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#### HOW TO ENSURE A SUSTAINABLE MARKET GROWTH FOR THE PV SECTOR: THE PV PARITY PROJECT

SUBJECT 6: PV – A MAJOR ELECTRICITY SOURCE SUBSECTION 6.1: MARKETS

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ABSTRACT: The European Directive 2009/28/EC for the promotion of Renewable Energy Sources (RES) sets the target of supplying 20% of EU's final energy consumption from renewable energy sources by 2020, which corresponds to meeting 30-35% of the electricity demand from RES. High RES scenario presented in Energy Roadmap 2050 by European Commission (EC) foresees that 75% of the gross final energy consumption and 97% of the electricity consumption can be supplied from RES by 2050. With the increasing system performances and decreasing production costs, PV will provide a strong contribution to reach these targets.

The PV sector needs an appropriate policy and legal framework to ensure a sustainable market growth. To reach this ambitious target, European and National policy makers need to be provided with objective and transparent information on the potentiality of the PV sector, such as the competitiveness of electricity produced by PV systems, and on the support schemes necessary to reach the PV competitiveness as well as to achieve further targets. Through the PV Parity project, policy makers will obtain the necessary information to ensure a sustainable policy framework for the PV sector. In order to ensure that the documentation elaborated during the PV Parity project is objective and transparent, the results achieved during the project will be shared with the relevant stakeholders of the PV sector, such as utilities, distributor system operators (DSOs), research institutes on energy and legislation, energy regulators.

The steps to be carried out during the PV Parity project to reach a sustainable policy framework for the PV sector are the following:

• definition of PV competitiveness

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- roadmaps to PV grid parity in 11 European Countries
- definition of the relevance of PV electricity import from Middle East North Africa (MENA) countries
- cost / benefits of the PV network integration
- state of the art of the support schemes
- elaboration of alternative support schemes
- dissemination of the project outcomes to National and European policy makers

The 27th European Photovoltaic Solar Energy Conference and Exhibition (EU PV SEC) will represent and unique opportunity to share information on the first results of the PV Parity project such as the definition of PV competitiveness and the roadmaps towards the PV competitiveness.

The PV Parity project started in June 2011 and will end in November 2013. The PV Parity project is co-financed by the European Commission in the framework of the Intelligent Energy Europe (IEE) Program.

#### 1. INTRODUCTION

The aim of the PV Parity project is to support the achievement of the targets of the EU RES Directive (2009/28/EC), which aims supplying 20% of EU's final energy consumption from renewable energy sources (RES) by 2020, which corresponds to meeting 30-35% of the electricity demand from RES [1]. The PV Parity project will also provide a strong contribution to the achievement of the High RES scenario presented in Energy Roadmap 2050, which sets the target of increasing the share of RES in gross final energy consumption to 75% in 2050 which corresponds to 97% of electricity production from RES in 2050 [2]. The PV parity project will support the achievements of EU RES Directive and Energy Roadmap 2050 by providing a sustainable policy framework, which will ensure the achievement of the grid parity and the deployment of the PV sector also beyond the grid parity achievement.

#### 2. APPROACH

The appropriate framework to ensure a sustainable development of the PV sector will be defined by the following steps to be carried out during the project:

- definition of PV competitiveness
- roadmaps to PV grid parity
- relevance of PV electricity import from Middle East North Africa (MENA) countries
- cost / benefits of the PV network integration
- state of the art of the support schemes
- elaboration of alternative support schemes

The results obtained during the project will be shared with the relevant stakeholders related to the PV sector, such as utilities, distributor system operators (DSOs), research institutes on energy and legislation, energy regulators, in order to share transparent and objective information on the PV competitiveness. Information on the PV competitiveness and support schemes to reach the PV competitiveness and beyond will be communicated during the timeframe of the PV Parity project to the European and national policy makers, who can have an impact on the EU and national legislation and therefore provide a sustainable policy framework for the PV sector.

