REACHING PV GRID PARITY: LCOE ANALYSIS FOR THE ITALIAN FRAMEWORK

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ABSTRACT

In order to reach the EU targets 2020 and the RES development, the significant key idea of the incentives should be allowing each technology to a progressive improvement towards the competitiveness or so-called grid parity. In Italy this process has already started, the first results show that the grid parity could be achieved in a few years, even if the presence of possible barriers could be delayed or accelerated the grid parity.

INTRODUCTION

Support schemes have been put into force to enhance the electricity production from renewable energy sources (RES), under the lines of the EU Directive 2009/28/EC. Throughout the issuance of the National Renewable Energy Action Plans, each Member State has set the local policy instruments to promote the development of RES generation along their territories, with mechanisms as feed-in tariffs, quota obligation, net metering and many others, in order to fulfill the EU 2020 targets, and with the main objective of supporting the technologies throughout the development stage until reaching the competitiveness in the market.

The approaching of the competitiveness of RES with conventional sources is a fact. During the last years, due to this reason, the incentive schemes have been gradually phasing out as support strategies for RES generation technologies to be one important role-player in the generation mix of all the EU Member States. As this gap is getting narrower, the concept of "grid parity" is introduced as the moment in which that competitiveness is reached (grid parity time, GPT). GPT refers to the achievement of the equality between the present value of the long-term revenues produced by the generation of a given RES technology with the long-term costs of acquiring the same energy from the grid. Therefore, from that moment and on, that technology would become self-sustainable, meaning that the investment would be feasible even without the support of an incentive scheme.

The paper is organised as follows: after this introduction, we describe the grid parity concept and the relevant results for Italian PV market segment. Then, we focus on the barriers for the RES electricity sector, and translate the improvements proposed to overcome those barriers, into quantitative figures, in order to analyze the performance sensitivity of the competitiveness by inputting those values. Finally, we provide some concluding remarks.

GRID PARITY CONCEPT

In order to develop the grid parity analysis, some variables have to be considered as the main influencing factors towards the GPT. For one side the purpose will be to reduce the costs associated to investment (affecting the Levelized Cost of Electricity, LCOE) and on the other side, to increase the revenues.

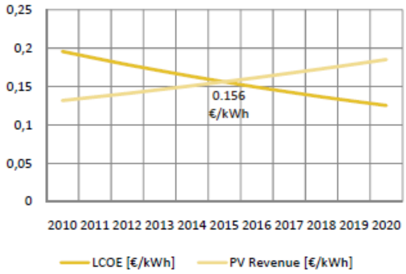
$$LCOE(€ / kWh) = \frac{CAPEX + NPV\_total\_OPEX}{NPV\_total\_Production}$$

Depending on these variables, each technology, for each segment of market, is going to be characterized by a specific GPT. These variables are listed below.

1. *EPC investment cost* of the RES plant: each technology has an initial investment cost which includes f.i. technology components, manpower, project management and administrative costs. These categories are going to vary according to the economy of scale and to the segment of market: residential, commercial or industrial.
2. *Operational cost* of the RES plant: to be expensed during the life of the project.
3. *Geographical position* of the RES installation: for each geographical region this factor will determine the level of power generated and the relevant capacity factor.
4. *Price of Electricity*: although the main component of the market electricity price is the fuel used for conventional generation, being subject of high volatility, for simplicity it will be considered with a constant evolution.

It has to be understood that the aims of the efforts in technology development and cost reductions due to R&D are going to produce a reduction in the competitiveness gap and a sooner approach to the grid parity, and this is the reason why the first two variables are the most important.

The grid parity can be found in the overlapping area between the LCOE which will be decreasing for the next, and the RES revenues given by the price projections for each market in the EU, which are expected to grow.



ASSUMPTIONS *Residential* 3 kW - Italy	
Installed Capacity (kW)	3
Capacity Factor (%)	19
CAPEX (€/kW)	3500
Cost Reduction Rate (%)	5
OPEX (€/kWh)	0.02
Discount Factor (%)	5.5
Lifetime (year)	20
Retail Electricity Price Annual Growth Rate (%)	3
Wholesale Electricity Price Annual Growth Rate (%)	3.8
Self-consumption (%)	30
Electricity sold (%)	70

Fig. 1 - Grid parity achievement in Italy PV residential market segment.

