

Chapter 2

State of the Art of Power Generation in Cyprus

Abstract This chapter provides background information about the power generation system of the Republic of Cyprus, such as the installed capacity by type of plant and fuel, as well as the current situation, the potential and future prospects for the major renewable energy sources available on the island—solar power, wind power and biomass.

Keywords Biomass · Biogas · Concentrated solar · Photovoltaics · Wind power

2.1 Overview

As mentioned in Chap. 1, Cyprus relies heavily on fossil fuel imports for power generation. Additionally, there are no electricity grid interconnections to neighbouring countries, so there is virtually no possibility to purchase electricity in order to meet peak demand, or sell excess electricity in periods of high generation and low local demand. As a result, the country has to satisfy all its electricity needs through indigenous power production.

By the end of 2015 the total installed power generation capacity (shown in detail in Table 2.1) was approximately 1,740 Megawatts (MW), of which 1,478 MW are operated by the Electricity Authority of Cyprus at three locations along the island's south coast (Vasilikos, Dhekelia and Moni). This capacity was—by the time of this writing—adequate to cover all national electricity demand and provided a large reserve margin. It should be noted that the units at the Vasilikos site can burn natural gas, once this becomes available, instead of diesel and heavy fuel oil as indicated in Table 2.1.

As an EU Member State, Cyprus is committed to reducing its greenhouse gas emissions of power generation by 2020 in line with decisions made by European leaders in 2009: being subject to the EU Emissions Trading System, thermal power plants have to contribute to a nationwide reduction of ETS emissions by 21 % in 2020 compared to 2005. In a similar fashion, following the decision made by

Table 2.1 Total installed capacity in Cyprus at the end of 2015

Installation	Type of technology	Fuel	Capacity (MW)
Vasilikos	Combined cycle gas turbine	Diesel	440
	Steam turbine	Heavy fuel oil	390
	Gas turbine	Diesel	38
Dhekelia	Steam turbine	Heavy fuel oil	360
	Internal combustion engine	Heavy fuel oil	100
Moni	Gas turbine	Diesel	150
Independent producers at 3 sites	Internal combustion engine	Heavy fuel oil or Diesel	ca. 20
Biomass		Animal waste	9.7
Wind		–	157.5
Solar photovoltaics	Connected to the grid	–	49.7
Solar photovoltaics	Connected to the grid and equipped with net-metering systems	–	>25*
Solar photovoltaics	Not connected to the grid	–	<1

Source CERA (2016), TSO (2015)

*Official data were not available for end 2015 by the time of this writing. Provisional information was provided through personal communication with Mr. George Partasides, Ministry of Energy, Commerce, Industry and Tourism of the Republic of Cyprus, January 2016

EU leaders in October 2014, emissions of these installations must continue to drop to 43 % in 2030 compared to 2005 levels.

Moreover, the country has to comply with Directive 2009/28/EC setting out minimum levels of renewable energy penetration in each Member State's energy system. The objective for Cyprus is to satisfy 13 % of its national energy needs through renewable sources by the year 2020. For this purpose, the Cypriot government prepared a National Renewable Energy Action Plan (NREAP) in spring 2010 to set a pathway for the island to reach its 2020 targets (MCIT 2010). According to this plan, which was under revision by the time of this writing, 16 % of electricity should be produced by renewables in order for the country to meet the 13 % objective in its entire energy system (which also includes final energy uses for heating, cooling and transport). By 2015 the country was on track to meet this target. Renewable energy technologies had a total installed capacity of approximately 232 MW at the end of 2015 and contributed to around 8 % of the total electricity generation (CERA 2016; TSO 2015).

2.2 Current Options for Renewable Power Generation

This section provides an overview of the state of play and the outlook for the main renewable electricity options considered in the case of Cyprus. Although additional technologies are possible, such as hydrothermal, geothermal or wave and tidal

energy, their potential is considered so low for the current state of technologies that they are not expected to have a sizeable contribution—if at all—to power generation by 2030. Therefore, they are not further considered in this study.

