BARRIERS FOR THE SECURE AND RELIABLE CONNECTION OF DISTRIBUTED SOLAR PV

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SUMMARY

Large penetration of distributed solar photovoltaic (PV) requires the development of solutions that integrate solar PV equipment, inverters, energy storage devices (electricity and heat), sensors, telecommunication equipment and smart meters. Despite of significant progress in the field of RES regulations, and in particular implementation of the RES Directive, still photovoltaics is being slowed by many barriers in European Union countries.
The regulatory, administrative, technical, financial and social barriers can contribute to slowdown in development of PV sector in EU.
The paper presents current obstacles limiting the rapid development of photovoltaic sources in 14 EU countries.

PV POTENTIAL IN EUROPEAN COUNTRIES

Solar photovoltaic is an environmentally friendly energy source, and among renewable energy is characterized by large dynamics of development in recent years.
In 2017 PV accounted for 17,4% of all renewable electricity in the European Union. Rapid increase of gross final electricity consumption has been driven by both:

- technological progress, cost reductions (in this, lower prices for modules), inverters and their greater efficiency, relatively short project deployment times, regional cooperation, and
- implemented climate policy instruments supporting development of renewable energy sources.

In 2000, total installed capacity of solar photovoltaic in the EU-28 amounted to approximately 0,2 GW, but increased to 94,9 GW in 2015 (i.e. near 41 times higher than in 2005 and 3 times higher than in 2010 years) and reached 114,04 GW in 2017.
The largest growth of solar photovoltaic capacity was between 2010 - 2012 by about 30 GW in absolute terms. In turn, the lowest growth rate of solar installation took place in 2013 - 2015 period, an increase of only 9% (from 86,8 GW in 2014 to 94,9 GW in 2015).

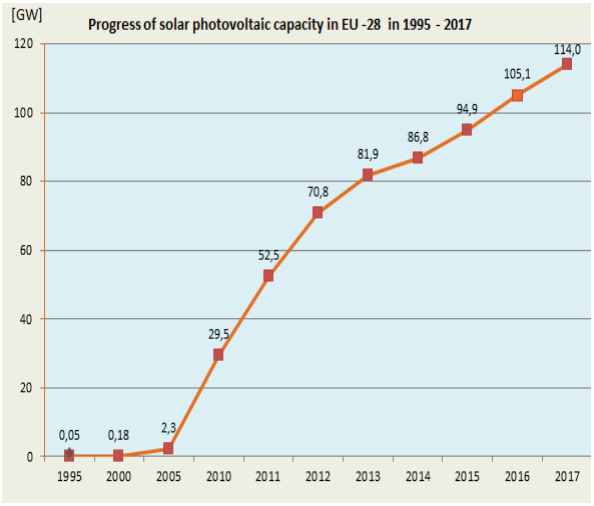

Fig. 1. Progress of solar photovoltaic capacity in EU countries in 1995 – 2017. Sources: Data EU energy in figures. Statistical Pocketbook 2014, 2015, 2016, 2017 and Renewable Energy BP Statistical Review of World Energy 2018

In 2015 solar gross electricity production reached 107,9 TWh, sharing 3% of gross final electricity consumption in the EU - 28. About 38% of solar PV electricity was produced in Germany, Italy and Spain. Solar energy resources in Europe are significant, but characterized by very uneven distribution of radiation, considerable in Southern Europe and lower in Northern and East parts of Europe.

Forecasts indicate further development of photovoltaic industry in EU countries. Experiences from completed projects are growing, science and material base has been built, which determines high efficiency of further investments and significant reduction of operating costs in highly competitive installation services market. It is also related to a continuation of the downward trend in prices of equipment, especially solar panels (regardless of price fluctuations resulting from periodically imposed additional customs fees for PV panels).

