. Geothermal power stations consume from 6 to 15 kg of steam and a good production well, with a flow rate of 70,000 kg/h, can feed a power of 10 MW. On land, there are large areas in which the subsoil are fluids at temperatures between 40 and 100 °C, easily accessible, which could be directly used for heating and cooling, thus allowing a considerable saving of hydrocarbons.

2.2 RES in the EU

In the EU, in 2012, the energy coming from RES accounted for 14.1 % of gross final consumption, covering about 8 % of EU electricity demand. There is an increase from 1 year to the other of the weight of the share of energy consumed from RES compared to the total energy consumed on average (Table 2.5).

Overall, RES status in the EU is good since some RES technologies have shown rapid progress. In fact, what you thought was in the 1990s an ambitious target for 2010 has already been reached for some technologies. In 1997, the European Commission had made some projections for RES in its White Paper for a Community Strategy and Action Plan. Wind and PV have even exceeded the target: wind energy, with a cumulative installed capacity at the end of 2010, amounting to 84 GW has exceeded the target of the White Paper of 40 GW; PV, at the end of 2010, has shown an installed capacity of approximately 27 GW against the target of 3 GW of installed capacity.

Albeit slowly, the use of RES increased in the EU, reaching a share of 14.1% in the Eu final energy consumption. According to Eurostat (2013), Sweden, Bulgaria, and Estonia have already achieved the 2020 targets set by the RES Directive (2009/28/EC). The EU countries that have increased the consumption of RES are Sweden (increased from 38.7 % in 2004 to 51 % in 2012), Denmark (from 14.5 to 26 %), Austria (from 22.7 32.1 %), Greece (from 7.2 to 15.1 %) and Italy (from 5.7 to 13.5 %). The countries most green in absolute terms are Sweden (EU record with 51 %, exceeding eight years ahead of the target of 49 %), Latvia (35.8 %), Finland (34.3 %) and Austria (32.1 %). Estonia was the first to reach the 2020 target early in 2011 (extendable to 25.2 % in 2012), followed in 2012 also from Bulgaria (16.3 %). The less virtuous countries regarding the use of RES are Malta (1.4 %), Luxembourg (3.1 %), Great Britain (4.2 %) and the Netherlands (4.5 %).

It is interesting to look at the situation of the individual RES in the EU.

With reference to wind power, 2012 has been a positive year for the EU wind energy market: the new installed capacity during the year was 11840 MW enabling the EU to greatly exceed the threshold of 100 GW of installed capacity (MW 105635). Subtracting the disused installations, wind power of the EU has increased by 11,593 MW in 2012, compared with an increase of 9299 MW in 2011.

The wind power capacity in the EU is currently 209.7 kW per 1000 inhabitants. By taking into account this indicator to assess the weight of wind power in a single state, the main EU countries are Denmark (754.8 kW/1000 inhabitants), Spain (4888 kW/1000 inhabitants), and Portugal (429.2 kW/1000 inhabitants).

Several factors have contributed to the strong growth of the EU market in 2012 and mainly they are related to offshore wind farms at high power in the North Sea as well as onshore parks in Scotland. Another factor is the emerging markets of eastern EU countries (Poland, Romania, and Austria in particular) that have been very dynamic in 2012, driven by the sharp increase in the price of gas.

As regards offshore wind, the power connected to the network in the EU amounted to 4705.8 MW in 2012, which corresponds to about 1156.4 MW of additional

Table 2.5 Primary production of RES, 2000 and 2010. (Source: Eurostat 2013)

	Primary production (1000 toe)		Share of total, 2010 (%)				
	2000	2010	Solar energy	Biomass and waste	Geothermal energy	Hydropower energy	Wind energy
EU-27	96,650	166,647	2.2	67.6	3.5	18.9	7.7
Euro area	65,006	118,679	2.9	64.3	4.8	19.0	9.0
Belgium	534	1989	3.0	89.8	0.2	1.4	5.6
Bulgaria	780	1475	0.8	63.6	2.2	29.5	4.0
Czech Republic	1339	2900	2.1	88.6	0.0	8.3	1.0
Denmark	1766	3123	0.5	77.6	0.3	0.1	21.5
Germany	9094	32,746	4.4	78.7	1.6	5.4	9.9
Estonia	512	988	0.0	97.3	0.0	0.2	2.4
Ireland	235	620	1.0	51.8	0.0	8.4	39.0
Greece	1403	1985	9.9	44.7	1.4	32.3	11.7
Spain	6928	14,657	7.0	42.2	0.1	24.8	25.9
France	15,874	20,793	0.5	69.1	0.4	25.6	4.1
Italy	9598	16,328	1.8	37.3	29.2	26.9	4.8
Cyprus	44	77	79.2	15.6	1.3	0.0	3.9
Latvia	1393	2101	0.0	85.4	0.0	14.4	0.2
Lithuania	682	1185	0.0	94.0	0.4	3.9	1.6
Luxembourg	39	92	3.3	81.5	0.0	9.8	5.4
Hungary	830	1922	0.3	91.4	5.2	0.8	2.4
Malta	0.0	0.0	0.0	0.0	0.0	0.0	0.0
The Netherlands	1347	2896	1.0	86.6	0.3	0.3	11.8
Austria	6608	8600	2.0	57.1	0.4	38.4	2.1
Poland	3808	6849	0.0	94.0	0.2	3.7	2.1

