On the current payback time for small investors in the photovoltaic systems in the Region of Madeira

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Abstract. Following a period of strong investment in renewable energy, Portugal is now facing a huge reduction in the support for such clean energy sources, namely through the reduction of the feed-in tariffs and removal of tax incentives. The region of Madeira benefits from a very good solar exposition and has strong fossil fuel based products dependency, which make it a favorable place to invest in photovoltaic. But unfortunately these recent changes made the feed-in tariffs too low for any informed investor to put money there. Throughout this paper we analyze the payback time for these investments, we select the best regime for selling energy and forecast the future for this area of activity along with the next decisions that will be important in this area.

Keywords: Photovoltaic systems, Feed-in tariff, Payback time, Micro Production, Mini Production, Self-consumption

1 Introduction

Following a period of strong investment in renewable energy, Portugal is now facing a huge reduction in the support for such clean energy sources, namely through the reduction of the feed-in tariffs and removal of tax incentives. The scenery change has been forced by a deep financial crisis but the payback time (PT) for small investors through the photovoltaic micro production regime has been getting higher and is no longer an attractive investment, in spite of a huge reduction of the necessary investment that is now below half of the necessary amount 8 years ago.

The Region of Madeira (RoM), situated almost one thousand kilometers south-west from the mainland, benefits from a good solar exposition and has strong fossil fuel based products dependency. It is potentially an ideal location for investing in photovoltaic production for small investors.

According to the Portuguese legal framework, Photovoltaic (PV) installations can be under several different regimes: micro production (up to 3.68KW), mini production

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(up to 250 KW) and general regime. The first two benefits from special feed-in tariffs (mini production only up to 20KW and after that falls into a reverse auction for prices) and in the latter energy is bought at the same price the consumers pay, until a recent change described in section 2.3.
During the last decade a large number of small companies were created to deal with the great number of requests for new micro production installations. These companies have now an unattractive product to offer to their clients. In this paper we analyze this situation and propose the most favorable regime for selling energy. We also forecast the future of this market and point the next decisions that will be important in this area.

1.1 Energy situation of RoM

In energetic terms, RoM has a high dependence on fossil fuel based products, although this has been mitigated by recent minor investments in renewable energy, specifically in the areas of photovoltaic and wind energy. This effort, though small, is commendable but is still in its infancy.
In the regional context we verify that there are many good examples of the application of renewable energy, with tremendous success in several points, especially in hydro, wind and photovoltaic energies, being these in descending order, from highest to lowest energy produced. The production of electricity comes mainly from diesel and natural gas plants, representing 74.5% of the total energy consumed, followed by 9% in hydropower, wind power is standing around 9.7%, solar energy at 3.8% and finally, energy from solid municipal waste (SMW) at 3%.
Figure 1 presents a graph of the energy situation of the RoM during the last 7 years.

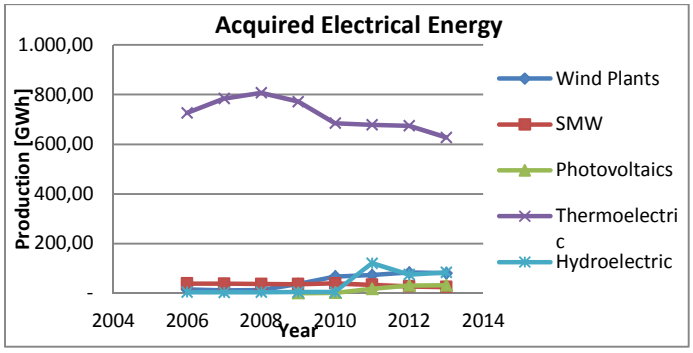

Figure 1 - Total acquired electrical energy by source in Madeira, 2013.

The electricity from solar power had an amazing growth over the past three years, with an extraordinary 200% increase in installed capacity. Already at the same level of wind energy, there has been a 120% increase in investment in this area.

