DEVELOPING MICROGENERATION PROFILES FOR ELECTRICITY MARKET USE

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ABSTRACT

Last years have testified a considerable growth of microgeneration (μG). This tendency is expected to continue in coming years, making μG a key contributor to the reduction of conventional electricity supply and fuel imports, reduction of carbon emissions and sustainable energy growth. In several countries, the amount of μG energy production is already significant when compared to others sources, which means that it must be considered in operation planning, dispatch procedure and market settlement. This paper describes the methodology adopted for deriving the solar and wind μG profiles. Results were adopted by the Portuguese regulatory entity for market use.

INTRODUCTION

Under the present world macroeconomic framework, several countries are trying to reduce their dependency of imported oil. At the same time, the concern with environment and climate changes is compelling the search for alternative clean energy sources. Microgeneration (μG) can make a significant contribution to work out these challenges.

Several countries are encouraging a mass market for small-scale renewables. Germany has invested about €15 billion in photovoltaic technology and Sweden has created significant incentives for consumers to install heat pumps [1]. A report, commissioned by the British Department for Business, Energy and Regulatory Reform, says that, with proper incentives, the potential of μG may be developed to generate in a year as much as five nuclear power stations [1]. Some USA States have imposed that a certain percentage of utilities power generation be from renewable sources. Transferrable "renewable source energy" credits are needed by power companies to meet this requirement. As a result, utilities subsidize a part of the cost of renewable source microgeneration projects in their service areas [2]

In the first National Energy Efficiency Action Plans (NEEAP) by 2008, the Portuguese Government stated the goal of achieving 165 MW of μG installed capacity by the year of 2015 [3]. The NEEAP includes several incentives to μG dissemination, namely a very attractive tariff outline. Most European countries are also implementing μG promotion policies, making the necessary legislative changes needed to overcome the current barriers, creating a favorable regulatory environment [3]-[9]. Claude Turmes MEP (Member of the European Parliament) affirms that "microgeneration must help the EU to move from a 20% to a 30% target for renewable energy by 2020" [10]. "Microgeneration" and "improving energy awareness of consumers" became the new priorities for the European Parliament's Subgroup Energy and Industry [5].

The adopted incentives policy is expected to stimulate the μG growth to noticeable levels, which means that μG contribution to the total power production must be taken into consideration in operation planning, dispatch routines and market procedures.

According to the Portuguese regulation laws the profiles are to be applied to all mini and micro-producers without a measurement device with production recording in a 15min base or for which the meter reading is not made daily. The distribution network operators that collect daily the μG data on a 15 min basis are not required to apply μG profiles. μG profiles are needed because distribution network operators exclusively in LV must send their production data to the distribution network operators in upper levels (MV and HV) and also to the incumbent energy provider. Besides, considering the expected μG growth in the next years, the amount of energy production from these sources will be substantial, meaning that μG profiles should be considered in dispatch scheduling. Another important application of these profiles is in the area of network analysis and planning. In fact, the inclusion of μG sources modifies networks power flows, potentiating loss reduction and postponing of investments in lines reinforcement.

This paper describes the methodology adopted for deriving the solar and wind μG profiles in Portugal. Above 95% of μG units are solar photovoltaic type. Wind μG units are the second group with a percentage slightly below 4%. There are also some cases of hydro and combined cycle but they represent less than 0.5% of the total.

This work was developed under the framework of a contract with EDP Distribution - Portuguese distribution system operator (DSO) - and the result was approved by the Regulatory Authority that adopted the proposed profiles for market use.

METHODOLOGY

The basic approach consists of analysing a sample of μG production diagrams, aiming at establishing adequate μG profiles. These profiles do not depend on the type of weekday, contrasting with the case of load profiles, where major differences are verified between workdays, Saturdays and Sundays. Hence, the determination of μG profiles may be summarised to the derivation of 12 representative 24h diagrams, one for each day of each month.

In order to obtain more robust solutions and to enhance profiles representativeness, the process includes several information sources:

1. Sample of μG solar and wind production, on a 15 min time base, during 12 months, spread all over the country;
2. Sample of wind and solar production of the main Portuguese wind parks and solar stations. This data was mainly used for comparison purposes and also for wind pattern completion –

Besides wind typical fluctuated behaviour, wind µG sample was not too extensive;

3. Monthly total µG production aggregated by technology, in the last 12 months;
4. Estimation of µG production growth. This is a very important factor because of the boom effect (the total installed power was expected to triple during 2010).

The first step of the methodology consists of data analysis and filtering, to deal with information gaps and erroneous records. The next step includes the computation of average 24h production diagrams, for each month and µG technology. Then, diagrams scale is adapted according to the expected µG growth factor – the result is a set of reference diagrams. Finally, the annual µG profiles are built by replicating the reference diagram for each day of the month.

