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Parametric cost–benefit analysis for the installation of photovoltaic parks in the island of Cyprus

Andreas Poullikkas *

Electricity Authority of Cyprus, PO Box 24506, 1399 Nicosia, Cyprus

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ABSTRACT

In this work a feasibility study is carried out in order to investigate whether the installation of large photovoltaic (PV) parks in Cyprus, in the absence of relevant feed-in tariff or other measures, is economically feasible. The study takes into account the available solar potential of the island of Cyprus as well as all available data concerning current renewable energy sources (RES) policy of the Cyprus Government and the current RES electricity purchasing tariff from Electricity Authority of Cyprus. In order to identify the least-cost feasible option for the installation of 1 MW PV park a parametric cost–benefit analysis is carried out by varying parameters such as PV park orientation, PV park capital investment, carbon dioxide emission trading system price, etc. For all above cases the electricity unit cost or benefit before tax, as well as after-tax cash flow, net present value, internal rate of return and payback period are calculated. The results indicate that capital expenditure of the PV park is a critical parameter for the viability of the project when no feed-in tariff is available.

1. Introduction

In recent years the PV industry has been experiencing a dramatic growth at a global level. Continuous increase of conventional fuel costs as well as growing pressure to turn towards renewable energy sources (RES) are the main drivers behind this rapidly expanding industry which since the start of the decade has achieved continuous annual growth of around 30%, (Šály et al., 2006). At a global energy output level, the PV industry is still lagging behind other RES technologies, such as, hydropower and wind energy (http://www.eupvplatform.org). This is due to the high costs associated with the manufacturing of PV solar modules, costs that will however steadily diminish as a result of continuous advancements in technology (Compaan, 2006).

In Cyprus, the PV industry is following global trends with more and more companies emerging that specialize in the field. The plentiful sunshine, the favorable legislation for small-scale applications up to 20 kW and the increasing awareness, coupled with the global expansion of the industry and the continuous technological breakthroughs are driving the Cyprus PV industry's growth. However, still there exists relatively low interest in PV installations due to the lengthy and time-consuming subsidy approval procedures. A detailed comparison of the PV promoting schemes in various European and Mediterranean countries is provided in Giakoumelos et al. (2008). Cyprus RES policy related to PVs is characterized as conservative, compared to that currently in place by Spain and Greece in which large-scale PV installations are eligible for funding.

The purpose of this work is to investigate whether the installation of large PV parks in Cyprus, in the absence of appropriate feed-in tariff or other measures is economically feasible. The study takes into account the available solar potential of the island of Cyprus as well as all available data concerning current RES policy of the Cyprus Government and the current RES-E purchasing tariff from the Electricity Authority of Cyprus (EAC). In order to identify the least-cost feasible option for the installation of 1 MW PV park a parametric cost–benefit analysis is carried out by varying the following parameters: (a) PV park orientation south at 28° fixed angle or two-axis tracking system, (b) PV park capital investment from 1000 to 8000 €/kW, (c) discount rate from 2% to 10%, (d) CO_2 emissions trading scheme (ETS) price 0 or 30 €/t_{CO2}, and (e) EAC monthly fuel price from 100 to 500 €/t. For all above cases the electricity unit cost or benefit before tax (in €/kWh), as well as after-tax cash flow, net present value (NPV), internal rate of return (IRR) and payback period are calculated.

In Section 2, the Cyprus current energy system is described and in Section 3, the Cyprus RES policy is discussed. In Section 4, the parametric cost–benefit analysis is carried out and the results are discussed in detail. The conclusions are summarized in Section 5.

* Fax: +357 22 201809.
E-mail address: apoullik@eac.com.cy

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2. Cyprus current energy system

Cyprus has no indigenous hydrocarbon energy sources and energy-wise is almost completely dependent on imported fossil fuels. For the year 2006 the primary energy generation, as presented in Fig. 1, was 90% oil-based, 6% coal-based (for cement production) and the remaining 4% was based on solar energy. In Cyprus solar energy is used solely for water heating in the domestic and tourist sector. It has been estimated that about 90% of individual homes, 80% of apartments and 50% of hotels are equipped with solar water heating systems, making Cyprus the first country in the world with installed solar collectors per inhabitant.

For many decades the power industry in Cyprus developed on the basis of available technology and know-how, and today it constitutes a key sector of the economy. Until 2004 the EAC was responsible for the generation, transmission and distribution of electricity in Cyprus (http://www.eac.com.cy). This situation, however, changed and the electricity market in Cyprus is now open. A Regulator's Office and a Transmission System Operator have been appointed and new participants are expected to join the electricity sector in the future. However, at the moment, EAC is still the sole producer of electricity on the island and operates three thermal power stations with a total installed capacity of approximately 1.2 GW. Future plans involve the installation of combined cycle technologies on the island using diesel as fuel in the first case and at a later stage natural gas when available to the island. The first combined cycle unit with capacity of 220 MW is expected to be in operation by the year 2009, while two more combined cycle units of the same capacity are expected to be in operation after the year 2012.