The project focuses on 11 target countries namely Austria, Belgium, Czech Republic, France, Germany, Greece, Italy, The Netherlands, Portugal, Spain and UK as exemplary markets, which allow exploring more than 70% of the EU electricity market. The target countries represent a perfect balance between southern European countries with a naturally high potential for PV (Spain, Portugal, Greece, Italy) and northern countries where the PV development is either already going on (Germany, Belgium, Czech Republic) or could start in the coming years (UK, Netherlands). The target country selection of the PV Parity project aims at covering a large proportion of the EU electricity market and a wide representation of various country configurations based on the following parameters:

- different levels of electricity prices
- subsidization that artificially lowers the electricity prices
- maturity of the national PV market and growth

Reaching a point where PV electricity could compete directly with conventional power generation requires identifying how the electricity prices have grown in the last decade and how they will grow in the coming decade and possibly later. To provide an overview of the trends in the last decade, the electricity prices in different market segments (power generation, power exchange, wholesale and retail segments) and consumer groups (residential and industrial/commercial end-users) in the target countries between the years 2001-2011 were collected from the PV Parity project partners and from Eurostat. The electricity prices collected during the project cover all segments of the electricity market as shown in Figure 1.



Figure 1: Structure of the electricity market [4]

The composition of electricity prices was assessed as well, with network costs, general system costs, variable and fixed costs, taxes and profits taken into account on top of procurement costs. In order to project future trends of the electricity generation, the electricity prices until 2020 and beyond foreseen in different scenarios were collected by different organizations, for instance European Commission, International Energy Agency and EPIA. The PV Parity project aims at providing a clear idea of the moment when grid parity could be reached in each target country (the time could vary depending on the country and the market segment). A fundamental step to achieve grid parity is to develop a commonly acknowledged "PV competitiveness" definition. With this scope, a workshop was realized in the frame of the PV Parity project in January 2012 with the participation of relevant stakeholders from the PV industry in Europe.

The objective of the workshop was to reach a consensus on a common PV competitiveness definition. After the agreement on a PV Parity definition, the first roadmap to PV competitiveness will be developed based on the electricity prices collected during the project. In order to obtain realistic roadmap to PV competitiveness, the roadmap will take into consideration:

- policy frameworks in the 11 target countries
- the impacts of PV network integration
- the relevance of PV electricity import from the MENA countries

### 3. SCIENTIFIC INNOVATION AND RELEVANCE

The PV Parity project will be able to give a relevant contribution to achieve an increased PV penetration in EU electricity markets and to achieve the PV grid parity

potential in the coming yearsvarious irradiation levels

at a lowest possible price for the community by ensuring an appropriate policy framework for the PV sector.

To reach this long-term objective European and National policy makers need to be provided with objective and transparent information on the potentiality of the PV sector, such as the competitiveness of electricity produced by PV systems, and on adequate support schemes to ensure a sustainable deployment of the PV sector, which can provide a relevant contribution to the achievement of the EU RES 2020 Directive and to the Energy Roadmap 2050. Several aspects of the PV Parity project show a high scientific innovation and relevance. Those aspects are related to the approach used for the definition of the PV competitiveness, which was until now usually referred only to comparison between the evolution of PV generation cost and electricity prices. The definition of PV competitiveness in the PV parity project will also take into account the following relevant aspects as shown in Figure 2.



Figure 2: Parameters influencing PV parity [3]

The PV Parity project will consider the following aspects:

- environmental costs and benefits;
- grid-related costs and benefits;
- other external costs and benefits.

Moreover, the project considers life-cycle costs and revenues rather than costs and revenues at one moment in time.

In the frame of the PV Parity project, the evolution of PV generation cost and the evolution of electricity prices have been defined in a transparent way taking into account the main components of electricity prices such as electricity generation, transmission and distribution cost, taxes and general system cost and their split into different components (network costs, general system costs, variable and fixed costs, taxes and profits). The grid parity concept has multiple definitions for the time being and that must be put together and simplified to deliver a coherent definition of grid parity. During the PV Parity project a clear definition of PV competitiveness has been agreed, which focuses on three kinds of consumer applications: household, commercial/industrial and utility applications.