1.2 Solar radiation in Madeira

Solar energy is an inexhaustible, abundant energy source on the planet. In Europe, Portugal is the country with more solar exposure, registering an annual average of approximately 8 hours/day with a reception above 1200W/m^2. The daily solar energy that reaches Portugal is on average 430000 GWh, which is equivalent to the energy the country consumes in approximately 1000 days [1] [2].

For the study of global radiation of RoM, we used data from various meteorological stations, in particular the Institute of Meteorology (IM), the Regional Laboratory of Civil Engineering (LREC), NASA Surface Meteorology and Solar Energy and World Meteorological Organization (WMO) [3].Figure 2 shows a graph of the monthly variation of the daily solar radiation average, from 2002 to 2005.

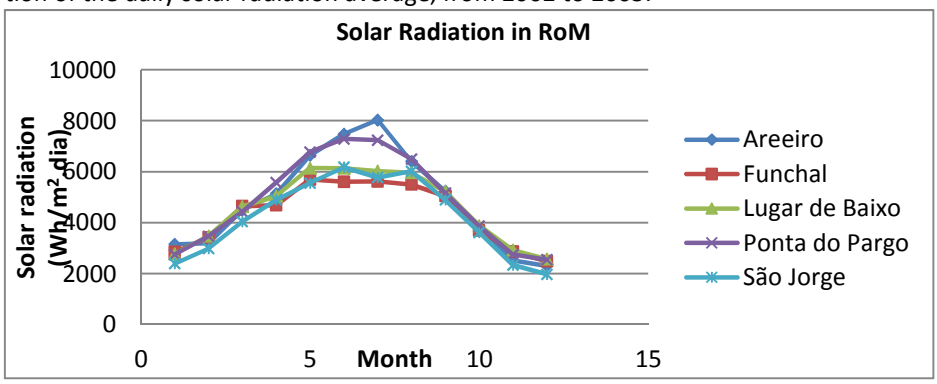

Figure 2 – Monthly variation of daily average solar radiation of RoM [4].

From figure 2, it can be concluded that the highest annual mean values were recorded in Areeiro (4873 Wh/m^2/day), followed closely by Ponta do Pargo (4868 Wh/m^2/day) in Calheta. The highest values recorded for the monthly average solar radiation, were for the months of June and July for the Areeiro and Ponta do Pargo stations. This period corresponds to the beginning of the summer season. The maximum monthly value was registered in July (8023 Wh/m^2/day).

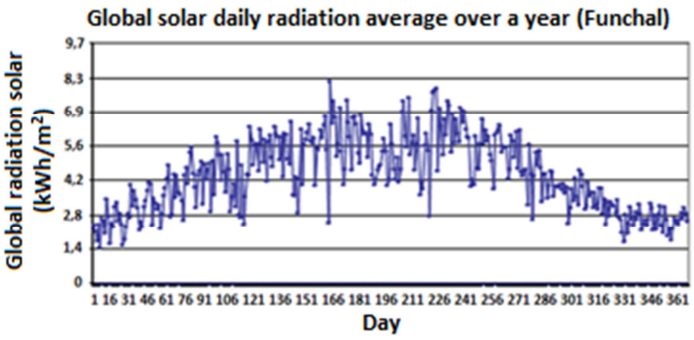

Figure 3 – Average daily solar radiation through the year for Funchal [5].

Figure 3 shows the daily average of solar radiation for Funchal over a period of five years (1999-2003) [5]. Through the data of NASA Surface Meteorology and Solar Energy System, the average measured values for monthly solar radiation on the horizontal plane was 5.63 kWh/m^2/day and the number of hours of sunshine for Madeira are around 2600 hours/year. These values are based on data prior to March 2008.
Figure 4 shows the radiation map of Madeira, Porto Santo and Desertas islands.