Development of technologies related to photovoltaic will enable more efficient solar energy use for utility purposes and gives the chance to generate electricity for millions of households. Intelligent networks will allow easier connection of PV systems to

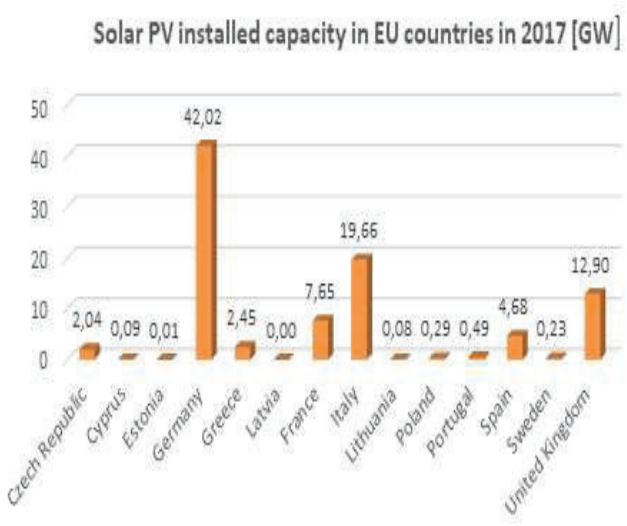

Fig. 2. Solar PV installed capacity in the EU countries in 2017. Sources: www.entsoe.eu

the power system, reduce network load, and minimize risks of breakdown and blackout. Development of smart grid, electroefficient household appliances, and electric cars, better and cheaper small home energy stores - all this means that current consumer of electricity is gaining more and more opportunities in production and management of its consumption.

BARRIERS FOR THE SECURE AND RELIABLE CONNECTION OF DISTRIBUTED SOLAR PV

The installation of photovoltaic panels is relatively simple, but proper design and implementation of any investment working in the grid system requires meeting several formal and legal requirements related to functioning of other energy market users. A degree of complexity of procedures, as well as scope and stability of support for development of prosumer electric power generation from photovoltaic power, affect the attractiveness of these investments.

In generally, we can identify a regulatory, technical, administrative, financial and social barriers that contribute to slowdown in development of PV sector in EU countries. In this:

- ✓ Regulatory framework for PV system development: policy uncertainty barriers, frequent changes in law, as well as interpretative uncertainties related to newly introduced regulations;
- ✓ Absence or insufficiency of precise information, clarity of regulatory and technical texts concerning connection of photovoltaic installations;
- ✓ Insufficient transparency of policies and legislation;
- ✓ Lack of dedicated institution, transparency procedure;
- ✓ Administrative hurdles such as planning delays and restrictions;
- ✓ Lack of coordination between different authorities;
- ✓ Long lead-times in obtaining authorizations;
- ✓ Insufficient spatial planning;
- ✓ Landscape permit and issues related, duration of administrative formalities;
- ✓ Technical barriers and infrastructure barriers that mainly centre on flexibility of the energy system;
- ✓ DSO infrastructure flexibility, conditions for connection of the PV system to the distribution network and release for exploitation, integration of PV;
- ✓ Non-technical - social barriers, lack of skilled personnel relating to insufficient knowledge, as well as insufficient number of skilled workers;
- ✓ Limited information on PV installations;
- ✓ Public acceptance;
- ✓ Information duties of prosumer to a distribution system operator about its microinstallation and installed electric power;
- ✓ Barriers associated with financial support;
- ✓ Obtaining permission costs;
- ✓ Grid integration costs;
- ✓ Levies and taxation systems [Deploying Renewables, Best and Future Policy Practice].

