CERTIFICATION ISSUES IN THE SOLAR PHOTOVOLTAIC SECTOR FOR INTEGRATION OF INTELLIGENT HOMES WITH SMART GRID IN INTELLIGENT CITIES, PROBLEMS AND SOLUTIONS IN TURKEY

AKILLI ŞEHİRLERDEKİ AKILLI EVLER İLE AKILLI ŞEBEKELERİN ENTEGRASYONU İÇİN FOTOVOLTAİK GÜNEŞ ENERJİSİ ALANINDA BELGELENDİRME FAALİYETLERİ, PROBLEMLER VE ÇÖZÜMLER

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ABSTRACT

In parallel to Turkey's developing technology and growing economy, to meet the expanding energy needs, Turkey should focus on smart grid and intelligent cities including renewable energy sources. Any growth in energy supply must be achieved in a low carbon way. Smart buildings meet the utmost needs of residents and respond appropriately to different weather conditions. Smart grid offer many benefits to utilities and consumers. It is mostly seen in big improvements in energy efficiency on the electricity grid and in the energy users' homes and offices.

In this process, the production of electricity from solar energy, namely photovoltaic technology, will have a large share. Because comparing with other renewable energy sources, solar energy is the most appropriate one in terms of area and feasibility. Hence determining the quality of photovoltaic modules to be used in smart homes has great importance for financial terms and intelligence.
Determination of quality and reliable photovoltaic modules is only possible by the product certification and inspection services. Thus, the production stage of the module and installation process can be demonstrated by checking all of the quality system standards. In order to ensure the most accurate and independent service, internationally accreditation is crucial.

There are three steps in front of Turkey during the integration of solar energy into the smart grid. First of them is quality production of photovoltaic modules, second testing and certification and lastly installation of photovoltaic modules. This paper finds solutions for the problems facing in certification process of solar pv modules which will be used in smart homes.

In the paper, importance of solar energy for smart grid and smart home applications will be emphasized. There are different elements which affect usage of solar energy in smart homes. This paper focuses on production of solar pv modules in Turkey, certification and accreditation for pv modules, regulations in Turkey, encountered problems and solutions for the certification of solar pv modules to be used in smart homes for smart grids.

Keywords: *Photovoltaic energy, smart home, smart grid, product certification.*

ÖZETÇE

Türkiye'nin gelişen teknoloji ve büyüyen ekonomisine paralel olarak artan enerji ihtiyaçlarını karşılamak için, Türkiye, yenilenebilir enerji kaynaklarını baz alan akıllı şebekelerle donatılmış akıllı şehirlere odaklanmalıdır. Enerji kaynaklarındaki herhangi bir gelişme düşük karbon salınımı olan kaynaklardan elde edilmelidir. Akıllı binalar içerisinde yaşayan insanların tüm ihtiyaçlarını verimli bir şekilde karşılamak ve farklı hava koşullarına uygun bir şekilde adapte olacak şekilde tasarlanmaktadır. Akıllı şebekeler hem altyapıya hem de tüketicilere birçok faydalar sağlamaktadır. Çoğunlukla elektrik şebekelerindeki, ev ve ofislerdeki enerji kullanıcıların enerji verimliliğinin artışı için önemli bir yöntemdir.

Bu süreçte, güneş enerjisi, yani fotovoltaik teknoloji, elektriğin üretimi büyük bir paya sahip olacaktır. Diğer yenilenebilir enerji kaynakları ile karşılaştırıldığında güneş enerjisi; alan ve uygulanabilirlik açısından en ideal çözümdür. Bu nedenle akıllı evlerde kullanılacak fotovoltaik modüllerin kalitesinin belirlenmesi gerek finansal açıdan ve gerek akıllı ev konsepti açısından büyük öneme sahiptir.
Kaliteli ve güvenilir fotovoltaik modüllerin belirlenebilmesi ancak ürün belgelendirme ve denetim hizmetleri ile mümkündür. Böylece, modülün üretim ve kurulum sürecinin

kalite sistem standartlarının tüm şartlarını sağladığı kontrol edilerek doğru yatırım hedeflenebilir. En doğru ve bağımsız hizmetin sağlanması amacıyla, uluslararası akreditasyon önemli gerekliliklerdendir.

Akıllı şebekelere güneş enerjisinin entegrasyonu sırasında Türkiye'nin önünde üç adım vardır. Bunlardan ilki fotovoltaik modüllerin kaliteli üretim olduğunun belirlenmesi, ikincisi test ve belgelendirmesi ve üçüncüsü fotovoltaik modüllerin akıllı evlere montajının doğru ve eksiksiz şekilde yapılmasıdır. Bu makale akıllı şehirler için gerekli olan akıllı evlerde kullanılacak Fotovoltaik güneş modüllerinin sertifikasyon sürecinde karşılaşılan sorunlara çözüm önerileri sunmaktadır.