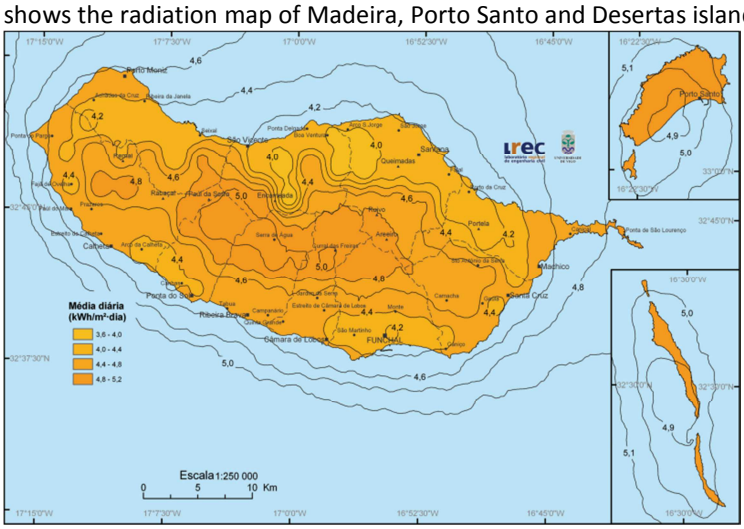

Figure 4 – Solar radiation map RoM (Vázquez et al, 2008).

Considering figures 2-4, it can be concluded that Madeira has very favorable conditions for the installation of photovoltaic panels as has been happening in the last decade.

2 Legislative framework

For small investors currently there are two regimes of selling the energy to the local electrical energy company: Micro production (McP) and Mini production (MnP).
These regimes have changed over time both in terms of feed-in tariffs and regulation. A short oversight is given in the next section.

2.1 Micro production regime

The McP regime has an upper limit of 3.68 KW of installed power, provided that the installed power is less than half of the hired from the electrical company.
Reviewing the prices since this regime was created, in 2008 the feed-in tariff was 0.65 €/kWh for the first 5 years. After that, for the next 5 years, the tariff is reduced annually, according to the ordinance definition to approximately 77 % of the value of previous year's tariff. Afterwards, the paid value goes down to the value of the cost

per kWh paid by the consumers (general regime) [6]. At that time, in 2008, the cost of each kWh consumed was around 0.11 €.
In 2010, the buying regime is composed of a contract with duration of 15 years divided into two periods, the initial with 8 years and the subsequent of 7. At the end the producer is forced to join general regime where energy is bought at the same price the local company sells the energy to consumers [7]. The feed-in tariff is 0.40 €/kWh for the first period and 0.24 €/kWh for the second period, and the value of both rates is decreased by 0.02 €/kWh a year for new installations [7].
For 2014 the new values defined by government ordinance are 0.066 €/kWh for the first 8 years and 0.145 €/kWh for the remaining 7 years.

2.2 Mini production regime

These facilities produce electricity from renewable resources, based on a single production technology (e.g. wind or PV) and their maximum power supply is 250 kW, provided that the installed power is less than half of the hired from the electrical company. This type of scheme has originally been launched in 2011, with a 15 year contract with a fixed rate of 0.25 €/kWh produced, with its value reduced annually by 7% [9]. Nowadays (2014), the reference tariff for MnP is 0.106 €/kWh with feed-in tariff and 0.142 €/kWh for the general regime.

2.3 General regime for micro production

The general regime was characterized by energy being bought at the same price consumers pay, but in 2013 a new tariff was introduced according to the following equation:

$$\mathrm{Re}\,m_m = W_m \times P_{ref} \times \frac{IPC_{n-1}}{IPC_{ref}} \qquad (1)$$

Where Rem_m is the remuneration of the month m(€), Wm is the energy produced in month m(kWh), Pref is the value of the share of energy from simple rate between 2.3 and 20.7 kVA applied in the year 2012 to the consumer; IPC_{ref} is the index of prices at the consumer, excluding housing, for the month of December 2011 (published by the National Statistics Institute), and IPC_{N-1} is the same index for the month of December of the year n-1 [8]. Currently the values for this regime are 0.142€/KWh.