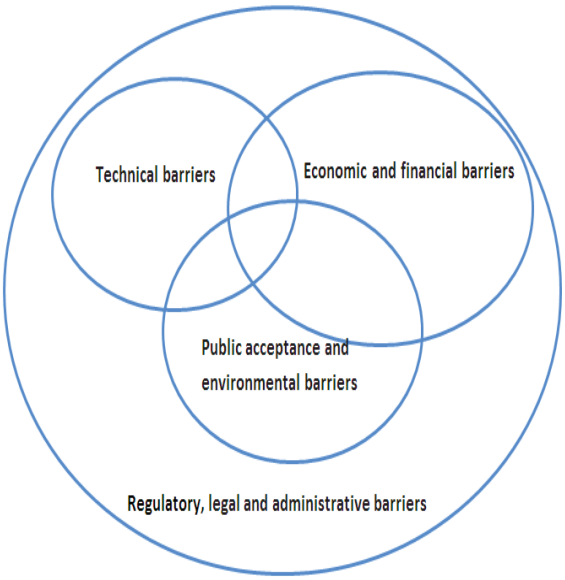

Fig 3. Scheme of barriers

Photovoltaic is being slowed by the regulatory, technical, administrative, financial and social barriers in many EU countries. The main obstacles that contribute to slowdown in development of PV sector in 14 EU countries i.e.: Czech Republic, Germany, Greece, Spain, France, Italy, Cyprus, Lithuania, Latvia, Estonia, Poland, Portugal, Sweden and United Kingdom have been identified and analysed in this paper.

REGULATORY AND ADMINISTRATIVE BARRIERS

Transparent, unambiguous and stable regulatory system favours investments in PV, especially in the initial stages.

Despite significant progress in the field of RES regulations, and in particular implementation of the RES Directive, still development of photovoltaics in some countries, is being slowed by regulatory barriers.

Regulatory and legal stability is of key importance for all RES investments. The regulatory and administrative requirements for PV installations can limit the possibilities of expansion of PV in European countries.

The following obstacles related to administrative and legal procedures that delay development of the PV were identified in analysed countries:

- ✓ duration of the grid connection permit process,
- ✓ insufficient spatial planning,
- ✓ lack or insufficiency of precise information concerning connection of photovoltaic installations,
- ✓ lack of coordination between involved authorities.

Regardless of improvements and simplification of the administrative procedures related to connecting prosumers to the power grid in all analysed European Union countries, shortening of times obtaining permission to install and operate a PV system and energy storage device, the administrative procedures can be still a complicated, uncertain and slow process for many investors.

Administrative requirements and interconnected legal procedures have a large impact on sustainable development of solar markets in many countries. In France the most significant impact of administrative barriers is the lengthening of the time required for the installation of photovoltaic systems. It would take between 39 and 220 weeks (for residential and ground-based facilities respectively) between the start of a project and the injection of the first kilowatt hour on the grid. This period can be extended by 20 to 140 weeks because of the connection procedure. Urban planning permits can also extend the deadlines.

Connection of electricity production equipment (up to 200 kW) to the electricity network can take from two months up to one year in Spain.

There are some bureaucratic barriers in Greece if an investor is aiming to operate a photovoltaic station of >1 MW. There are approximately ten steps that the investor should follow and usually for most of them there is a long wait period.

In Estonia there is no dedicated regulatory body, nor are there standardized procedures for the creation or operation of a renewable energy scheme. Connection of electricity production equipment (up to 200 kW) to the electricity network can take from two months up to one year. Rules and waiting times vary between the 290 different municipalities in Sweden and they can range from 7 to 10 weeks.

The majority of member states have established maximum time limits for permitting procedures, as well as facilitated procedures for microinstallation, an increasing number of member states offer project developers the possibility to submit on-line applications.

In Germany, with the tenant's electricity law, which was implemented in July 2017, an attempt was made to bring PV electricity to a larger number of households outside of the house owner sector. However several regulatory barriers still exist, which lead to a small number of installations in the first year of the program (only 5 MW installed while the upper limit was set to 500 MW). These are several issues regarding the processes, especially metering and billing regulations, as well as the fact that housing companies may lose the tax reductions when selling electricity to the tenants.

The key barrier to development of photovoltaics in Poland and Czech Republic is volatility of legal regulations, including changes in basic mechanisms of support for photovoltaic installations and construction law. This has a significant impact on the low sense of security and level of investor confidence in the stability of the investment regime, as well as decisions of financial institutions that credit PV installations. Regulatory instability causes investors uncertainty on the support conditions in the next years, and the level of the current costs of their operations. Frequent legal amendments cause difficulties in interpretation of entries and increase risk in implementation of long-term development strategies.