Makalede, akıllı şebeke ve akıllı ev uygulamaları için güneş enerjisinin önemi vurgulanacaktır. Akıllı evlerde güneş enerjisinin kullanımını etkileyen farklı unsurlar vardır. Bunlar; belgelendirme ve akreditasyon, fotovoltaik modüllerin yerli üretimi, Türkiye'deki yasal düzenlemeler, akıllı şebekeler için akıllı evlerde kullanılacak Fotovoltaik modüllerinin sertifikasyonu konularıdır.

Anahtar Kelimeler: *Fotovoltaik enerji, akıllı evler, akıllı şebeke, ürün belgelendirme*

1. INTRODUCTION

With rising prices of gas and oil, the cost of powering a home is increasing at an uncomfortable rate. However, with developing technologies, homeowners are turning towards "smart-homes," technologically integrated, energy and money saving houses. With the integration of the technology into the home, owners are able to see the amount of energy being used and curb any unnecessary electric consumption from appliances, which use up large amounts of energy while plugged in but not in use. The next step of the smart home should be to reduce the usage of power even more by allowing for the home to produce its own electricity. An emerging important feature of a smart home is conservation of the earth's limited resources. More and more people are becoming aware of the ability to make their homes truly smart and green [1].

The issue "energy transition" is an important factor for household users. Producing its own energy from solar photovoltaic energy contributes to transition losses, providing technology for establishing a clean and decentralized energy supply. That implies PV system operators could meet their entire energy demand with their own PV electricity. Producing home's own electricity is one of the best ways for smart homes. Solar energy, obviously, is the leading technology for smart homes [2].

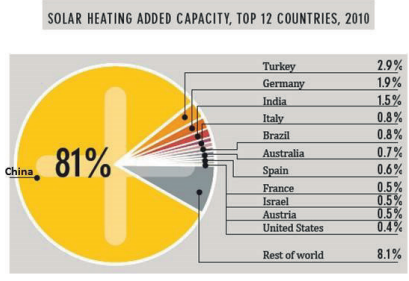
By using solar photovoltaic energy in smart homes, you can reduce your home's carbon footprint without the hassle of changing your lifestyle or going into debt and demonstrate how a smart house can play an important role from the demand side in a smart grid, where renewable energy such as solar power will be significantly implemented in the future [3].

Here are some of the benefits of solar energy usage in smart homes;

- Planning security and cost saving through solar energy in the home at fixed, cheap rates
- Maximum environmentally friendly energy supply through use of self-generated solar energy
- Energy management without compromising comfort or energy supply security
- All optimizations run automatically taking individual consumer wishes into account
- Greater independence from rising electricity prices
- Economization potentials are made visible through complete transparency of electrical energy consumption.
- Prepared for the future by incorporating variable electricity prices and upcoming smart grid business models

In order to have a reliable photovoltaic energy system in smart homes for smart grid, each unit of the system should work in harmony. If a photovoltaic module is not sufficient to work in harmony, in that case there is no meaning of group work. Hence, photovoltaic module's quality and reliability has the priority.

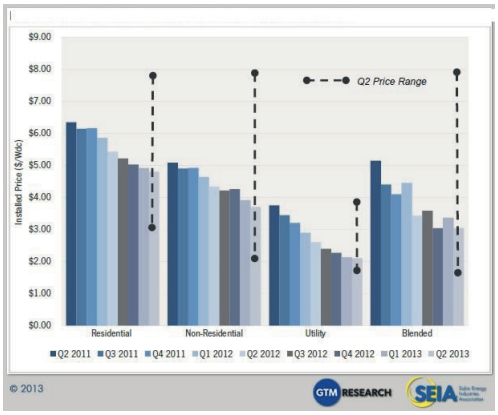
Turkey is the world number two after China in the usage of solar collectors as shown in *Graph 1*. However for photovoltaic technology, Turkey is recently trying to progress together with the last announcement of 600 MW licensed solar photovoltaic power plants. In June 2013 approximately 9000 MW applications were made by 496 different applicants. The process of evaluation is still going on.



Graph 1: Solar Thermal Capacity in the World

2. PRODUCTION OF SOLAR PV MODULES IN TURKEY

Solar panel costs are probably partly down due to technological and manufacturing advancements. However, the main driver of the reduction in installed solar panel costs is most likely just economies of scale as more solar panels are produced, costs come down and market maturation (as the market grows, competition grows, driving down the price of solar and installers achieve economies of scale and cut their price). *Graph 2* shows the trend of PV installation prices. Naturally, as solar panel costs continue to drop, solar power grows even faster, which further brings down the cost of solar investments [4].