Table 2.5 (continued)

	Primary production (1000 toe)		Share of total, 2010 (%)				
	2000	2010	Solar energy	Biomass and waste	Geothermal energy	Hydropower energy	Wind energy
Portugal	3759	5438	1.4	55.1	3.5	25.5	14.5
Romania	4040	5677	0.0	69.6	0.4	29.6	0.5
Slovenia	788	1041	0.6	59.5	2.7	37.3	0.0
Slovakia	496	1398	0.0	67.0	0.6	32.3	0.1
Finland	7748	9030	0.0	87.4	0.0	12.3	0.3
Sweden	14,741	17,408	0.1	65.4	0.0	32.8	1.7
UK	2264	5327	1.7	76.0	0.0	5.8	16.4
Norway	13,481	11,554	0.0	11.9	0.0	87.5	0.7
Switzerland	4437	4968	1.0	31.3	5.2	62.4	0.1
Croatia	879	1232	0.4	39.9	0.6	58.1	1.0
FYR (Former Yugoslavic Republic) of Macedonia	322	422	0.0	47.6	2.8	49.5	0.0
Turkey	10,102	11,627	3.7	38.9	16.9	38.3	2.2

Table 2.6 Cumulative installed offshore wind power capacity in 2012 (MW). (Source: EurObservurO and ENEA 2013)

	2011	2012
UK	1838.0	2679.0
Denmark	817.5	921.9
Belgium	195.0	380.0
Germany	200.3	280.3
The Netherlands	228.0	228.0
Sweden	163.4	163.4
Finland	26.0	26.0
Ireland	25.2	25.2
Portugal	2.0	2.0
Total EU 27	*3549.4*	*4705.8*

power connected to the network compared to 2011. According to the European Wind Energy Association (EWEA), offshore power's increase is mainly due to new plants put into operation in the UK that have brought the cumulative offshore capacity in the UK to 2679 MW at the end of 2012. Denmark is the country's second largest producer of offshore wind, with a total installed capacity in the late 2012 at around 912.9 MW (Table 2.6).

Although the EU wind energy market in 2012 has exceeded expectations, prospects for growth in the short term are less encouraging. Among the causes, the political uncertainty that is characterizing the EU has led a number of countries to review their incentive systems or not to provide sufficient guarantees to investors in the coming years. In fact, during 2013 in the EU, 28 have been installed 11,159 MW of new wind energy capacity, a decrease of 8% compared to 2012. This is what emerges from the report wind power in 2013 published by EWEA, which emphasizes that previously healthy markets such as those of Spain, Italy, and France have recorded very substantial declines compared to 2012: −84%, −65% and −24%. This has resulted in a change in the distribution of the plants which in 2013, unlike in previous years, have focused mainly on just two countries, Germany and the UK, with 46% of new installations. Despite the sharp decline, annual wind power installations in the EU have increased steadily over the past 13 years from 3.2 GW in 2000 to 11 GW in 2013, a compound annual growth rate of over 10% (EWEA 2014; Table 2.7).

With reference to PV energy systems, they play a key role in the transition to a low-carbon energy supply of carbon. This potential has led to the development of efficient PV panels and transformed the area into one of the fastest growing industries. The production of PV cells and modules increased from 46 MW in 1990 to 38.5 GW in 2012. The plants statistically documented all over the world representing almost 100 GW in 2012, putting the EU in a position of advantage with its share of over 69 GW. Actually, the market is shifting towards Asia and America, although the EU remains the main area of installation, the internal market is slowing down for the first time since 2006. In 2012, the EU accounted for just over half the world

Table 2.7 Cumulative wind power installed in Europe by the end of 2013 (MW). (Source: EWEA 2014)

	Installed 2012	End 2012	Installed 2013	End 2013
Austria	296.0	1377.0	308.0	1684.0
Belgium	297.0	1375.0	276.0	1651.0
Bulgaria	158.0	674.0	7.1	681.0
Croatia	48.0	180.0	122.0	302.0
Cyprus	13.0	147.0	0.0	147.0
Czech Republic	44.0	260.0	9.0	269.0
Denmark	220.0	4162.0	657.0	4772.0
Estonia	86.0	269.0	11.0	280.0
Finland	89.0	288.0	162.0	448.0
France	814.0	7623.0	631.0	8254.0
Germany	2297.0	30,989.0	3238.0	33,730.0
Greece	117.0	1749.0	116.0	1865.0
Hungary	0.0	329.0	0.0	329.0
Ireland	121.0	1749.0	288.0	2037.0
Italy	1239.0	8118.0	444.0	8551.0
Latvia	12.0	60.0	2.0	62.0
Lithuania	60.0	263.0	16.0	279.0
Luxembourg	14.0	58.0	0.0	58.0
Malta	0.0	0.0	0.0	0.0
The Netherlands	119.0	2391.0	303.0	2693.0
Poland	880.0	2496.0	894.0	3390.0
Portugal	155.0	4529.0	196.0	4724.0
Romania	923.0	1905.0	695.0	2599.0