Bureaucracy, prolonging of administrative procedures by both authorities and grid operators, still poses the main barriers to rapid deployment of PV in many EU countries. In Italy these are examples of complex legislation that is difficult and costly to follow for the investor and eventually can create losses as it is easy to make errors.

In Poland no installation permit is required for the installation up to 50 kW provided that its height does not exceed 3 meters. If the height of the PV installation exceeds 3 meters then the investor must notify the investment to the competent authority architectural and building administration. A construction permit is required for over 50 kW of installations. An administrative procedure related to any location in case of a PV larger system is connected with obtaining a building permit. In the case of construction of terrestrial PV system planned in area that does not have a zoning plan the barrier is the duration of the procedure for obtaining a decision on land development conditions for the location.

Most countries require that PV installations obtain a prior notification the authorities to start the operations, in Portugal and Spain a large installation needs to be registered. Most of the analysed countries do not require an energy permit cost or payment for small installations such as PV panels in rooftops. This are regulated at the national, regional and/or local level. The country reports showed the diversity of the existing legal and regulatory measures in the area related to applications and the grid connection fees.

The German EEG levy is paid by the consumers for every kilowatt hour consumed to finance the EEG remuneration for renewable energy systems in the country. The levy is also paid partially on own consumed PV electricity. Prosumers with a PV system below 10 kWp (or own consumption below 10 MWh) are exempted from the levy on their own consumed electricity. For larger systems the need to pay the EEG levy represents a regulatory barrier.

Some other barriers are related to insufficient knowledge of legal regulations and difficulties in obtaining connection conditions resulting from the lack of appropriate distribution infrastructure, including overloading of power grids. These constitute the main barriers in the process of connecting a PV installation to the power grid.

Solar PV investors must meet applicable rules of the local operator regarding safety and reliability. In many countries it is possible to refuse to connect a PV system to the network due to insufficient network capacity associated with obsolete infrastructure.

In some Baltic Countries renewable energy is not given priority. According to the grid regulator, the plant operator is entitled to non-discriminatory treatment. The grid operator may refuse to connect a plant to the grid in case of insufficient grid capacity. It shall give a reason for its refusal in writing within 30 days (Latvia).

Operators of new PV plants who sell their electricity to the market also have no special treatment compared to other generation plants. In order to promote the construction of these plants, the only support action that can be carried out by the government is by auctions (Estonia).

In the case of Spain on 7th October 2018 the Royal Decree-Law 15/2018 came into force on Urgent Measures For Energy Transition And Consumer Protection, which removes most of the administrative barriers imposed on self-consumption PV projects and the so called “sun tax“.

This law modifies and repeals certain aspects of Law 24/2013 of the Electricity Sector (LSE) Royal Decree 1955/2000, which regulates the activities of transportation, distribution, marketing, supply and procedures of authorization of electric power installations (RD 1955/2000), of Royal Decree 900/2015 which regulates the administrative, technical and economic conditions of the supply of electric power with self-consumption and of production with self-consumption (RD 900/2015), of Law 15/2012, December 27, of fiscal measures for energy sustainability (Law 15/201”).

Regarding self-consumption, the RD-Law 15/2018 modifies the LSE by introducing three fundamental principles:

- Recognition of the right to self-consume electric energy without any charge (sun tax eliminated);
- Recognition of the right to shared self-consumption by one or more consumers;
- Introduction of administrative and technical simplification, especially for the lower PV installations (up to 100 kW), included in the method of self-consumption without surpluses. These installations have to comply exclusively with the requisites of the corresponding technical regulations and, in particular with the Electrical Low Voltage Regulation. PV installations of self-consumption without surpluses up to 15 kW do not need to process the access permits and connection.

The commonly known "sun tax", which established tolls and charges for access to the electricity system networks for self-consumption, is removed.

A transitional measure is introduced that exempts producers of energy incorporated into the electricity system from the Tax on the Production Value of Electrical Energy (IVPEE) for a period of six months. The exemption covers the last calendar quarter of 2018 and the first calendar quarter of 2019.

