

# ANALYSIS OF THE INCENTIVES FOR SMALL SCALE PHOTOVOLTAIC ELECTRICITY PRODUCTION IN PORTUGAL

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## Abstract

The Portuguese decree-law n° 363/2007 from 2 of November implements new incentives for small scale production of electricity covering several types of electricity production systems: wind, hydro, fuel cells (solar thermal), Biomass (combined electricity and heat production cycle) and solar photovoltaic (PV). For electricity producers using photovoltaic systems, two remuneration schemes are available: *Geral* or *Bonificado*. The word *Geral* translates to “General” while *Bonificado* translates to “with bonus” or subsidized.

This paper establishes a comparison between both types of schemes for a PV installation in Lisbon, under different scenarios. The output of the installation was modeled using WINSUN, a simulating tool developed at LTH (Lund Technical University, Sweden) derived from TRNSED/TRNSYS.

Different scenarios were drafted and compared. The payback time and the overall return on investment (RoI) of the installation are influenced by several factors such as equipment costs, installation costs, panel efficiency, overall photovoltaic installed capacity in Portugal or future electricity prices. These factors are also analyzed here.

Lastly, a suggestion was drafted for a more efficient use of this incentive scheme in PV applications.

## Introduction:

Although the usage of fossil fuels is practical, convenient and well developed, it is also, unfortunately, associated with huge environmental impacts. Thus, there is an imperative to change our energy sources. Since fossil fuels technologies are both very well developed and strongly inserted in the market and since there is not yet in place a way to incorporate the cost of the pollution in the costs energy produced by fossil fuels, there is a need for subsidies to support the development of alternative energy sources that can compete with fossil fuels.

This paper focuses on the micro production of electricity using photovoltaic solar panels. The Portuguese legislation that enables the microgeneration of electricity through PV is analyzed and a set of scenarios and assumptions are created in order to access the viability of these installations under the current law.

## Relevant Legislation:

According to the decisions set by the National Strategy for Energy and, as foreseen on the Simplex 2007 Program (administrative and legislative simplification program), the Portuguese Government launched, in November of 2007, a new legislation for supporting the activity of microgeneration of electric energy in the scope of the Special Production Program (PRE) published in the decree law n° 363/2007” of November 2<sup>nd</sup>, also known as program “Renováveis na Hora”. This program applies to very low power units, named Group I (low voltage connection, monophasic 25A, with power up to 5.75 kW), which use renewable resources as primary energy or which produce simultaneously heat and electricity (cogeneration) and deliver all the electric energy produced to the grid.

The program launches two remunerative schemes: *Geral* and *Bonificado*. The word *Geral* translates to “General” while *Bonificado* translates to “with bonus” or subsidized.

The general remuneration scheme embraces the most of the microgeneration units, while the subsidized scheme, limited to connections with power up to 3.68 kW, is only applicable to production installations which use renewable sources and meet certain requirements. This diploma also establishes a considerable simplification on the licensing proceedings of the microgeneration units, substituting the previous registration system by a simple and more convenient electronic registration, for the most of the electricity producing centers of the Independent Electric System (SEI), decree-law n° 312/2001 of December 10<sup>th</sup>.

### **Background to the program “Renováveis na Hora”**

In Portugal, the Special Production Program was introduced approximately 20 years ago with the publication of the decree-law n° 189/88 of May 27<sup>th</sup>. Throughout the years, there have been several revisions and amendments leading to the present situation by which the program “Renováveis na Hora” has been included. The microgeneration program now created comes to fill a gap existent on the producer-consumer regulation for the Group I systems and results in a specific new remuneration scheme that is different, both to the production of electricity from renewable sources that allows any private consumer to be a producer as well (set by decree law n° 189/88 of May 27<sup>th</sup>, with the several amendments) and to the producer-consumer remuneration scheme by eliminating the obligation to consume at least 50% of the electricity produced (set by decree-law n° 68/2002 of March 25<sup>th</sup>).

### **The “Renováveis na Hora” program**

#### **Objective**

The program “Renováveis na Hora” aims at promoting small scale production of electricity from renewable energy sources using low power equipment as well as small scale combined production of electricity and heat. The program focuses on renewable energy sources such as solar, wind, hydro, biomass (for cogeneration) and fuel cells (hydrogen based).

This program contributes to achieve the national objectives regarding the increase of renewable energies usage, the reduction of emissions of greenhouse gases and the decrease in the dependency on foreign energies. In addition, as microgeneration generates electricity close to the consumption location, it can also avoid losses due to energy transport over larger distances and be therefore considered as an energy efficiency measure.

#### **Access conditions**

Any entity possessing a contract to purchase low voltage electricity from the grid can become a micro electricity producer at that location. The following table details the access conditions to both remuneration schemes. Table 1 details the pre-requisites for the access to both remuneration schemes.