2.2.1 Wind Power

In Cyprus wind power was exploited many years ago, with windmills used mainly for water drilling from wells and milling grain. According to measurements conducted by the Cyprus Department of Meteorology shown in Fig. 2.1, average wind speed at an altitude of 10 m ranges between 3 and 5 metres per second (m/s) along the coast. In some elevated areas in the mainland wind speed can reach 6 m/s as well, whereas slightly higher speed levels occur in specific areas. This means that, although the wind potential is not particularly high on the island, there are still areas where wind speed is sufficient (6–7 m/s) for the development of wind parks.

In recent years the efforts to promote wind power for electricity generation have become more pronounced, especially after accession of Cyprus to the EU. By the end of 2015 there were seven wind parks operating in Cyprus with an installed capacity of 157.5 MW, contributing around 5 % of annual nationwide electricity production. One of them is connected to the distribution system, whereas the rest are connected to the national transmission system. Licenses for additional over 148 MW have already been granted for constructing new wind parks (EAC 2015; TSO 2015). According to the Cypriot NREAP, it is expected that capacity will reach 300 MW and wind power will contribute to power generation more than any other renewable source up to 2020. These projections have been modified in the

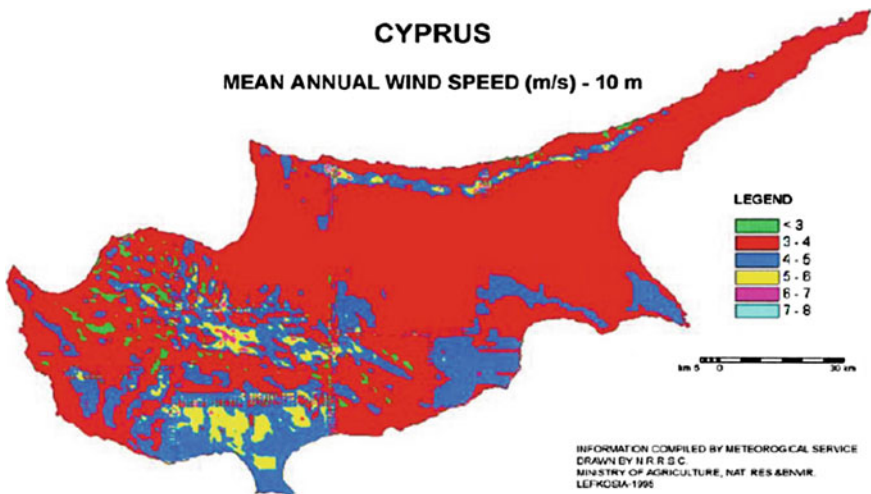


Fig. 2.1 Wind speed measurements at an altitude of 10 m. Source CMS (2015)