PV installations under the self-consumption modality, up to 100 kW, will be exempt from being obliged to register in the Administrative Register of installations of Production of Electric Energy.

TECHNICAL BARRIERS

Solar PV investors must meet applicable rules of the local operator regarding safety and reliability. In many countries, it is possible to refuse to connect a PV system to the network due to insufficient network capacity associated with obsolete infrastructure. Modernization of existing network and development of smart grid allows for optimal use of PV systems, reduction of network load, minimization of blackout and emergency threats. High PV penetrations can have positive impacts on the network, but also negative if integrations are not properly manged.

Potential positive impacts on grid operation can include reduced network flows, and hence reduced losses and voltage drops. Potential negative impacts at high penetrations include voltage fluctuations, voltage rise and reverse power flow, power fluctuations, power factor changes, frequency regulations and harmonics, unintentional islanding, fault currents and grounding issues [R. Passey, T. Spooner, I. MacGill, M. Watt, K.].

The negative impacts affecting local grids may be solved by implementing smarter electric grids and flexible management of the system. The distribution system in many EU countries needs to be reinforced by creating new lines or by increasing their cross-sections, which requires financial expenditure for development of smart grids, network management technologies and interconnections.

In general, development of electricity network infrastructures is not perceived as a barrier to PV growth and in all in the selected countries there is technical capacity and infrastructure to develop PV.

Technically PV systems are mature, so there are no technical barriers regarding the systems themselves,

but more regarding integration of these systems in the local grid.

Accelerating the development of PV energy technology has become a major priority for energy policy makers around the world**.** Although PV technologies in small and medium scale enable safe and easy operation of devices with quite high efficiency, there are still several technical issues and obstacles to overcome.

The technical condition of distribution networks is a basic factor determining development potential of photovoltaics, especially in some areas, for example in Italy, where grid capacity limitations could affect both the output and the technical design of PV plants (the DSO reduces the plants' PV power that can be connected to the grid) and the normal operation of the PV plant: in some periods of the year (i.e. summer time) the DSO might impose temporary disconnections; the probability of such events increases in the rural areas in the south of Italy. Italy's electricity grid (Transmission and Distribution) shows some capacity criticalities in the south of the country, this factor has become more consistent in the last five years due to the huge increase of utility scale PV installations in such areas so even the installation of commercial/industrial scale PV plants may incur excessive costs for connection to the grid or risks related to temporary power output reductions requested by the DSO to preserve grid stability.

In Spain one legal-technical barrier should be highlighted, because it is currently causing problems in some regions, and it is the misunderstanding in the "boundary point" term. The boundary point is the point where the installation is connected to the grid. This concept is not clearly defined in the regulatory framework, resulting in technicians from the distribution companies differing in the interpretation of the term. Some technicians are of the opinion that the boundary point is outside the property, while others argue that the boundary point can be situated near the PV panels, inside the building. If the boundary point is situated outside the property, in some cases this may mean an important economic impact for the user. Similarly there is another barrier related to the distribution grid. Spanish electricity grid is distributed by nodes. New consumers have to connect to a determined knot. Information about the admissible power of each knot is very difficult to obtain, which makes it difficult to decide between different knots, and can make the installation more expensive.

Some other barriers related to technical obstacles are identified in France: the efficiency of the cells and modules, the mounting structures and the technologies of integration to the electrical network.

In Poland technical barriers concern:

- limited number of energy storage units,
- necessity of using master control systems that will control state of the energy demand of consumers, the amount of energy stored in storage devices, state of their charge and the potential for renewable energy from PV systems (based on this data, the master system must manage the energy transmission in the power grid,
- problems with precise energy demand forecasting,
- problems with precise weather forecasting,
- limited number of energy generating units,
- in general increasing capacity of the line is associated with its modernization,
- unequal phase load, potential disturbances may cause impact on PLC meters (9-150kHz),
- high photovoltaic penetration rate of the network periodically (i.e. in the conditions of high insolation and low energy demand) can lead to increased voltage in the network and thus to violation of energy quality indicators.