Table 1 – Pre-requisites common to both schemes

<b>Pre-requisites common to both schemes</b>	1) A contract for the purchase of electricity in low tension from the grid;
	2) The unit must be installed at the location where the electricity consumption occurs;
	3) Maximum power injected into the grid can be at maximum 50% of the contracted power to the electricity provided. This restriction does not apply to installations done in condominiums;
	4) If the sum of the power of all microgeneration contracts in one specific zone is above 25% of the power of the respective transformation station, the operator of the power distribution grid may prohibit further installations;
	5) On-line registration is obligatory;

Table 2 shows the different requirements to access the remunerations schemes.

Table 2 – Requirements for access to the remuneration schemes

Requirements	Geral	Bonificado
<b>Maximum Power</b>	5,75 kW	3,68 kW
<b>Fuel Possibilities</b>	Any	Renewable sources only
<b>Solar Thermal</b>	Not required	Installation of a minimal of 2m <sup>2</sup> of solar thermal for domestic water heating. The exception to this rule is the situation of condominiums where instead an energy audit must be performed and all measures identified as having a payback time of less than time of 2 years must be implemented.
<b>Attribution</b>	Automatic	Subject to the result to a trial

### Remuneration Schemes

The decree-law n° 363/2007 establishes that each technology is to be subsidized in a different manner. In the situations where a combination of these technologies is used, the feed-in tariff is established based on a weighted average using the respective percentages of the technologies.

Table 3 – Technology used and corresponding reference value of feed-in tariff

Technology	Technology tariff (€/kWh)	Percentage of base tariff (0.65€/kWh)
Solar	0.6500	100%
Wind	0.4550	70%
Hydro	0.1950	30%
Cogeneration using biomass	0.1950	30%
Fuel cells	*	*

\* Tariff corresponds to the technology used to produce the hydrogen

### Remuneration *Geral*

The value of the feed-in tariff for the *Geral* incentive scheme is equal to the price that the consumer pays for the electricity supplied by the national electricity provider.

### Remuneration *Bonificado*

In the year 2008, the *Bonificado* feed-in tariff was introduced with a starting value of 0.65 c€/kWh. This starting value is reduced by 5% every time the accumulated installed PV in Portugal reaches 10MW. Regarding the annual installation of PV under the incentive scheme *Bonificado*, in the year of 2008, the Portuguese government allowed, a total of 10MW of PV micro generation systems to be connected to the national electricity grid. The annual value of 10MW is to be increased by 20% every year, meaning that in 2009 the annual limit was 12MW, in 2010 is 14,4MW and so on.

This way, for each installation, the tariff value varies during 3 defined periods of time:

- 1) For the year when installation is connection plus the 5 following years, the tariff remains unchanged at a value that is fixed at the moment of the registration to sell electricity to the grid.
- 2) For the following the 10 years – The tariff for each year equals the reference tariff to be applied to the first new connection of that year (i.e., it is the reference tariff valid on January 1st of that year).
- 3) After 16 years and for the remaining years, the tariff is the same as on the *Geral* remuneration scheme, thus equaling the price that the consumer pays for electricity.

Note: The feed-in tariff for the *Bonificado* incentive scheme can never be inferior to the tariff of the *Geral* incentive scheme.

### Annual electricity sale limit

Table 4 presents the annual limit for the electricity sold to the grid (MWh/year/installed kW). However, for PV, with the currently available technologies, this limit is not reachable.

Table 4 – Annual electricity sale limit for different types of production

Electricity Production Technology	Annual electricity sale limit (MWh/year/installed kW)
Solar	2.4
Other	4.0

### Fiscal Benefits

“Expenses with the purchase of new equipments which use renewable energies and with equipments which produce electrical and/or thermal energy (co-generation) by microturbines up to 100 kW and consuming natural gas, including complementary equipments essential to its functioning, may be deducted by 30% up to €777.” In Fiscal Guide 2008 – Deloitte, February 2008 [14]

Adding to this, another benefit is the exemption from the income tax (IRS), regarding microgeneration revenues, up to €5000 per year, as stated in number 6 of the 12<sup>th</sup> article of the Decree-law n° 363/2007 of November 2<sup>nd</sup>, added by the 2008 State Budget Law.

### Winsun Simulation - Input Data & Results

The output of the PV installation was modeled using Winsun, a simulating tool developed at LTH (Lund Technical University, Sweden) derived from TRNSED/TRNSYS.