Graph 2: Installed Price Rates of Last Three Years

Production of any machine or material brings the research and development activities together with some innovations. Therefore, manufacturing of solar photovoltaic modules in Turkey is important for Turkish market in the coming years. There are many Chinese manufacturers which produce photovoltaic modules not compatible to EU standards, but the quality of Turkish modules will certainly be same with European standards because of Turkey's European Union integration.

Turkey has around ten to fifteen PV module manufacturers among which have large capacities around 30 MW. Although half of them have really quality production line, other producers are investing more at the moment. These producers need to test their products before marketing and certificate them according to international standards. Since it is not currently possible in Turkey, the producers have to send their modules to outside especially to accredited European PV certification bodies to get the required certificates.

3. CERTIFICATION AND ACCEREDITATION

In the scope of accredited certification, schemes for production of photovoltaic modules that includes conditions, factory production of photovoltaic modules and inspection of on-site modules are prepared. The prepared documents should provide the conditions to be met by the manufacturer such as tests during production line, installation requirements and important points to be evaluated.

On the other hand, according to the Turkish regulations, in order to certificate the domestic production and benefit from additional financial incentives, equipments and components that are used in renewable energy power plants are required to carry conformity certificate of international or national standards given by organizations of TS EN 45011 or TS EN ISO / IEC 17065 Product Certification System [6],[7],[8].

One of the important points in certification process is for testing laboratories. They are eligible when they bear the standard of "TS EN ISO/IEC 17025 General requirements for the competence of testing and calibration laboratories" [9].

Figure 1: A photovoltaic module production line in Tekirdağ

Product certification satisfies product-specific standards and other standard documents to provide assurance for compliance. Product certification systems include initial experimental evaluation of the supplier's quality system, subsequent plant periodic inspection and testing of sample products of the suppliers taken from free market. With TS EN 45011 product certification system, it is assured that a product is manufactured according to the standards, stages and processes of international standards IEC 61215 for crystalline silicon photovoltaic modules, IEC 61646 for thin film photovoltaic modules and IEC 61730 for safety requirements [10],[11],[12].

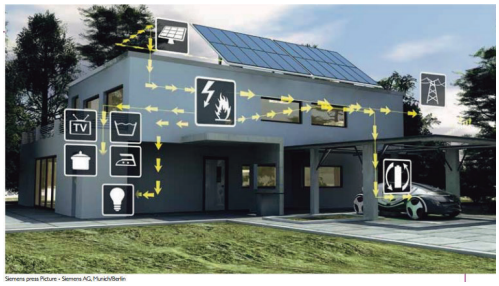


Figure 2: Smart Home Applications

For PV modules to be used in buildings, there are different testing procedures stated in IEC 61730 standard. Since the risk of fire is higher and safety is more important for the buildings, there are three safety classes of PV modules. The most durable class is Safety Class A. While purchasing PV modules, customers need to care about these safety classes.

4. REGULATIONS IN TURKEY

In order to evaluate the solar irradiance potential in Turkey as shown in *Figure 3*, in the Official Gazette No. 27969 dated 19 June 2011 a new regulation called "Local manufacturing of the equipments used in power plants producing electrical energy from renewable energy sources" has been published [6].

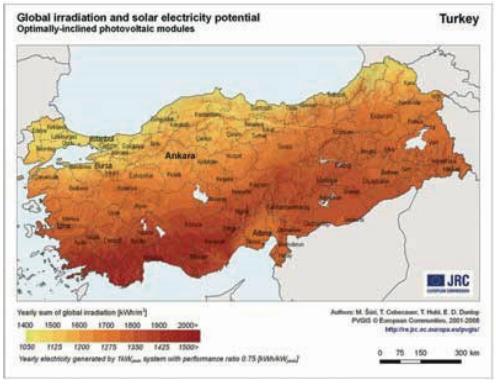


Figure 3: Solar irradiance in Turkey

According to previously published regulations, renewable energy power plants which use domestically manufactured equipments are provided by the state up to 6.7 cents/kWh additional incentives for solar photovoltaic plants. This incentive was for the plants to be commissioned by 2015 and valid for 5 years. By the recent legislation, it has been extended for the plants which will be commissioned by 2020. When renewable energy market's high costs are considered, any additional incentives provided by the government will facilitate the issue for investors. In this context, investors who plan to invest in this sector are willing to benefit from additional incentives by using domestic products as much as they can.

Nevertheless, Turkey's renewable energy technologies and production has great significance for domestic production. Developed countries all over the world in their respective industries have production-oriented work and have been pioneers in the market. Therefore it has great importance for Turkey in the coming years to encourage domestic production and its use, constituting itself as having high solar energy potential in order to be a pioneer in renewable energy.

