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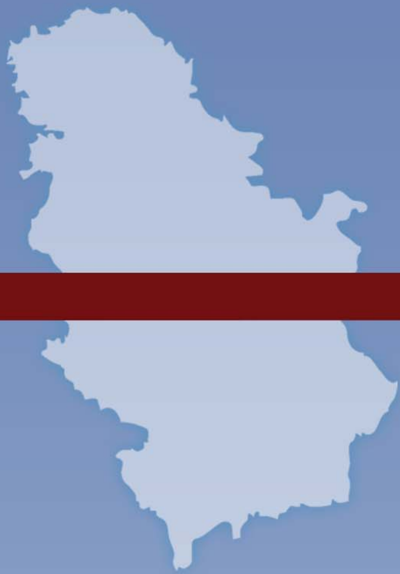

Solar PHOTOVOLTAIC power in Serbia

SOLAR PHOTOVOLTAIC POWER IN SERBIA

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ABSTRACT

The average solar radiation in Serbia is about 40% greater than the European average, but still the use of solar energy for electricity generation is far behind the countries of the European Union. Creating conditions for development and functionality of sustainable markets of photovoltaic systems is of great importance for the economy and preserving the natural environment in Serbia, so that the following main objectives for the implementation and development of solar photovoltaic system in Serbia have been proposed:

- Implementation of existing legal provisions relating to the production of electricity from renewable energy sources. In fact, the law of energy passed in 2004 introduced categories of preferred manufacturers of electrical or thermal energy using renewable energy, who have right to subsidies, taxation, customs and other facilities. This year of 2009 a regulation defining criteria for the status of a privileged producer of electricity from renewable energy sources was adopted, and as part of this act an encouraging purchase price of electricity was determined. This legal document should enable faster and wider application of photovoltaic technology in the total electrical power system of Serbia;
- Increase in media and public activities in order to develop an interest in renewable energy (RES) and inform wider layers of population on the importance and benefits of energy efficiency and using solar energy;
- Activation of the old and building new centers for monitoring the activities of solar radiation on the whole territory of the country, with the aim of identifying suitable regions for the application of photovoltaic solar device; • Involvement of local scientific research and development centers in European research projects of photovoltaic systems.

GLOBAL POTENTIAL SUN ENERGY

The energy of the sun rays coming to Earth's surface that is potentially usable radiation of the sun, is about 1.9 x 10^8 TWh (190 million terawatt hours) per year. This is the energy approximately 170 times greater than the total energy of coal reserves in the world and when compared to the energy needs of humanity, which amount to 1.3 x 10^5 TWh (130 thousand terawatt hours) per year, we obtain information that the solar energy that reaches the Earth's surface during only 6 hours sufficient to meet all the needs of the world annually. In order to get a better insight into these data the average household in some of the most developed countries spends about 10.000 kWh of electricity a year and it would take about 100.000 years to spend a TWh [1]. About 37% of global energy demand is met by the production of electric energy which in 2008 amounted to 17.000 TWh. If the energy was generated by the photovoltaic (FN) systems (systems that convert solar energy into electric) with modest annual power output of 100 kWh per square meter, this would require an area of 150 x 150 km^2 for the accumulation of solar energy. A large part of the absorption surface could be placed on the roofs and walls of buildings, and would not require additional area on the ground.

The energy of the sun's radiation is sufficient to produce an average of 1.700 kWh of electricity energy annually per square meter of soil, and the more the radiation in one location, the more the generated energy. Tropical regions are more favorable in this respect than other regions with moderate climate (Figure 1). Middle radiation in Europe is around 1.000 kWh per square meter, while, by comparison, it is 1.800 kWh in the Middle East.