The Winsun simulation considered a PV installation with the efficiency of 15% and a standard ground reflectance of 10%. Several simulations were done to study the optimal tilt. The latitude of Lisbon is 38.7° however, since the summer months produce more than the winter months, the optimal annual tilt for this type of installation is 29°. The application of these parameters produced the following results:

Table 5 – Winsun simulation results

Parameter	Annual output in kWh/m <sup>2</sup> .year	Added tracking benefit (%)
Fixed installation	261,4	0
East-west tracking around collector axis	338,8	29,6
Vertical tracking axis with 47° (from horizontal)	336,6	28,7
2 axis tracking	350,2	33,9

### Model Input Data

Table 6 – Base parameters for the model

Base model parameters	Value	Unit
Inverter efficiency	95,6	%
PV cells efficiency drop	1	%
Tax exemptions	777	€
Average maintenance value	1000	€/12 years
Return on the solar thermal equipment	180	€/year
Starting feed-in tariff price (for the year of 2010)	0,6175	€/kWh
Electricity price without added value tax	0,1221	€/kWh
Electricity price with 5% added value tax	0,1277	€/kWh

Table 6 – *Geral* and *Bonificado* Parameters for the model

Parameter	Scenarios		Unit
	<i>Geral</i>	<i>Bonificado</i>	
Installed Power	5,75	3,68	kW
Area of panels	38	24	m <sup>2</sup>
Cost of PV equipment	18500	29000	€
Cost of solar thermal equipment	1500	0	€
Savings accomplished by the use of the solar thermal equipment	0	180	€/year

Tables 6 and 7 were made based on the following information:

- The inverter efficiency is given by the site for solar radiation estimation site from the European Union’s joint Research Center [2] as well as using the specifications given by manufacturers;
- The annual PV cells efficiency drop is based on a thumb rule;
- The cost of the PV and solar thermal equipment were based on an average of five estimations given by authorized Portuguese installers companies. The average maintenance value of 1000€ per 12 years was also based on the same data;
- The starting feed-in tariff of 0.6175 €/kWh for the year of 2010 was extracted from site of the program “Renováveis na Hora” [11];
- The savings on the solar thermal equipment are based on a study by ENAT. The savings are accomplished by the replacement of an electrical equipment for domestic hot water. However, in Portugal, the main source for DHW is gas which is in principle cheaper than electricity. Despite this, it was considered that the difference would not bear a significant impact on this study;
- The electricity price and the 5% added value tax is extracted from the company site of “Energias de Portugal” (EDP) [13]. For simplification, it was considered that the 5% tax would not be changed throughout the lifetime of the investment;
- It was considered that the microgeneration producer maximizes his profit and hence installs the maximum allowed power both for the *Bonificado* and the *Geral* incentive schemes;
- The lifetime of the PV installation is 25 years;

### Scenarios for the remuneration schemes

#### Electricity prices

The consumer electricity price is an important component of the assessment of the return on investment. This way, 2 scenarios were established for the variation of the electricity prices where the annual cumulative increase is 2% or 4%. These scenarios were based on the data of consumer electricity prices of previous years [13] and common sense.

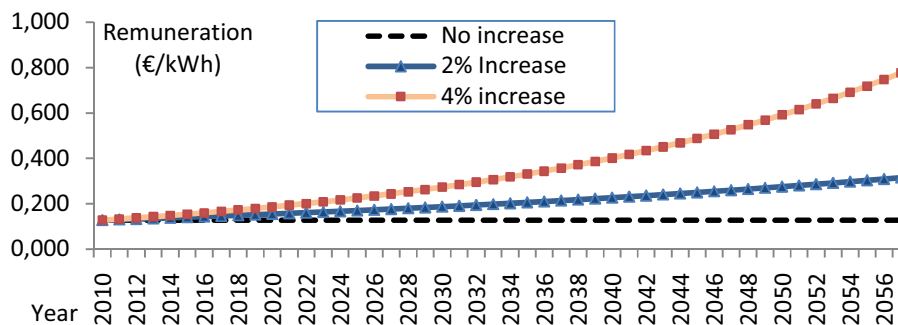


Figure 1 – Scenarios for consumer electricity prices variation

### Expected average annual installation of photovoltaic systems in Portugal

The expected average annual installation of photovoltaic systems under the *Bonificado* incentive scheme will also make a difference in remuneration. Two scenarios were drafted. The first considers that 100% of the permitted capacity by law is achieved (worst case situation for the microgeneration producer) while the second, more realistic, considers that only 50% of the annual power available for grid connection under *Bonificado* is actually installed.

From 2008 to the beginning of 2010, the starting tariff has only dropped one level.

### Scenario Outlook

This way, the 6 different scenarios considered are described in the table:

Table 7 - Characteristics of the 6 different scenarios done for the 2 remuneration schemes.