3 Price of Energy

As can be seen from the previous section the values of the feed-in tariffs have been changing over time. Also the prices for energy at the consumer level have been increasing based on inflation and the costs to produce energy, but were also subjected to changes in taxes, namely a change in VAT value. The VAT value was initially of 4% (2008) and was increased to 16% (2011) and is now of 22% (since 2013), but since these values were changed during fiscal years the average value in 2011 was 7% and in 2012 20.5%.

Figure 5 compares these values, considering the prices of energy at the consumer level under the Low Voltage Normal regime (BTN) up to 20.7 kVA, with bi-hourly rate, which is the most common contractual arrangement in RoM, including taxes.

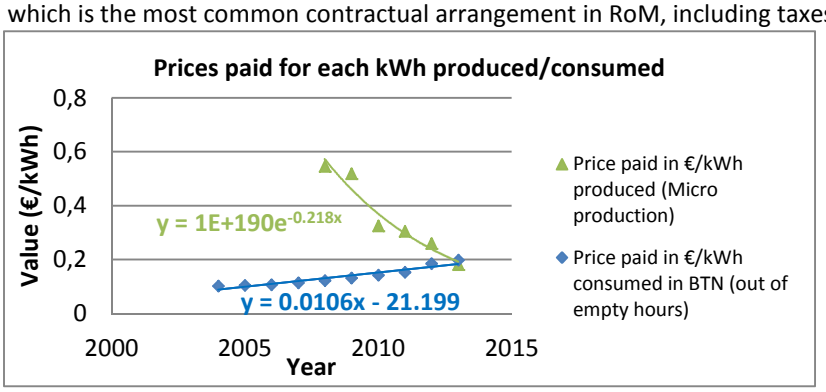

Figure 5 – Prices paid for each kWh produced in micro production and prices paid for each kWh consumed in the public network.

Analyzing this graph it can be seen that since 2010, the average value per kWh produced with McP feed-in tariff decreased significantly (from 0.547 €/kWh to 0.182 €/kWh, considering the average values along the 15 year contracts), continuing a descending trend that is approximated by $y = 1E+ 190e^{-0.218x}$.

In 2013, the amount paid for each kWh consumed exceeded the value received for each kWh produced under the McP feed-in tariff. This is a new situation where it just started to compensate to produce energy for self-consumption, instead of applying to obtain a feed-in tariff.

Figure 6 shows the feed-in value paid for each kWh in MnP and the amount paid for each kWh consumed (including taxes) during peak and full hours, under the Special Low Voltage regime (BTE) exceeding 41.4 kW, with tetra-hourly rate, which is the most common contractual arrangement in RoM for public buildings.

The values used for figure 6 were approximated by straight lines: the price paid for each kWh produced in MnP regime (y = 0.1579) and for each kWh consumed during peak hours (y = 0.0082x – 16.422) intersected in the year 2012, i.e., from this date on it compensates to consume the energy produced by the photovoltaic system for self-

consumption rather than to sell it to the local energy company, since the amount received per kWh produced is lower than the price paid for each kWh consumed.

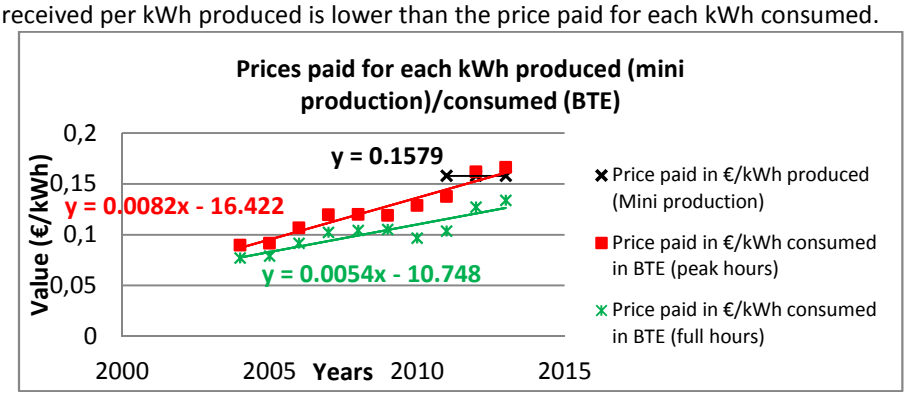

Figure 6 - Prices paid for each kWh produced in mini production and prices paid for each kWh consumed in public network.