The Fig. 1 shows the results for the evaluation of the LCOE and PV revenues for residential market segment in Italy; it demonstrates the moment in which each of the analyzed projections are crossed, i.e. the moment in which the competitiveness of the technology is met (GPT).
From the preliminary estimations, we derive that Italy (on which this paper is focused) should be one of the first EU countries in reaching grid parity in all market segments, due mainly to higher irradiation factors and electricity prices with respect to Spain and Germany that are the other EU countries with large amounts of RES.
But on the way through the RES deployment strategy, in order to encourage sustainable development, all the environmental, social and economic effects are to be taken into consideration. All the potential barriers need to be overcome and the opportunities for renewable energy deployment should be exploited. In our study, the potential barriers can be described under three subcategories: socio-cultural, information and awareness and economic barriers, all of which pose a threat to the renewable energy deployment in the sustainable development concept. The most common barriers that the majority of the EU countries suffer from are: permitting procedures, grid connection rules and technical standards, and grid capacity issues. Among all, the duration of the procedures, high amount of money paid for the connection fees and the necessities for excessive labor slow down the improvements on the RES integration process.

SENSITIVITY ANALYSIS

After identifying the barriers for the RES electricity sector, the following step will be to translate the improvements proposed to overcome those barriers, into quantitative figures, in order to analyze the performance sensitivity of the competitiveness by inputting those values. By introducing the figures assumed as descriptive for the policy recommendations, the sensitivity analysis will be focused on showing the sooner or later achievement of the new GPT.

Administrative and connection barriers

The first studied barrier deals with administration procedures (complex and long processes), which are actually translated into indirect costs and time extensions in the investment schedule (cost a). These procedures delay the start-up of the plant, and consequently, the flow of the PV revenues. Therefore, these problems have been considered in the BAU scenario as extra costs that could be avoided from the LCOE. Thus, overcoming these barriers is reflected to the LCOE by a corresponding reduction on it.
As a second parameter affecting the LCOE, the virtual saturation of the grid can be considered (cost b). Regarding this issue, the AEEG has amended TICA (Integrated text for active connections) [2] by introducing a fee of 20,25 €/kW [3] to be paid by the future producers to the network operator for the grid capacity booking (in case of network saturation). The "virtual" saturation barrier was handled by the regulatory body by introducing this fee which forces the producers to take commitment on their investments. On the contrary, tackling this barrier would reduce the CAPEX by 20,25 €/kW and indirectly touch the LCOE of the technology by means of another reduction.
Bearing in mind that, by reducing the complexity and time extensions of the administrative procedures (the sum of costs a and b) by the potential removal of the virtual saturation issue, the investor would be reducing the risk of potential delay of incomes due to a sooner starting date for operation. The sensitivity analysis will be introduced by showing the effect of reducing the CAPEX by 50, 100 and 200 €/kW.
From the analysis shown above (Fig. 2), the effect of a potential reduction of LCOE trends due to administrative and virtual saturation barriers improvements can be observed. According to the results, competitiveness in the Italian PV residential segment could be advanced almost a year, expected to be at the end of 2014, if this potential scenario is put into force. For the cases of commercial and industrial segments, the analysis throws a similar behavior for both markets, achieving a potential parity on the beginning of 2013 for both of the segments.

Grid curtailments

The problem of grid curtailment stemming from the hosting capacity issues [1] in Italy is the second studied barrier. Although the specified grid curtailment problem is mostly common on the wind power generation, some curtailment issues on the PV electricity generation are foreseen. The current situation and the statistical data on PV curtailments may not constitute a significant concern on the grid security and mass power loss issues, but parallel to the increase in the installed PV capacity, the situation would lead to gain more importance as it does for wind power.

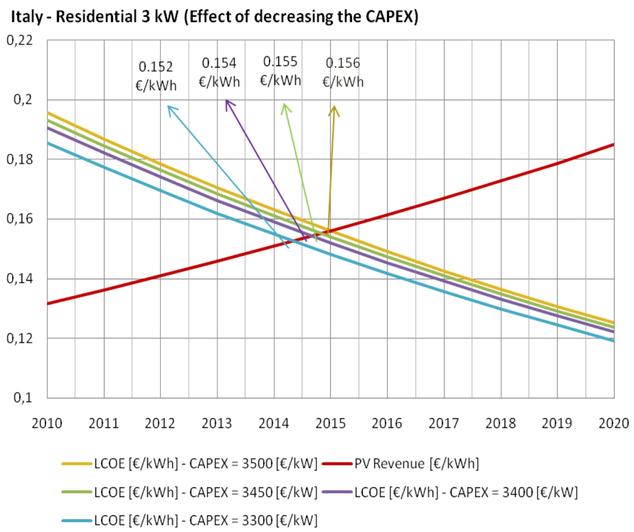


Fig. 2 - LCOE versus PV revenues sensitivity for residential market segment as function of the CAPEX, reduced by administrative and virtual saturation barriers improvements.