Name of incentive scheme	Annual increase in consumers electricity price	Expected average annual installation of photovoltaic systems in Portugal
Geral	2%	Not applicable
Geral	4%	Not applicable
Bonificado +	2%	Half of the annual value permitted by law
Bonificado -	4%	The full value that the law permitted per year
Bonificado +	2%	Half of the annual value permitted by law
Bonificado -	4%	The full value that the law permitted per year

The incentive scheme *Bonificado* is represented with a plus or a minus sign depending on how much annual installation of photovoltaic system in Portugal were expected. The plus sign symbolizes better feed-in tariff for the microgeneration electricity producer which means less annual installed PV.

### Results

Figure 2 shows the Return of the Investment through time for the different remuneration schemes under each scenario, after deducting equipment and maintenance costs and including system performance losses:

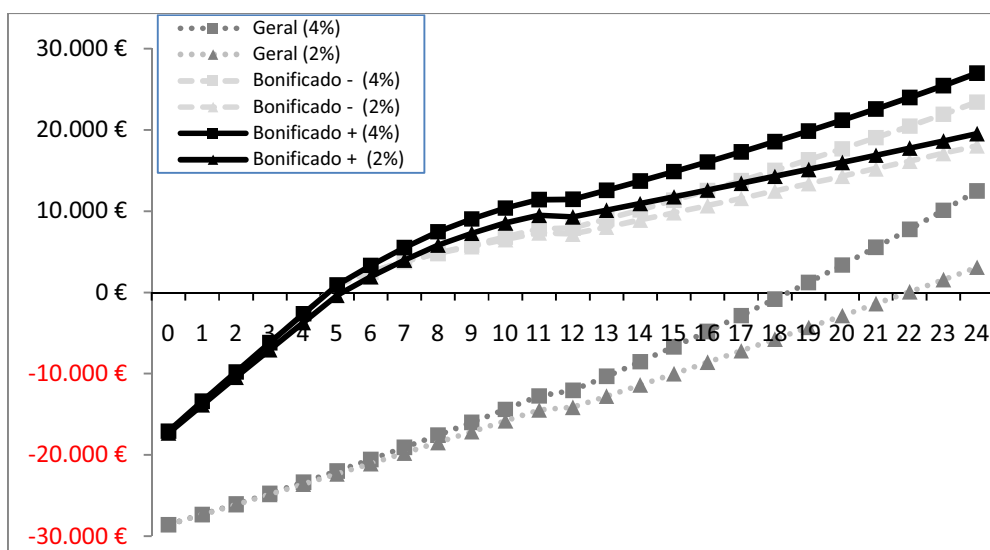


Figure 2 – Return of Investment for the different scenarios

## Conclusions

The conclusions of this study are presented below:

The decree 363/2007 of November 2<sup>nd</sup> is, in the authors view, a well conceive way to support the implementation of microgeneration of electricity from renewable sources. Solar technology is the most promoted renewable.

Although, solar thermal for DHW is the most efficient way to use solar energy, it is only efficient where there is a sufficient need for hot water. If the need for DHW is low, the result will be a high payback time of the investment. In this way, the obligation to its use may lead to situations where their installation is not justifiable, such as summer houses. A way to bypass this problem more effectively could be to include a 3 option system where the microgeneration producer would chose freely between the installation of solar thermal, an energy efficiency audit or an extra charge of around 800€ (that would revert to the government). This way, only the people without a real benefit would not install the solar equipment or perform the energy efficiency audit.

Solar tracking can proof to be a good option to increase the total amount of produced energy in a cost efficiency manner as long as the cost of solar tracking equipment is below 30% of the total cost of the PV equipment. However, solar tracking equipment requires a flat surface and even more space (typical market PV technologies present an already high relation of 7m<sup>2</sup>/kW).

As expected, the return of the investment after 25 years in the *Geral* incentive scheme situation is very susceptible to the variation of the consumer electricity of price while the *Bonificado* is initially mainly affected by the number annual PV installations connected and only later on by variation of electricity price.

Under the current assumptions, the *Geral* remuneration scheme can never compete with the *Bonificado*, for solar PV at the present time. Even if the *Geral* allows the productive system to have a 56% bigger installed capacity, it offers a much lower initial feed-in tariff along with a heavier initial investment. However, in a few years, with the decrease of the starting feed-in tariff and subjected to the extent of the rise that occurs in the consumer electricity, the *Geral* remuneration scheme may become a better alternative once it allows a bigger annual production. In the authors view, this perspective of a smooth change to a less subsidized remuneration schemes with bigger annual electricity production is a sign that decree is well designed.

The *Bonificado* remuneration scheme provides a successful way to shorten the number of years necessary to payback the investment (around 6 years for all installations in all scenarios due to the fix rate in the first 6 years) without having an extremely large 25 year return of investment that would unnecessarily over burden the Portuguese state.

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