With the current increasing trend in the price paid for each kWh consumed at full hours (y = 0.0054 x – 10.748) and the stable value paid for each kWh in MnP, it is expected that in late 2018 the former will exceed the latter.

Also note that, the amount paid for each kWh consumed in Portugal, is 13.6% higher than the average EU price and with a further increase of 2.8% proposed by the Energy Services Regulatory Authority (ERSE), added on January 1st, 2014 [10] [11].

4 Cost of photovoltaic installations in RoM

This section analyses the prices of photovoltaic installations under the McP regime in RoM. This type of installation was selected because it was the first to be regulated, and prices could be obtained from several companies. This is a regional analysis since the prices of solar modules vary by country and region in which they are acquired. The objective is not only to calculate the PT but to predict trends for future prices of these installations. The prices used are for a maximum output power of 3.68 kW, as defined in the legislation but the installing companies found out that to achieve a better payback time it would compensate to install a higher power so on average these installations are of 4.05 kW. The prices shown in figure 7 include VAT.

Since 2007 until early 2013, with the market stimulated by the presence of various manufacturers of solar cells, competition between companies has increased considerably, causing a steady decline of about 15 % per year in the prices. From mid-2013 to date, there has been a small slowdown on this decrease of prices, anticipating future price stabilization.

Nowadays, a PV installation of this size costs around 10500€. It can be seen that there is a steady fall in prices of PV installations. To characterize this behavior we have chosen an exponential function with a negative exponent. Notice that there is not enough data to build a detailed model, but this function will be much more ap-

propriate for the behavior that can be expected in this situation. Analyzing the function of the trend line ($y = 2E+155e^{-0.173x}$) it is observed that in the short term (≈ 4 years), will reach up the minimum value of 5000€, from which the price of the PV installations will remain roughly stable.

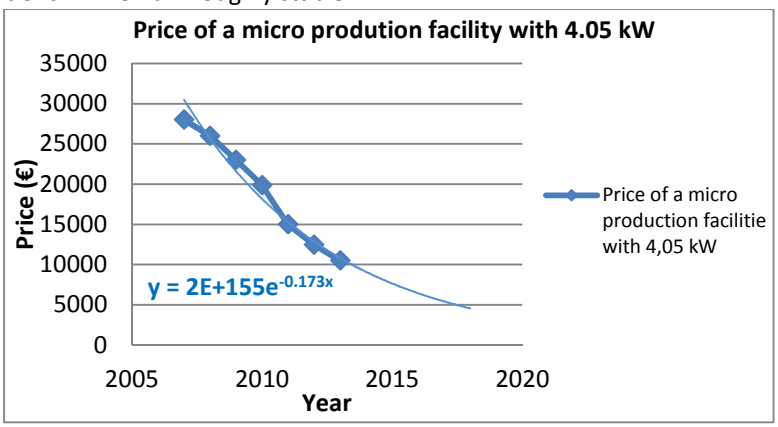

Figure 7 - Historic of prices of micro productions facilities with 4.05 kW of installed power.

5 Payback time

The graph in Figure 8 represents the number of years necessary for PT to be reached for a McP plant with an installed capacity of 4.05 kW located in Funchal, under different energy buying regimes. The value of installed capacity was calculated using the average installed power of micro production in the Funchal area. From these installations we have selected a set of 10 with available data and no failures over 2 years to calculate an average annual production of approximately 5800 kWh. These values were used in the calculations that follow.