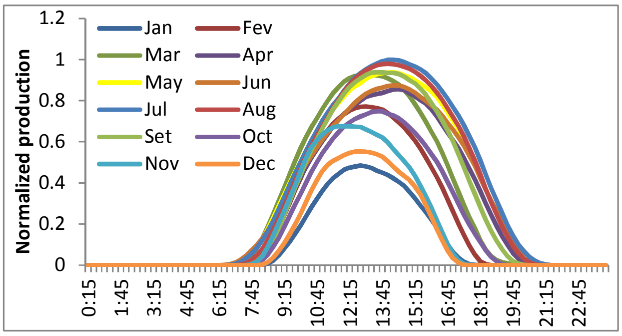

Figure 1 – Solar µG reference diagrams

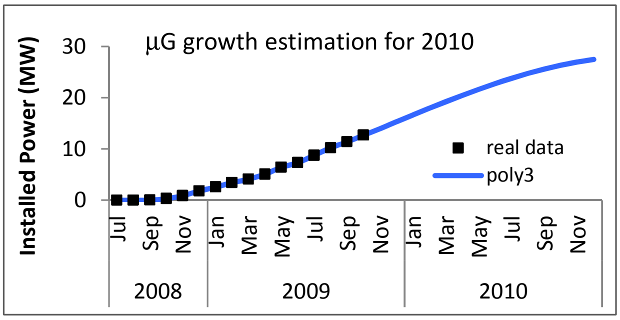

Figure 2 – Growth estimation of µG installed power

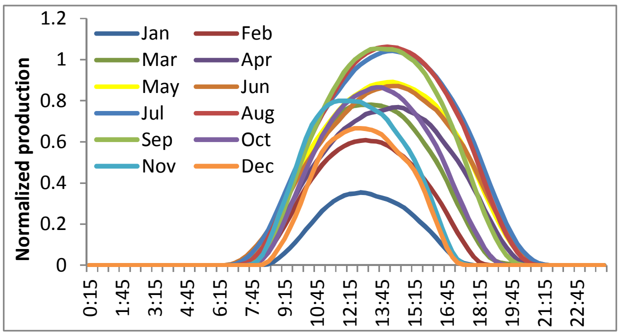

Figure 3 – Solar µG reference diagrams after application of the µG growth factor for 2010

Fig. 1 shows the average production diagrams for the solar case. The expected µG growth is illustrated in Fig.2, where black squares represent the real data available at the time the study was performed. The blue line represents the 3rd order polynomial tendency (poly3) – a conservative option triggered by the Portuguese economy situation and the uncertainties regarding future remuneration of µG. The solar reference diagrams shown in Fig.3 are obtained by combining this growth tendency with the average diagrams of Fig.1.

These diagrams are then used to build the annual solar µG profiles. The week profiles for August and December are shown in Fig.4. These curves were directly drawn from the approved µG profiles [12]. Naturally, the solar production follows the sun daily and annual cycles. Note that basic reference diagrams in Fig.1 are normalized to a maximum of 1, while the annual profiles, as usual, are normalized so that the sum of 15 min records totalizes 1000.

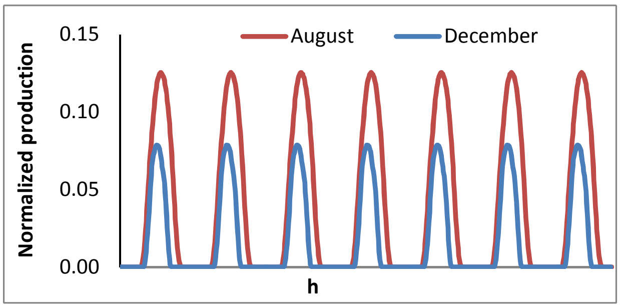

Figure 4 – Solar profiles for March and August (week portrait)

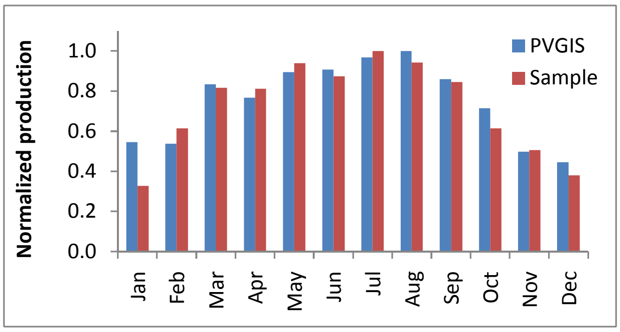

Figure 5 – Variation of the µG solar production with the month

Fig.5 compares the normalized energy production of each month of the year. The red bars respect to the real µG production – based on the sample records in the year of 2009 and on the information on monthly total µG production aggregated by technology. The blue ones correspond to an estimation based on the average solar radiation since 1981 to 2008 [11]. The comparison between the two cases shows that slight differences may occur from year to year in the monthly production. Still, one may conclude that April production is smaller than March's - in Portugal, April is usually a very rainy month, so this result is a kind of confirmation of this known fact. This figure also shows that comparison between May and June average productions are quite similar.