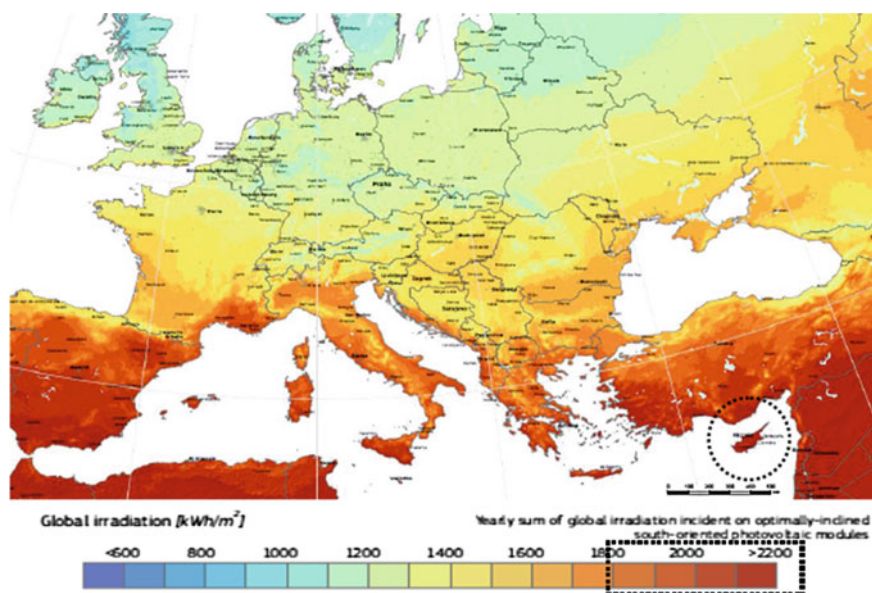


Fig. 2.3 Solar irradiation (direct and diffuse) around Europe. Cyprus is indicated on the map with a circle. *Source* PVGIS database (Šúri et al. 2007)

The annual average daily solar irradiation at a horizontal level amounts to 540 Watt-hours per square metre (Wh/m^2)—230 Wh/m^2 in winter months and 720 Wh/m^2 in summer months. Throughout an entire year, total solar irradiation at horizontal level reaches 1727 kWh/m^2 , out of which 70 % is direct radiation and 30 % diffuse radiation (CERA 2014; CMS 2015). Figure 2.3 highlights the island's high levels of solar irradiation.

Figure 2.4 illustrates that the countrywide solar potential of Cyprus is the highest in Europe. Moreover, studies have shown that a polycrystalline or monocrystalline solar PV system with nominal power of 1 kW installed in the coastal region of Cyprus, with a 27° still angle of the panels and south direction, produces on average more than 1500 kWh per year throughout the first 20 years of its operation. This evidence highlights the importance for the country to invest in this technology at a much higher rate than in the recent past. Bearing also in mind the very substantial decline in the cost of solar panels, which is the main cost item of PVs, the time is probably ripe for a significant deployment of this technology across the island.

The installed capacity of PV systems connected to the national distribution grid was close to 80 MW at the end of 2015, originating from more than 4700 individual PV units (CERA 2016; TSO 2015). Out of these, over 2800 were small installations that were connected through a net-metering system, thus allowing its owners low electricity charges. Of the rest, more than 70 % are small (mostly rooftop) units of less than 20 kW each. Three PV parks stand out because of their size: one has a capacity of 3 MW and the other two are of 1.5 MW each. All three parks started

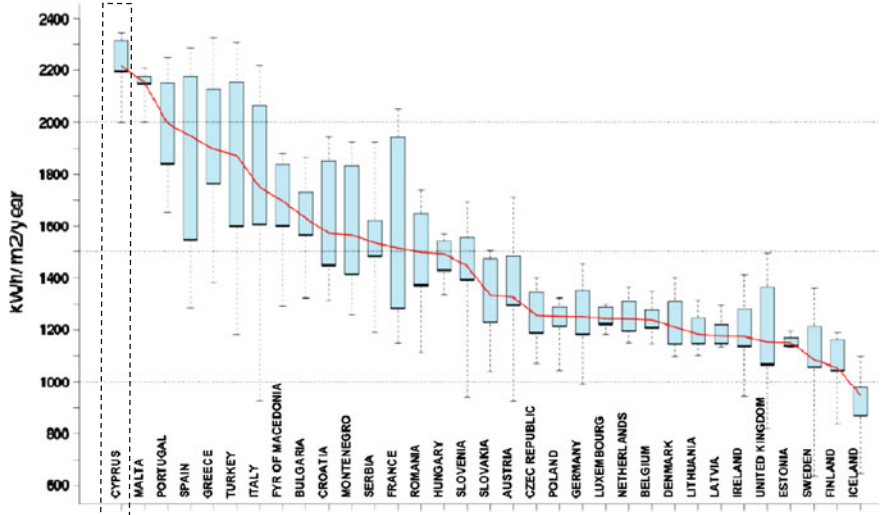


Fig. 2.4 Average annual solar irradiation levels (expressed in kWh/m² per year) in 33 European countries. *Source* Šúri et al. (2007)

operating (in various locations of the island) in 2014. Apart from the above, a small number of autonomous PV systems are also installed; these amounted to less than 1 MW by the end of 2015. Overall, power generation from photovoltaics in 2015 amounted to around 2 % of total national electricity needs.