Cyprus power system operates in isolation and for electricity production relies totally on imported fuels such as, heavy fuel oil and diesel with a share of 98% and 2%, respectively. Cyprus economic growth in the past 30 years averages 5.8% per year and 3.1% per year over the last 10 years. In order to support the economic growth experienced in Cyprus the electricity consumption has risen from 2181 GWh in 1995 to 4135 GWh in 2006. This is translated by an 89.6% increase, averaging to 8.1% per year. The average price of electricity for the year 2006 was approximately 13 €c/kWh.

The penetration of RES for power generation (RES-E) technologies in Cyprus is currently negligible. It amounts to a few cases of small PV systems installed in homes, and to a smaller degree, biomass gasification (using wood, agricultural wastes, olive kernels, almond husks, etc.). In accordance with data available from the Cyprus Institute of Energy (http://www.cie.org.cy), a total of 1290 kWp distributed PV systems has been installed up until October 2007. As seen from Fig. 2, during 2005 and 2006 the majority of PV systems installations were grid connected. During 2007, significant off-grid installations have taken place as well. Despite the almost zero penetration of RES-E technologies in Cyprus, a large amount of licenses have recently been granted by Cyprus Energy Regulatory Authority (CERA) pertaining to electricity generation from wind parks. The wind park installations that have been so far approved account for a total generation of approximately 840 MW, while there are still pending applications for approval for another 246 MW of wind energy.

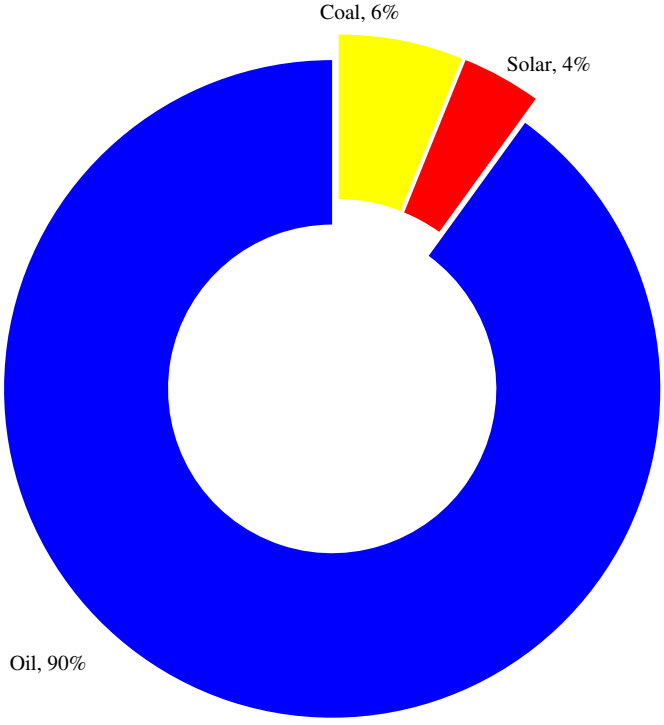

Fig. 1. Share of primary energy sources in Cyprus in 2006.

3. Cyprus RES-E legislative framework

Energy policy aspects are becoming increasingly important in the European Union (EU) international policy agenda (http://www.eupvplatform.org). The recent oil price volatility and the disruption of gas supply from Russia to Europe have illustrated the vulnerability of European countries economies because of the growing dependence on energy imports. In addition, the high contribution of CO_2 emissions in the atmosphere to global warming underline the environmental implications of long-term energy strategies and also the need to focus on RES. Having regarded the above it is clear that promotion of RES-E is linked with energy demand management and satisfies the efficient energy production of the EU long-term energy policy and obligations derived from the Kyoto Protocol ratification and the security of supply schemes.

For the achievement of the national goal for 6% of electricity generation by RES-E in 2010, few years ago the Cyprus Government through the Ministry of Commerce Industry and Tourism has prepared and endorsed the Cyprus White Paper (http://www.cie.org.cy). According to estimations, the national electricity consumption in 2010 will be around 5000 GWh, necessitating approximately 300 GWh of RES-E production. Based on the Cyprus White Paper and various feasibility studies conducted for the purposes of the introduction of RES-E in Cyprus, the proposed

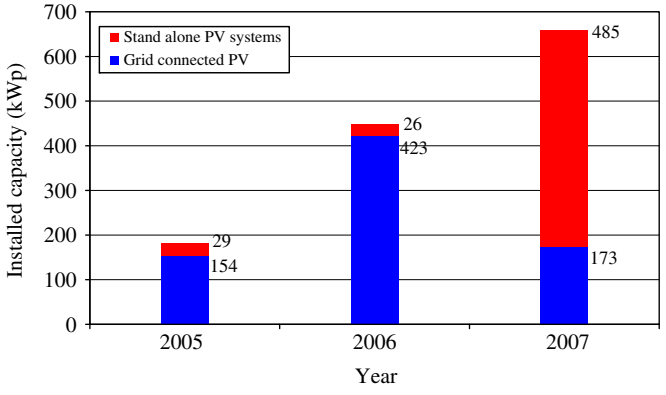

Fig. 2. PV installed capacity in Cyprus.