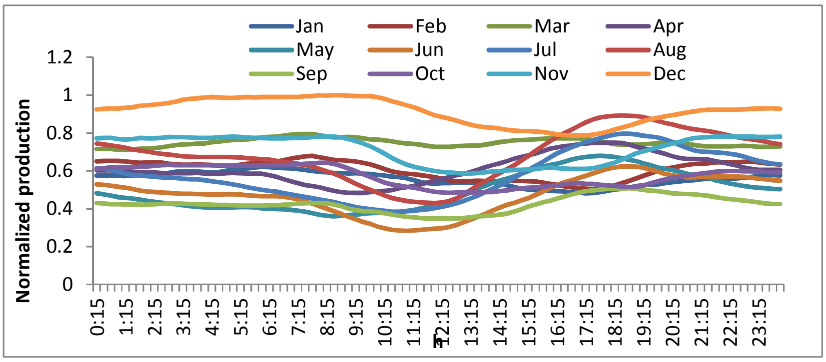

Figure 6 – Wind μG reference diagrams

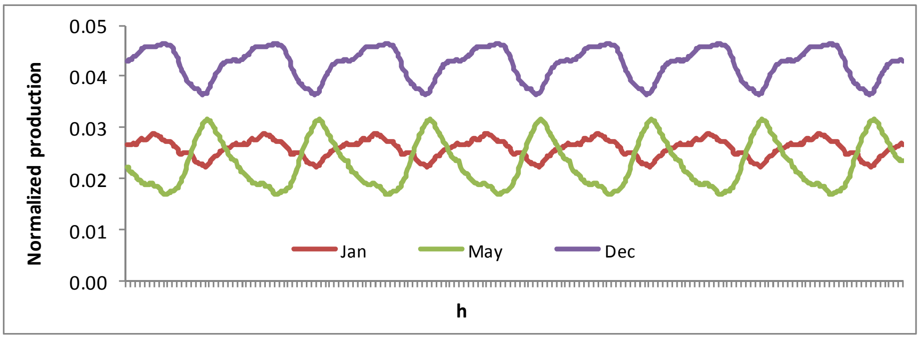

Figure 7 – Wind profiles for January, May and December (week portrait)

A similar approach was used for the case of wind μG profiles. In this case, the computation of the reference diagrams was based not only on wind μG data but also on the data concerning the production of Portuguese wind parks in the years 2007-09. This option is justified by the typical fluctuation on wind production and also because of the limited number of wind μG samples available at the occasion (about 20). The final wind average diagrams result from a weighted combination of average μG production diagrams for each month and average wind park production for each month and year.
Fig.6 shows the wind μG reference diagrams and Fig.7 presents the week profiles for three different months.

Table 1 – Equivalent hours (solar)

Region	EH (h)
North	1598.5
South	1837.6

Another useful information provided by this study is the number of equivalent hours (EH), given by the quotient between the total energy produced in a year and the installed power. In order to quantify the well-known geographic differences – the Southern region of Portugal is sunnier – the solar μG units were divided into two groups (North and South).
The average annual energy production and the average installed power are then computed for each group. Table 1 shows the value of EH obtained for each case.
This result is quite useful because it allows the calculus of the expected energy production. For instance, a low voltage consumer that intends to settle a solar μG with 3.68 kW of installed power may expect an annual energy production of about 5.88 MWh if it is in the Northern region or 6.76 MWh if in the South.
A similar analysis was performed for wind μG, although in this case the μG units were geographically divided into two groups: Shore and Interior. Table 2 compares the equivalent hours obtained for the two groups.

Table 2 – Equivalent hours (wind)

Region	EH (h)
Shore	697.8
Interior	538.3

Contrary to the solar case for which the production is noticeably uniform, the wind EH depends a lot on the specific characteristics of the location: in this sample, it varies from 250 h to 1530 h. These values are rather small compared to wind parks which present an average of 2182.8 h, varying from 1235.9 h to 2699.6 h. Besides, the number of equivalent hours for wind μG is also small when compared to the solar μG.

CONCLUSIONS

This article describes the methodology adopted for building solar and wind microgeneration profiles for market settlement purposes.

The µG profiles were for the first time approved by the regulator in the directive nr 1/2012 [12]. This directive states that these profiles are to be applied for solar PV installations, as this technology is clearly dominant. For all the other cases, it is assumed that the production within each tariff period is uniformly distributed by all the 15 min periods.

As referred before, µG profiles are actually used in market procedures. According to [13], the distribution network operators that collect daily the µG data on a 15 min basis are not required to apply µG profiles. However, nowadays the data collection on a 15 min base is still expensive, and can hardly be justified for the typical amounts of µG production. Thus, generally DSO does not utilize this measurement hypothesis on µG installations, preferring the cheaper choice of profile application.

Given the expected µG production growth in the next years, µG profiles should also be considered in dispatch scheduling.

These profiles should also be included in network analysis and planning, particularly in the case of systems with a considerable penetration of µG production.

Finally, as a complementary result of the profiles derivation, the present study provided interesting results about wind and solar microgeneration potential in the country in terms of equivalent hours, providing estimates on annual energy production according to the location.

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