Figure 2.5 displays the installed PV systems around the Republic of Cyprus, excluding small net-metering installations. Evidently solar panels are distributed uniformly across the most densely populated areas of the island.

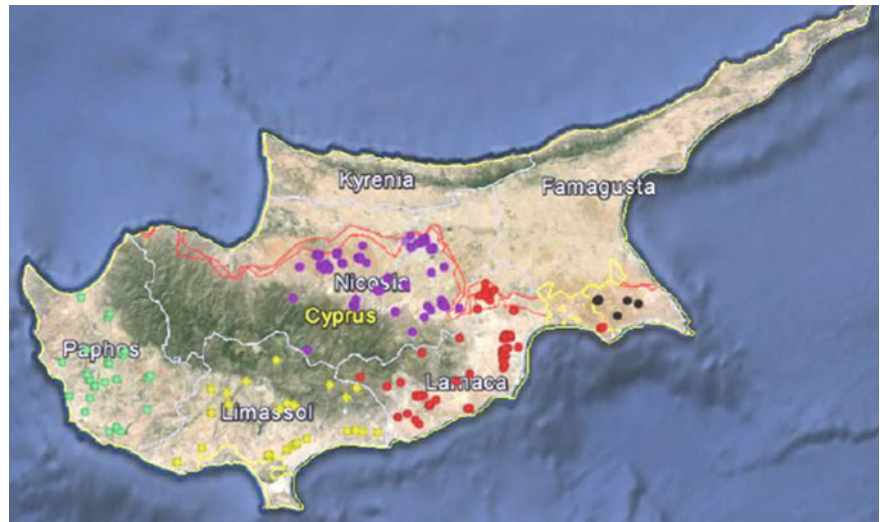


Fig. 2.5 Geographical distribution of installed solar PV systems by the end of 2014. Map created by Kanatzia (2015) with Google Earth® software

2.2.3 Concentrated Solar Thermal Power

Concentrated solar power (also called concentrating solar power, concentrated solar thermal, and CSP) systems use mirrors or lenses to concentrate a large area of sunlight, or solar thermal energy, onto a small area. Electricity is produced when the concentrated light is converted to heat, which drives a heat engine (usually a steam turbine) connected to an electrical power generator.

CSP is being gradually commercialised, and the CSP market has seen about 740 MW of generating capacity added between 2007 and the end of 2010. More than half of this (about 478 MW) was installed during 2010, bringing the global total to 1095 MW. There were less than 100 operational CSP stations by the end of 2014. Most of them are located in Spain (with total capacity of 2204 MW in January 2014), the Middle East and the USA.

As already shown in Fig. 2.3, Cyprus is located in an area where the CSP potential is rather high. Therefore, there has been a comparatively high interest by investors to build and operate CSP plants on the island. By the end of 2012, nine relevant applications had been submitted to the Cyprus Regulatory Authority for Energy, with a total capacity of 175 MW. Three licenses were granted, amounting to 75 MW in total. By 2015 two of these plants had been at an advanced stage of development: one by the Electricity Authority of Cyprus with an installed capacity of 50 MW in Akrotiri in the district of Limassol; and one to be developed by a private investor on a total land area of 1.5 million square metres, in the area of Alassa, Limassol, with a nominal capacity of 25 MW. Financing of these plants has been ensured through the European NER300 funding scheme.