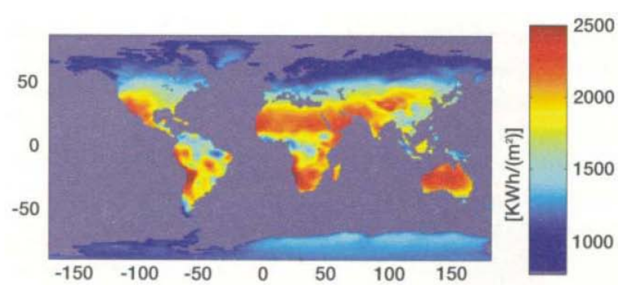

Figure 1a. Global radiation variations

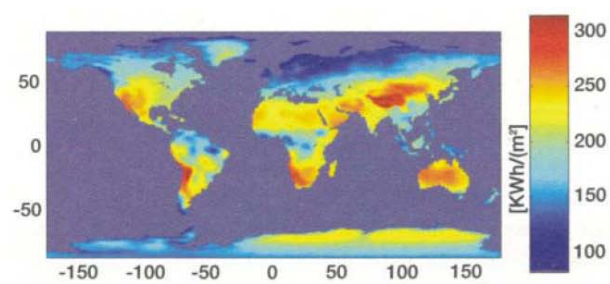

Figure 1b. The energy potential of FN device

Figure 1a shows the difference in solar energy radiation in all continents, and Figure 1b potential energy image of the world on the basis of calculation of energy obtained from the FN device assuming secondary statistical data on solar radiation and ideal conditions for the installation of these devices.

SOLAR RADIATION IN SERBIA

The potential of solar energy is 16,7% of total of useful potential of RES in Serbia. The energy potential of solar radiation is about 30% higher in Serbia than in Central Europe and the intensity of solar radiation is among the largest in Europe. Average daily energy of global radiation for flat surface during winter ranges between 1.1 kWh/m^2 in the north and 1.7 kWh/m^{2}in the south, and during the summer period between 5.4 kWh/m^2 in the north and 6.9 kWh/m^2 in the south [2]. For the purpose of comparison, the average value of global radiation for the territory of Germany is about 1000 kWh/m^2, while the value for Serbia is 1400 kWh/m^2. The most favorable areas in Serbia record a large number of sunny hours and the annual ratio of real radiation and total potential is approximately 50% of. Table 1 presents the mean daily sums of global solar radiation energy on the horizontal surface in some places Serbia.

Place	Month												Total per year	Medium per year
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII		
Beograd	1,40	2,20	3,35	4,85	6,00	6,45	6,75	6,00	4,65	3,05	1,60	1,15	1446,80	3,96
Zrenjanin	1,30	2,15	3,45	4,90	6,05	6,35	6,55	5,90	4,45	2,95	1,45	1,05	1419,45	3,89
Kikinda	1,00	2,05	3,55	5,10	6,40	6,55	6,85	5,95	4,45	3,00	1,50	1,05	1456,50	3,99
Vršac	1,00	2,00	3,35	4,40	6,00	6,40	6,55	6,85	4,60	3,00	1,55	1,00	1424,75	3,90
Dolovo	1,30	2,05	3,40	4,80	5,85	6,20	6,55	6,00	4,55	3,00	1,55	1,05	1412,05	3,87
Sombor	1,35	2,15	3,35	4,85	5,95	6,30	6,15	5,65	4,20	2,80	1,35	1,40	1387,35	3,80
Palić	1,30	2,10	3,45	5,00	6,15	6,25	6,35	5,85	4,30	2,85	1,40	1,15	1407,40	3,80
Vrbas	1,45	2,35	3,45	4,80	5,90	6,15	6,40	5,70	4,35	2,95	1,45	1,20	1406,85	3,85
Novi Sad	1,45	2,35	3,20	4,65	5,80	6,20	6,35	5,75	4,40	2,90	1,45	1,20	1392,64	3,82
Ćuprija	1,55	2,35	3,50	5,00	6,10	6,15	6,65	6,10	5,15	3,40	1,80	1,30	1495,40	4,10
Kruševac	1,65	2,55	3,50	4,90	5,95	6,05	6,45	5,90	5,10	3,30	1,80	1,35	1519,85	4,10
Niš	1,75	2,60	3,45	5,00	6,10	6,35	6,70	6,15	5,35	3,45	1,85	1,50	1531,40	4,20
Kuršumlija	2,15	3,00	3,60	5,05	5,85	6,05	6,55	6,10	5,30	3,50	2,00	1,75	1550,50	4,25
Peć	1,85	2,95	3,70	4,85	5,95	6,15	6,75	6,15	4,90	3,65	2,25	1,60	1546,25	4,24
Priština	1,85	2,90	3,70	5,25	6,30	6,60	6,95	6,30	5,10	3,35	1,90	1,60	1578,25	4,32
Vranje	1,70	2,70	3,65	5,15	6,15	6,40	6,50	6,35	5,25	3,45	1,85	1,50	1543,40	4,23
K. Palanka	1,85	2,80	3,80	5,20	6,20	6,45	6,90	6,30	5,10	3,40	2,00	1,65	1567,80	4,30
Prizren	1,50	2,45	3,50	4,80	5,90	6,65	7,20	6,55	4,85	3,15	1,70	1,35	1512,25	4,14
Loznica	1,50	2,30	3,05	4,35	5,30	5,75	6,15	5,60	4,30	2,80	1,45	1,20	1333,50	3,65
Ivan Sedlo	1,45	2,25	3,05	4,30	5,06	5,85	6,30	5,65	4,35	2,75	1,50	1,20	1332,26	3,65
Kraljevo	1,60	2,50	3,35	4,95	5,90	6,20	6,60	6,05	4,65	3,05	1,65	1,35	1458,40	4,00
Kragujevac	1,50	2,40	3,35	4,80	5,85	6,10	6,45	5,90	4,85	3,30	1,70	1,30	1447,85	3,97
Smed. Palanka	1,45	2,30	3,35	4,95	6,00	6,30	6,55	5,95	4,85	3,20	1,70	1,20	1418,80	3,89
Smederevo	1,45	2,25	3,40	4,80	5,70	6,30	6,50	5,95	4,75	3,15	1,65	1,10	1432,75	3,93
Negotin	1,35	2,05	3,25	4,85	6,05	6,60	6,95	6,25	4,75	2,90	1,45	1,20	1453,35	3,98
Crni vrh	1,40	2,15	3,15	4,65	5,70	6,05	6,50	5,85	4,85	3,10	1,60	1,15	1393,10	3,82
Zaječar	1,50	2,25	3,25	4,80	6,05	6,45	6,95	6,30	4,95	2,95	1,50	1,30	1498,05	4,02
Valjevo	1,45	2,25	3,10	4,40	5,35	5,95	6,35	5,75	4,45	2,95	1,50	1,20	1362,60	3,73
Užička Požega	1,35	2,15	3,15	4,40	5,20	5,40	5,70	5,10	4,00	2,25	1,45	1,10	1266,35	3,47
Zlatibor	1,50	2,30	3,10	4,35	5,10	5,65	5,90	5,35	4,30	2,75	1,60	1,30	1316,40	3,61