In many grid configurations with PV installation grid congestion and therefore overvoltage issues, malfunctioning of inverters and electronic equipment as well as transformer overloading can occur.

In Czech Republic challenges remain insufficient growth rates of smart meters. Some other barriers are related to battery management. For example, in Germany when using KfW subsidy for PV battery systems the feed-in power at the grid connection point must be limited to 50 % of the installed nominal power of the modules for 20 years. This should motivate the smart operation of the battery, which charges the battery with the peak PV production (delayed charging) to avoid/decrease PV peaks in the pubic grid. However most of the installed batteries do not operate in this smart way (often not using the KfW subsidy). Therefore often the batteries are fully charged at noon on sunny days, resulting in no reduction in peak production.

In the case of Sweden the lack of standards for technical components and grid-connection are barriers that historically have disincentivized the adoption of PV, however the main barriers that prevent the adoption of PV systems are the low sun radiation and the low price of electricity, which results in PV installations being scarcely profitable.

The energy system in United Kingdom is currently undergoing a transformation towards a smarter and more flexible system.

Currently, technical barriers are no longer among detailed barriers to development of PV. Modernization of the existing network and development of smart grids in all EU countries allows for optimal use of PV systems, reduction of network load, minimization of blackout and emergency threats.

ECONOMIC BARRIERS

Capital constraints are an important economic barrier to PV development, occurring primarily in case of households and small and medium-sized enterprises, which is most often observed in Central European Countries and Baltic Countries. Prosumers may not always be able to cover investment costs from savings they accumulate, they may also have problems with

showing sufficiently high own contribution enabling them to apply for investment loans. Due to high costs of obtaining a loan or lack of creditworthiness, this form of assistance may not be available to all interested parties and constitutes a serious barrier.
Relatively high initial costs of the solar PV modules and high installation, maintenance and repair costs, and the low costs of competing sources of energy (for example natural gas, biomass) may be the most significant barrier to rapid development of PV generation.

The above is confirmed by surveys carried out in Poland, as well as we observed in Lithuania and Latvia. In 2015, the Consumer Federation in Poland carried out surveys on a sample of 1,597 consumers. Based on surveys carried out among home users, the most important factor that influenced decision to install a home photovoltaic system was economic calculation and expected financial benefits from production of own energy and reduction of energy consumption from the network.

When deciding on investment, consumers primarily considered profitability, followed by environmental issues. The research shows that the biggest barrier to installing renewable energy in Poland is the financial barrier, i.e. high installation costs - as indicated by over 70% of respondents. Other important barriers were: long payback period, lack of information on conditions of use of the PV system, problems with access to information, lack of financing for investment. 67% of respondents identified their reason for resignation from RES installations: high price, 25.5%, - lack of possibility to obtain co-financing (another reason was lack of enough information about RES - 23%), and 21% indicated technical barriers, that is, solutions technicalities did not meet their expectations.

The results of the Consumer Federation's surveys are confirmed by surveys conducted on a sample of 2,000 households from Lower Silesia. Most respondents (over 60%), among those who have RES, indicated that premise for installing renewable energy were expected long-term savings. The vast majority of respondents (52.9%) indicated basic barrier to economic factors, i.e. lack of financial resources to complete investment. Profitability is seen as a crucial determinant of household investment decisions. High costs of investment for PV system is perceived as a major barrier to the transformation of an electricity consumer into a prosumer in Poland and Baltic Countries, and the cost of PV systems is still generally considered to be high.

Insufficient and ineffective policy support, what was observed in Czech Republic after 2014, created uncertainty in the market and was an important driver for slowed down PV development. The ongoing debate on the support schemes also creates uncertainty for investors in many countries.