Table 2.7 (continued)

	Installed 2012	End 2012	Installed 2013	End 2013
Slovakia	0.0	3.0	0.0	3.0
Slovenia	0.0	0.0	2.0	2.0
Spain	1110.0	22,784.0	175.0	22,959.0
Sweden	846.0	3582.0	724.0	4470.0
UK	2064.0	8649.0	1883.0	10,531.0
Total EU-28	*12,102.0*	*106,454.0*	*11,159.0*	*117,289.0*
Total EU-15	*9879.0*	*99,868.0*	*9402.0*	*108,946.0*
Total EU-13	*2224.0*	*6586.0*	*1757.0*	*8343.0*

market while the previous year had its share of almost three quarters. In 2012, the EU has added to the network 16.5 GW of new capacity for PV, showing a decrease of 25 % compared to 22 GW recorded in 2011.

Over the past 3 years, the growth in the EU was primarily driven by speculative investments that took advantage of the constant difference between the levels of guaranteed remuneration and the very rapid decline in production costs. Some governments have difficulties to overcome this situation and they are trying to mitigate the costs by introducing taxes on electricity production or retroactively changing their own laws. The situation is quite critical so that the European Photovoltaic Industry Association has appealed to the EU for you to take measures against countries that fail to fulfill their commitments on support of RES. It is possible to note the paradox of the EU market where some governments have decided to reduce the volume of installations when it is about to be reached grid parity in their electricity market.

The EU photovoltaic industry is dominated by Germany and Italy, respectively on the first and second place (Table 2.8). Together, the two countries in 2012 accounted for over two thirds of the total number of new solar capacity installed at community level, thanks to respectively 76 and 35 GW. Anyway, there have been a decline in demand in Italy and Germany due to cuts in incentives and uncertainty linked to the trade dispute with China[4].

Lower decrease of installations, compared to 2012, is being recorded even in smaller markets such as Belgium, Denmark, Bulgaria, France, Greece, the Netherlands, Slovenia, and Spain, while the UK, Austria, and Romania in 2013 have grown significantly. In particular, the UK market is the largest market in the first quarter of 2014, especially in the rush to complete the great PV parks before the cuts of the renewable obligation certificate that are British green certificates. After four consecutive quarters of decline, Germany is expected to resume and regain his place as leader of the PV in the second half of 2014 even though the installed capacity in 2014 will be lower than in 2013. To keep alive the German demand, there will be mainly installations in self-consumption; self-consumption will be the spring that will restart the Italian market.

Despite the current difficult economic conditions, the number of new PV markets is increasing. This, together with rising energy prices and the pressure to stabilize the climate, maintains high demand for solar energy systems. The production of electricity by PV modules has already demonstrated that it can be cheaper than conventional electricity currently provided to consumers in many countries.

Concerning biomass, data available in November 2011 on the use of solid biomass in the EU (practically wood for the production of heat or electricity) highlight the increase of the use of biomass during the entire 2010, an increase of 8 % corresponding to an amount passed from 73.4 Mtoe in 2009 to 79.3 Mtoe in 2010. It has

[4] China imposes two kinds of duties: the antidumping and antisubsidy for imports of polysilicon for photovoltaic panels from the USA and South Korea. As part of the Chinese government, the decision should strongly discourage the use of external materials, strengthening domestic production.

Table 2.8 Primary solar photovoltaic production in the EU (GWh). (Source: EurObserv'er and ENEA 2013)

	2010	2011	2012
Belgium	560.0	1170.0	2148.0
Bulgaria	15.0	101.0	814.0
Czech Republic	616.0	2182.0	2149.0
Denmark	6.0	15.0	104.0
Germany	11,729.0	19,599.0	26,380.0
Estonia	0.0	0.0	0.0
Ireland	0.0	0.0	0.0
Greece	158.0	610.0	1694.0
Spain	6425.0	7441.0	8193.0
France	620.0	2078.0	4016.0
Croatia	0.0	0.0	2.0
Italy	1906.0	10,796.0	18,862.0
Cyprus	6.0	12.0	22.0
Latvia	0.0	0.0	0.0
Lithuania	0.0	0.0	2.0
Luxembourg	21.0	26.0	38.0
Hungary	1.0	1.0	8.0
Malta	0.0	8.0	13.0
The Netherlands	60.0	100.0	254.0
Austria	89.0	174.0	337.0
Poland	0.0	0.0	1.0
Portugal	211.0	280.0	393.0
Romania	0.0	1.0	8.0

Table 2.8 (continued)

	2010	2011	2012
Slovenia	13.0	66.0	163.0
Slovakia	17.0	397.0	424.0
Finland	5.0	5.0	5.0
Sweden	9.0	11.0	19.0
UK	40.0	244.0	1188.0
EU (28 countries)	*22,505.0*	*45,317.0*	*67,236.0*

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