Hence, the curtailments of the PV systems and tacking this barrier will have an important place by reaching the competitiveness sooner. Specifically on the analysis done, the effect of decreasing the amount of annual grid curtailments is represented in the capacity factor by an increment. By means of increasing the capacity factor, a resulting enhancement is observed on the NPV of total production which will decrease the LCOE. While the LCOE values are decreasing, there is no change on the PV revenues per unit production therefore, only the LCOE line shifts left on the graph, as presented in the following graph (Fig. 3).
The original average capacity factor assumed for Italy in the BAU scenario is 19%. For the sensitivity analysis, the capacity factor has been increased by 1% and the acceleration on reaching the grid parity is observed. If it is assumed that tracking the barriers for grid curtailment have increased the capacity factor by 1% of its original value, the grid parity would have been reached approximately 5 months earlier, which would correspond to the first half of 2014, instead of 2015 for the residential market segment. Taking this significant effect of the capacity factor into account (approx. 5 months of shift in grid parity time for each 1% change), there should be necessary actions in order to prevent the danger for grid curtailments.

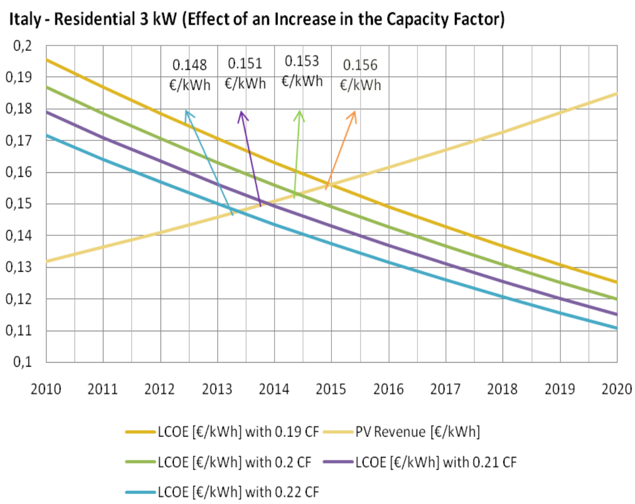


Fig. 3 - LCOE versus PV revenues graph for residential market segment with the effect of varying the capacity factor.

In this content, the most rational idea consists in the expansion of the grid. Through the smart grid concept, there are many investments and researches that the authorities have been working on. As stated in the barrier tables, the missing expansion of transmission and distribution grid capacities have crucial role on operational security of the grid. On the other hand, the risk of unnecessary islanding for DGs due to the narrow range in frequency states is another concern. These barriers can be solved by more investments on grid infrastructure and smart grid solutions.

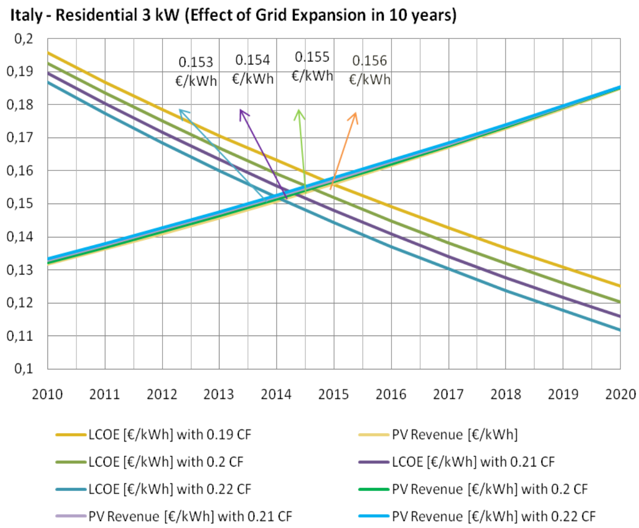


Fig. 4 - The effect of grid expansion and the smart grid solutions on the approach to competitiveness.

The reflection of these ideas into the quantitative analysis is different from the one that is done for grid curtailments. It is obvious that the grid expansion and development of the smart grids will be projected in the medium and long term. Due to this fact, in the analysis, the increase in the capacity factor is taken into account after the year 2020, counting eight years from now on.
As demonstrated on the Fig. 4, the grid expansion and following increase in the capacity factor resulted in remarkable decrease in the LCOE (shift to the left) and correspondingly less increase in PV revenues (increased PV energy injection into the grid corresponds to a decrease of the final price of electricity and thus decreases PV revenues). By combining the both effects on the curves, the grid parity would be reached sooner than the current scenario if the importance given to the grid expansion is enhanced. The same effect was achieved for the other two segments.