Table 1. Medium daily sums of global solar radiation energy on a horizontal surface in kWh/m^2 in Serbia

All these data clearly show that Serbia has the energy resources of solar radiation well above the European average, with a very favorable seasonal schedule, and that its effective and long-term use is necessary to design in the most recent time period, among other things, to comply with EU measures and plans in relation to renewable energy sources.

APPLICATION OF SOLAR ENERGY

The application of solar energy can be achieved in two ways: converting solar energy into thermal energy and converting solar radiation into electrical energy. Solar systems for heat production are used in households, industry, agricultural buildings and other facilities which, for example, use large quantities of sanitary water. However, in the last ten years, photovoltaic (FN) conversion of solar energy has become a primary solar device industry due to the large number of technological advantages over conversion into heat and due to the rapid development of relevant technologies and their projected opportunities.

Production of photovoltaic devices doubles every two years with an average annual increase of 48% since 2002, so that this industry is showing the fastest development in the world compared with all other branches of energy technology. From the economic point of view, the price of electricity derived from solar energy is gradually falling as a result of technological improvements and growth of mass production, while it is expected that fossil fuels become more expensive in the near future. At this time, for Serbia it is more reasonable to encourage use of solar radiation energy to produce heat and electricity in households, industry and some branches of agriculture for smaller investments. Such a policy would, among other things, be also useful for the development of domestic economy and the employment of the population in the field of clean energy. But in a longer term, the future of solar radiation conversion is in FN technology and its integration with other sectors of technology, which is in accordance with positions, plans, and current conditions in the European Union and other economically leading countries. Therefore, further consideration only exposures devices and systems based on photovoltaic conversion of solar energy and the corresponding program, plans and possibilities of use and development in Serbia.