The policy of the European Union and the member states supports projects in the field of PV installations. To increase the number of consumers willing to engage in prosumer activity various types of incentives, subsidies, low-interest loans were introduced, which shorten payback periods and increase the attractiveness of the investment opportunity. In 2015, more than 1300 support measures (economic, financial, regulatory, administrative) for the development of renewables were in place in the EU countries. Despite this there are still barriers that constrain PV deployment.

In Germany, there is a subsidy by the German state development bank KfW (German “Kreditanstalt für Wiederaufbau”) supporting the installation of storage systems of up to 10 kWp in combination with a PV system. The subsidy is bound to a loan, which is given to the investor via the local bank. In the beginning of the program, which started in May 2013, many banks were not interested in giving such a loan to their customers. In addition the application process was perceived as complicated. The subsidy program will end in December 2018.

The German feed-in tariff was decreased strongly until 2015 and is adapted every three months based on the PV system adoption in the previous 12 months. It has been relatively stable in recent years. The adaptation based on the last 12 months was criticized: A strong decrease in the feed-in tariff meant a sharp decrease in the number of installations. However looking back at the last 12 months the high numbers of installations from the months before were included in the analysis. The tariff was therefore further decreased until the number of installations had dropped significantly.

The subsidies for PV have been gradually reduced, and in many countries substantial changes in the policy support framework for PV panels has been observed.

Support schemes have constituted major drivers for investment in the PV sector. Market mechanisms and structural changes, especially net metering when it is rationally constructed and well-adjusted, will allow for higher PV shares. However in some cases, when net metering was not compatible with existing value-added rules, the changes introduced create additional difficulties. This was observed in Poland. Amendments to the Renewable Energy Act of 7 June 2018 introduced provisions recognizing conduct of business prosumer as being subject to value-added tax. Input and consumption of electricity to / from the network by prosumer is currently subject to VAT, which may mean for micro-installation owners additional bureaucracy.

The new RES law regarding PV systems introduced a net-metering scheme for new PV installations. The Greek government however has to date not promoted it adequately. Also the old feed-in-tariff scheme still exists, but is only in theory eligible for relatively low prices (57 €/MWh).

The economic benefits do not encourage new installations. Net metering is a method of offsetting between the generated and the consumed energy for a 3-year period. After that PV owners do not get any compensation for the possible excess of produced energy. Moreover there is large scale confusion about the calculation of levies and taxes. Some of them are based on the energy absorbed from the grid, others are based on the energy consumed while others are based on the agreed power of the household. Only two of the

banks in Greece provide loans for purchase and installation of photovoltaic systems and there are not many options for the prosumer to choose from.

There are also some restrictions about the size of a PV installation. In commercial applications, where the required load exceeds 20 kWp, the net-metering scheme allows for installations that reach only up to half the power consumption of the consumer (up to 500kWp).

The country's new renewable energy law also approves virtual net metering for specific investors. However, the PV system should be in the same Regional unit of Greece with the different consumption supplies and they should also be property of only one prosumer. As a result, different prosumers cannot cooperate with the current regulations.

Households implementing PV installations for energy generation can count on reducing maintenance costs as a result of reducing demand for conventional energy, the price of which is subject to change. Moreover at the time of an interruption of electricity supply from the power system, PV installations allow for partial independence due to the possibility of charging from a PV installation or potentially using the energy storage device of the microgeneration system.

SUMMARY AND CONCLUSIONS

Despite the presented barriers the idea of prosumer energy production is developing rapidly in the European Union countries.

Prosumer energy is a chance for society to actively participate in the energy market, opportunity to take advantage of technological progress to improve quality of life, environmental protection and energy security.

Photovoltaic investments are generally accepted by local communities and there are rare social protests associated with planned investments. Approach of societies to photovoltaics is shaped by the ecological and renewable nature of this form of energy, i.e. clean energy, whose use in local and global dimension brings several social and environmental benefits.

The greater environmental and energy knowledge of the society, the greater is acceptance and interest in use of photovoltaics.

Social barriers to prosumers in the energy sector are low awareness of consumers in the field of activities for their own production of energy, lack of education in respect of the possibility of rational energy management in households, failure to perceive benefits of being a prosumer.

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