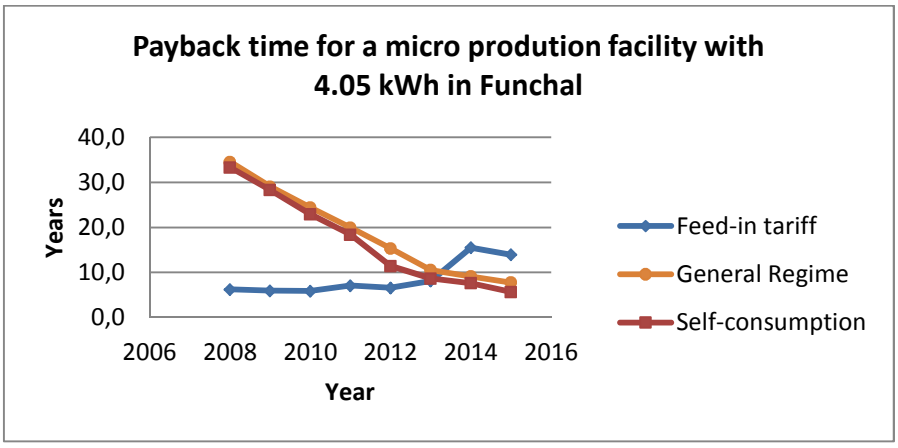

Figure 8 - Comparison between different types of regimes.

PT is a key issue to attract investment in this area. As can be seen from figure 8 the initial feed-in tariffs were designed so that this solution is commercially attractive with a PT around 6 years. Gradually these feed-in tariffs got worst and even though the installation prices reduced a lot, the PT is now over 10 years.
At the same time the energy prices for consumers increased an astonishing 209.3% over the last ten years and also had to face a VAT increase from 4% to 22%. As a result it is now more attractive for investors the use of energy for self-consumption or to go to the general regime than to apply for the feed-in tariffs. It should be noted that the self-consumption always had better PT than the general regime. Nevertheless self-consumption requires that there is enough consumption all the time to use the energy produced which will not be the case for most of the households.
It is anticipated that the future trend regarding the PT for the feed-in tariffs will be increasing, thus favoring the general regime and self-consumption.
One should note that these conclusions only apply to McP facilities, since, for MnP a different formula is applied. Moreover, the forecast for the price of electricity was determined using the average value of the index of prices at the consumer from the previous years.

6 Conclusion

From the average annual solar radiation map, we can say that Madeira has very favorable general conditions for using this resource since, in general, values above 4kWh/m^2/day are attractive for investment in PV or even heat based systems. It was shown that the areas with higher annual average solar radiation are Areeiro and Calheta. It can be stated that in most of RoM (exceeding 75% of the area), solar energy is an endogenous renewable energy resource with great interest in exploration.
The price of PV installations decreased 59.6 % over the last 5 years and the price paid to the local company per kWh consumed rose approximately 186 % in BTE scheme and 209.3 % in the BTN regime in the past 10 years.
The cost of McP facilities has decreased in the last eight years, to the current values near 10500€ and it is expected that it will stabilize at values close to 5,000€ in 2018, if the verified trend continues.
From the analysis of the different PV production regimes, it was found that currently they are not very attractive to investors, especially the McP. This is because the PT is high, between 9-10 years and, especially, the price paid per kWh produced is relatively low and less than the amount paid for each kWh consumed.
To change this situation and make it appealing again, the average price paid per kWh produced should be greater or equal to 0.275€, in order to reduce the PT to less than 6 years, as seen in 2008. If we consider a continuous decrease in the cost of PV, the PT will decrease, making the regime more attractive.

However, with the progressive increase of energy prices (BTN clients) and considering the past downwards trend of installation costs for McP, we estimate that, in 2016, the PT will be less than 6 years.
Currently, the most attractive regime is the self-consumption though it needs the associated electrical installation to be able to use the energy produced. An interesting alternative could come from the expected legislation for this regime if it contemplates measuring production and consumption using the prices for consumers.

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