2.2.4 Biomass/Biogas

In theory, exploitable biomass could be both of solid form (from agricultural and forest residues) and liquid biomass (mainly from agricultural, animal and industrial waste). According to national agricultural statistics as well as a national action plan for the utilisation of biomass that was carried out in the mid-2000s (CRES 2008), solid agricultural residues across the country amount to about 100,000 tonnes per year. This leads to an exploitable energy potential of the order of 35–45 kilotonnes of oil equivalent (ktoe) annually, coming mainly from vine and olive trees. Taking into account that these quantities are dispersed in farms across the island, it becomes evident that this potential is difficult to utilise in a cost-effective manner.

As regards forest residues, the Forestry Department of the Republic of Cyprus has estimated that the available quantities are insufficient for a reasonable exploitation of this type of biomass (Loizou and Pattichis 2007). This should be attributed to the semi-arid climate of the island and the low biomass productivity of forests. Short-rotation crops that are compatible with local climatic conditions may

be a promising future option, but they hardly exist in the country by the time of this writing, and their cost-effectiveness remains to be explored.

In contrast to the above mentioned constraints for solid residues, the outlook is more promising for liquid biomass. Through anaerobic digestion, waste from agricultural, animal and industrial activities as well as municipal waste processed in treatment plants can produce significant amounts of biogas, which contains a large fraction of energy-rich methane.

Currently, biomass for power generation in Cyprus is utilised through the production of biogas primarily from animal waste. According to a recent agricultural census (Cystat 2014), animal population of the country in the year 2010 comprised about 440,000 pigs, 56,000 cattle and 580,000 sheep and goats, producing in total more than 1.7 million tonnes of organic waste. Half of this amount comes from pigs. This is a low-end estimate of the available quantities as it does not include waste from other animals, mainly poultry. Other sources of liquid biomass, such as waste of the food and beverage industry or from olive mills, are not exploited at a large scale.

According to data shown in Fig. 2.6, the history of medium-scale biomass/biogas exploitation started with a power plant of 250 kW capacity in year 2007 and has evolved quite fast. At the end of 2015 fourteen installations were in operation around Cyprus (Fig. 2.7), their capacity reaching 9.7 MW and generating 37.5 GWh of electricity—less than 1 % of total electricity produced in that year (CERA 2016; TSO 2015).

Despite the fact that a substantially higher penetration is possible due to the available quantities of biomass and municipal waste, financing constraints seem to have been the major obstacle against further investments. Subsidies in the form of feed-in tariffs were 0.135 Euros per kWh, considerably lower than the corresponding ones in other European countries like Denmark, Germany or the Netherlands, which amounted to about 0.2 Euros/kWh (Kythreotou et al. 2012).

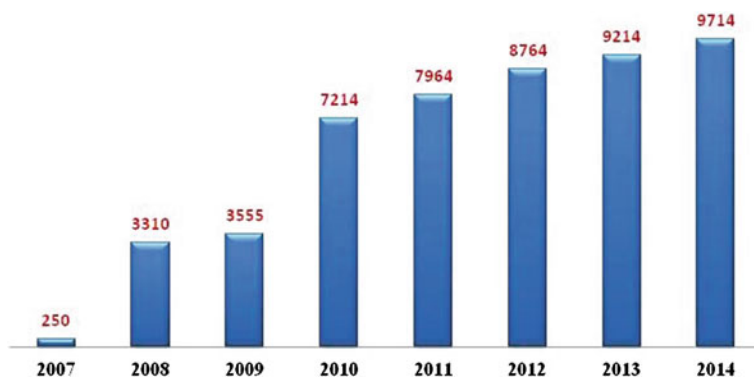


Fig. 2.6 Installed capacity (in kW) of biomass/biogas plants in Cyprus. *Source* Kanatzia (2015)



Fig. 2.7 Geographical distribution of existing (blue dots) and licensed (red dots) biogas plants by the end of 2014. Installations with capacity less than 20 kW are not included. Map created by Kanatzia (2015) with Google Earth® software

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