In order to share the results of the definition of PV grid parity to the relevant stakeholders, a workshop has been organized in the frame of the PV Parity project. At the workshop the definition of PV competitiveness and the methodology adopted by the PV Parity project partners were shared with the relevant stakeholders in the European PV industry and with representatives from European Commission, Distributor and Transmission Operators, utilities and PV sector. Through this workshop the cooperation between PV sector and utilities and grid operators was strengthened. The PV Parity project can be considered as a pioneer since for the first time PV competitiveness will be defined for various consumers (residential, commercial/industrial and utilities) for 11 European countries and shared with all relevant stakeholders. Another innovation of this work is the development and the roadmaps to PV grid parity for 11 European countries.

The work also includes forecasting the cumulative cost of current incentives and cost/benefit analyses of the integration of PV systems in the markets and in the grid. Benefits related to externalities, such as the avoided  $CO_2$  costs and other environmental benefits such as the energy pay-back times and the cost of avoided fossil fuels imports are also considered.

4. RESULTS

The aim of this paper is to provide the relevant stakeholders with information on the achievements of the PV parity project since the beginning and the on the actions that will be taken in the following months. The 27<sup>th</sup> European Photovoltaic Solar Energy Conference and Exhibition will represent a unique opportunity to share this relevant information with the stakeholders, which represents a fundamental step to ensure a sustainable policy framework for the PV deployment towards and beyond the achievement of the PV competitiveness.

In the beginning of the PV Parity project, electricity prices have been collected for retail (residential, commercial/industrial end-users), wholesale (commercial/industrial end-users), power exchange (average purchase and average peak load prices) and power generation costs, one example representing Germany shown in Figure 3.



Figure 3: The evolution of the German electricity prices in the period 2001-2010

For the electricity price projections until 2020 and beyond alternative scenarios have been taken into account to define the future trends of electricity prices, which are Energy Roadmap 2050 (2011) by EC [2], On the way to competitiveness (2011) by EPIA [5], Solar generation VI (2011) by Greenpeace/EPIA [6] and Technology Roadmap (2010) by IEA [7]. Future electricity prices have then been calculated by taking into account the main cost components, namely electricity generation, transmission and distribution grid cost and taxes and general system cost.

On the road to grid parity and in competition with the other renewable energies the development of the cost will be decisive. Even if support for PV in some countries is increasing, the costs of PV are still the key factor in the political discussion of all the examined countries. As it seems there is a strong link between the development of the markets and the development of the costs. That means that the support in future will continue to depend on how the policy allows the PV market to grow. Europe is still the biggest PV market, even though other regions have a stable growth. In order to achieve grid parity by further cost reductions and production costs decrease, the support policies of the EU Member States continue thus to be of great importance for the PV development. The following table provides an overview of the support status for PV in all target countries.

Table 1: Support schemes for PV

Countries	Commitment to promote an expansion of PV			Relevance of the market in comparison	
	In the	In the	compared	In the	In the
	past	future	to past	past	future
Austria	Low	Low	equal	low	
Belgium	High	High	equal	low	
CZ	High	Low	decreased	Medium	Low
France	Medium	medium	equal	Low	medium
Germany	High	High	decrease	High	High
			d		
Greece	Medium	High	increased	Low	Medium
Italy	High	High	increased	Medium	High
Netherland	Low	Low	equal	Low	Low
s					
Portugal	Low	Low	equal	Low	low
Spain	High	Low	decreased	Medium	Medium
UK	Low	High	increased	Low	Medium

Since the market size is decisive for the reduction of PV costs with regard to the goal of grid parity, it is important to link the analysis of policy strategies with the market size. For this reason an overview of PV market developments and PV support schemes and regulations for all target countries was also prepared. Of the 11 Member States studied, a continuous support at a high level can be observed only in Germany. Italy's policy still aims a strong support of the PV. The countries with cumulated installed capacity less than 1.5 GW, formed by Austria, Belgium, France, Greece, Netherlands, Portugal and the UK, have in common that they will play a moderate role in the promotion of PV.