Hence, it is a key point for the legislation to emphasize domestic production by stating "the certificate taken from TS EN 45011 Product Certification - General requirements for certification bodies" is mandatory in accordance with the standard of product certification [7].

There are three documents to be prepared and presented to the ministry for having additional incentives.

These are:

- Domestic Manufacturing Status Certificate received from Chamber of Commerce and Industry
- Type Certificate or eligibility criteria and / or Product Certificate issued by "TS EN 45011 General requirements for bodies operating product certification system" or "TS EN ISO / IEC 17065 Conformity assessment - Requirements for bodies certifying products, processes and services" national accreditation bodies of the International Accreditation Forum (IAF) and the mutual recognition agreement [7],[8].
- In case of type certification is declared, documents showing holder of the certificate's legal person domestic producer information and details of the assembly according to the type certificate

With this regulation, presence of mandatory product certification will be held in the country of manufacture and assembly of PV panels compliance with relevant standards. Thus, the relevant domestic component or system manufacturers will not only focus on their own technologies, they will have chance to follow the most current national and international standards at the same time and fulfill the requirements of this certification. This will undoubtedly bring quality and reliable products together for the complex assembly structures in renewable energy.

In the legislation, there are domestic production ratios for each equipment used in solar energy systems. For example; if the PV module's glass is a domestic product 20% is added. In order to have additional incentive, the total ratio should sum up to 55%.

5. ENCOUNTERED PROBLEMS AND SOLUTIONS

Integration of solar pv systems into the smart grid is a ambiguous point for Turkish grid system. The transmission lines are considered not have enough capacity however by a minuscule investment, we can overcome the problem.

When it comes to components of PV systems, the most common problem encountered during certification process is the reliable testing laboratory and certification institution. Secondly, the distance of the laboratory plays an important role for the producers. In case there will be local laboratories around the production area, they will send their products for testing more often and analyze the results. In that case, they will be able to improve their modules which leads research and development activities for the producers. If there is a local laboratory and certification body, the prices will be more convenient.

Transportation issue plays an important role during testing process. In case there will be some failures during transportation from factory to testing laboratory, it will affect the results of the tests and may cause negative consequences.

Nearby laboratories will shorten the testing time and certification period which is an important advantage. Especially for situations of material changes, some additional tests are required and producers are not willing to send their modules every time. Therefore they do not change their raw

material although they are suspicious about the quality of material.

Local certification bodies play an important role for the investors of module production line. Because in case they will receive support and advise from local test laboratories and certification bodies. The production line can be designed according to the experiences.

Climatic conditions of Turkey are also more different than European regions. This affects the module efficiencies. Because the temperatures are higher and some places have dusty areas. In this case, the modules may need to have additional tests and certification procedures. "Salt mist corrosion testing of photovoltaic modules" and "Environmental testing – Test of Dust and Sand" are important tests and reliable indicator the modules used in Turkey.

Additionally, in the certification process factory inspection is crucial. If the certification body is close to the manufacturer, they will always follow the qualification procedure without any problem. Hence some type tests might be repeated in a defined period [14].

6. CONCLUSION

Each country shapes its own future. In order to build intelligent cities with smart grids and smart homes, solar energy is indispensable. For a growing PV market in Turkey, regulations and standards need to be stable. Turkish government shall try to slot the regulations and not make sharp changes. Otherwise they will not be able compete with foreign producers. Nongovernmental organizations in Turkey such as GÜNDER and GENSED has a critical status in this process. There should be fixed rules for the acceptation of the projects.

Local certification and testing institutions are a background for high quality modules. Although domestic production of solar modules is an advanced sector for the countries such as Germany and Far Eastern countries, it is a new topic for Turkey. Many countries have the experience by determining the quality of PV modules and making investments accordingly. However in Turkey such a situation does not exist yet.

Since Turkey is a developing country for solar energy sector, investors need to be convinced to enter the market. In this context, they need some additional supports from the government. Turkish government is trying to regulate the market by publishing such type of legislations. The additional incentives are really an important factor for the investors. Therefore the process of having these incentives needs to be realized as soon as possible. This research focuses on how to realize the domestic production incentives in terms of product certification system which is a mandatory topic as stated in the legislation.

Each region has different climatic conditions which brings varied testing techniques. For Turkish region, a detailed and more composite certification process is necessary including additional tests and factory inspection criteria. For a smarter future, quality is primary issue.

7. ACKNOWLEDGMENT

I would like to thank my company UGETAM and especially to Prof. Ümit Doğay ARINÇ, Serkan KELEŞER, Muhammer SALİMOĞLU for their most support and encouragement during . They kindly read my paper and offered invaluable detailed advices on grammar, organization, and the theme of the paper.

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