Imbalance costs

The last barrier taken under study for grid operation in Italy was the lack of accurate forecasting in the non-programmable RES producers, leading to an increase in the system costs due to the imbalances derived from this operation inefficiency.
Currently, for the production units powered by non-programmable RES, the actual amount of unbalance produced by generation is paid at the Day-Ahead Market (MGP) price at the location of the dispatching point; if the energy electricity actually delivered to the grid by these units is different from that forecasted, the costs induced on the system are not charged to the producer, but socialized. In this manner, the described approach can be considered as an additional implicit incentive for non-programmable producers. Also, it means that the dispatching user (PV producer) is not prompted to take an active part in the

management of the interrelationship between plant and network, thus neglecting various activities (such as forecasting and planning of electricity fed into the grid), which instead are normally performed by all other users, creating further distortions in electricity prices.

The AEEG has recently issued the resolution 281/2012/R/EFR which is making the "cost reflection" regulation effective from January 2013. From that date, the new regulation carries part of the imbalances costs induced by the RES system for producers themselves. During this year, there will be a franchise in which imbalance charges will continue to be supported by consumers. For the first semester it will be equal to 20% of the binding program modified and corrected for the dispatching point, and during the last 6 months it will be reduced to 10%, being soon revised for the oncoming years. Out of that exemption, the costs of imbalances will be charged on producers.

Currently in Italy, the TSO has grouped the national system in regional zones according to the dispatching service market (MSD) [4]. Each of these regions is characterized by an hourly dispatching service market price, when a balancing service is required in order to keep the system security. According to the type of aggregated imbalance (of a whole zone, given by all the imbalances produced at zonal level), the zone is considered to have a positive (+) imbalance (overfrequency) or a negative (-) imbalance (underfrequency). In addition, each of the RES producers contributes to those imbalances when they produce less (-) or more (+) than the amount of energy sold in the Day-ahead market. This situation generates four types of imbalance fees:

	TYPE I	TYPE II	TYPE III	TYPE IV
Zonal aggregated imbalance	+	+	-	-
RES produced imbalance	+	-	+	-

Table 1 – Type of imbalances zones according to aggregated imbalance and RES imbalance.

From the four possible imbalances situations exposed in table 1, the most difficult in terms of operational conditions and system costs is the last one, type IV, the one which is going to be assumed for this sensitivity study.

When the new resolution comes into force next year, the potential imbalances costs attributable to a PV generator (500 kW of capacity assumed), for one hour of produced effective imbalance, will be calculated as follows:

$$IC = E \cdot P(MGP) - IP \cdot Max\,[P(MGP)\,;\,P(MSD)]\ [€]$$

Thus, for our estimations we will assume an E(MGP) equal to (0,076 €/kWh), and an P(MSD) with the higher value registered by the TSO, 0,184 €/kWh. The value to be changed will be the IP, which will be 50, 100, 200 kW. As one can observe in the Fig. 5, the application of the resolution 281/2012/R/efr would delay almost half a year the grid parity for the industrial sector (red line), if the imbalances produced under the assumption of 1 hour per day are around the 100 kW (20% of power plant capacity). For an extreme case (200 kW – 40%), the grid parity would be delayed by almost a year.

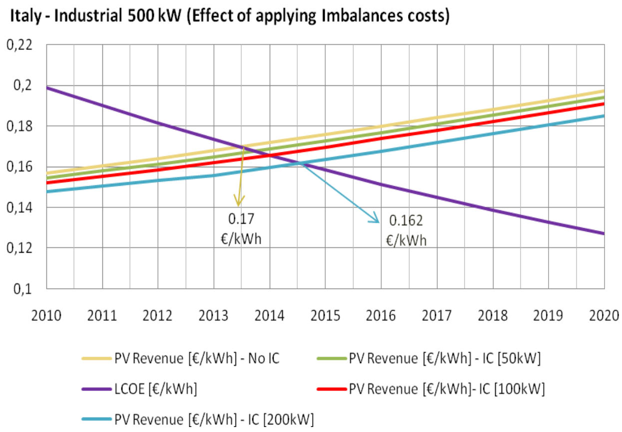


Fig. 5 - Grid parity delay effect after the application of imbalance costs for PV producers.

CONCLUDING REMARKS

In this paper, the current business market situation of PV technology was analyzed under certain assumptions, taking as a driver of the study the PV technology in the residential market segment in Italy. After the thrown results, it was concluded that the grid parity of PV technology would be reached soon in Italy (around 2013, starting from southern regions), mainly because of the higher irradiance factors and electricity prices. Thus, phasing out of the support schemes for RES should be considered the option, not meaning that the financing of new projects should be reduced suddenly, but in a gradual level, depending on the country and the segment of market; f.i. the financial resources budgeted for supporting the RES can be the source of financing the future network investments and smart grids infrastructure. In one word, it would be "to shift" resources from one field to other one. In this context, balancing the sustainable growth by supporting grid development and therefore, increasing the hosting capacity at distribution level, reducing the criticality of areas, can be an idea to smooth the way for the RES self sustainability race beyond 2020.

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