Cost/benefit analysis of PV network integration is also relevant to obtain objective information on PV competitiveness. In the PV Parity project, the costs and benefits of the PV network integration are named "system cost" and are taken into account in total cost of the PV with the following formula:

#### PV cost = PV LCOE + / - system integration cost

The PV Parity project is supporting the integration of PV electricity, in the market and the grid. The project will indirectly increase the number of PV installations by providing objective and transparent information to decision makers to properly create a sustainable policy framework for ensuring the PV market growth.

Additionally the project puts importance on the Middle East and North Africa (MENA) region taking into account the grid connection constraints with the prospective of importing electricity in EU. The selected countries are Morocco, Tunisia, Egypt, Libya, Algeria,

Turkey, Jordan (interconnected and/or very close to develop it). Within the project information and data have been gathered which are the existing status in electricity tariffs, the existing PV market and the PV support schemes.

In Figure 4, the PV system price development is given until 2030 in all target countries. After a certain period of price development in all countries the prices will be the same. We expect this to happen after 2020.



Figure 4. PV system development in all target countries

In parallel, the formula to be used to calculate the Levelised Cost of Electricity (LCOE) of PV systems has been identified [8], which is:

$$LCoE_{PVSystem,i} = \frac{CAPEX_i + OPEX_i}{EP_i}$$

Where

- *LCoE*<sub>PVSystem,i</sub> stands for the levelized cost of electricity production of a PV System in a year
- *CAPEX<sub>i</sub>* represents the capital expenditures (incorporating rate-of-return and depreciation of a PV System investment)
- *OPEX<sub>i</sub>* is the operational expenditures (O&M cost) in a year
- *EP<sub>i</sub>* is the electricity production (solar irradiation, efficiency) of a PV System in a year

In figure 5 the average retail price for electricity development until 2030 in the target countries is provided.



Figure 5: Evolution of the average retail price for electricity in the target countries

Definition of PV competitiveness and the related mathematical equations have been identified for three types of consumers, i.e. prosumers: household, commercial/industrial and utilities. The definitions of PV competitiveness for each type of prosumer are described below:

- Dynamic Grid Parity with grid integration features refers to installations where PV electricity production can partially or totally compensate the electricity consumption. This is what is usually called "grid parity" because of the comparison with "grid electricity prices". The drivers of competitiveness are in this case the savings in the electricity bill and the earnings that PV electricity generates.
- Dynamic wholesale prices competitiveness refers to installations where PV electricity compensate little or no electricity production at all. In this case, PV cost must be compared with wholesale electricity prices.
- Fuel-Parity for island power generation refers to installations where PV electricity competes with one specific source of electricity but is not replacing it: diesel-based power generation on islands not connected to larger networks.

Based on the electricity price scenario, on the PV LCOE calculation and on the definition of PV competitiveness the first roadmap to PV grid parity have been developed, as shown in Figure 6.



Figure 6: Simulation tool developed for creating roadmap for the PV Parity project [9]

The roadmaps have been developed per each market segment (residential, commercial / industrial and utility scale) of the 11 European target countries. The roadmaps have been based on a dynamic model developed and empirically scaled in the project "PV Parity". An overview for all target countries and the calculated year for achieving PV competitiveness in the residential sector based on the dynamic model is shown in Figure 7.



#### 5. CONCLUSIONS

In future PV will become competitive in more and more European countries for different market segments. This requires to develop alternative support schemes and to have them in place when PV competitiveness is achieved for those segments in the European countries.

#### REFERENCES

- Directive 2009/28/EC (http://eurlex.europa.eu/LexUriServ/LexUriServ.do?uri=CE LEX:32009L0028:EN:NOT)
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Further information on the PV Parity project is available at the link: http://www.pvparity.eu/.