PHOTOVOLTAIC SOLAR EQUIPMENT TECHNOLOGY

Direct conversion of solar energy into electricity, so called. photovoltaic effect was observed almost two centuries ago, but only with the development of quantum theory at the beginning of the 20th century this phenomenon was explained and understood. The first solar photovoltaic cell was created in Bell Labs (Bell Laboratories) in 1954. Photovoltaic cells manufactured from silica semiconductor soon, with the development of space exploration, became the main source of electrical energy to satellites, primarily because of their reliability, while the cost was of minor importance. The importance of their use on Earth became current during the world's energy crisis in early 70's, when they began to think about improving their working characteristics and efficiency, and lower production cost. Today photovoltaic conversion involves high technology of electricity production from solar energy.

Photovoltaic systems consist of a module, and they are made of solar cells. FN systems are modular so that their energy can be designed for virtually any application. Moreover, additional components to increase the output power are easily adapted to existing photovoltaic systems, which is not the case with conventional sources of electricity such as power plants and nuclear power plants whose economic viability and feasibility request multi-megawatt installation. FN modules contain a number of serial or parallel connected FN cells to produce the desired voltage or current. Solar cells are laminated between two layers of protection. On the one side there is a specially tempered glass with low iron content, and on the other protective plastic Tedlar material or another layer of glass (Figure 2). In a typical solar module solar cells are integrated and laminated with laminating plastic (EVA). So laminated FN module is protected from adverse environmental impacts, in order to extend working life. A typical manufacturer's warranty period to FN module is 25 years. FN panels contain one or more modules that can be used individually or in groups in order to form a modular system, together with supporting structures and other necessary components. The systems can be fixed at a certain position towards the Sun, or can be mechanically continuously adjusted to the direction of the sun (adjustable supporting systems).

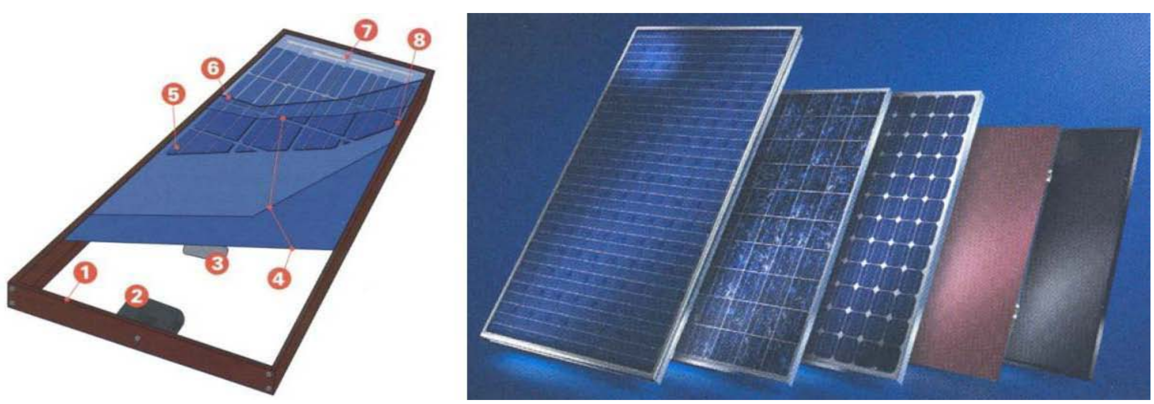

Figure 2. The structure and layout of photovoltaic module (1. Frame; 2. Junction box; 3. Label with the characteristics of the module; 4. EVA; 5. Solar cells; 6. Glass; 7. Bass conductor; 8. Tedlar)

FN latest generation of solar modules consists of so-called thin-layer FN cells and panels in which the thickness of photovoltaic material or layer is about 2μm (micrometers or microns). It is almost 100 times less than the traditional FN cells made of crystalline silicon. This reduction in the quantity of used semiconductor material reduces the cost per unit area, the price of the generated power (expressed in W), as well as the cost per installed kWh and increases profitability. However, the total price (balance of costs) of FN system is still somewhat higher for thin-layer FN modules because of additional costs of supporting structures required to install these modules, and to a lesser extent because of the costs of inverters and connecting to the distribution network. Also, operation and maintenance is more expensive because of greater surface area they cover in relation to the classical FN modules, so these additional costs must be compensated by the benefits arising from savings of materials. In the past several years the price, related to larger module surface, has been constantly falling due to substructure optimization, higher module efficiency, as well as better quality of electrical connections. In the period 2005 – 2007 the total cost of thin-layer FN modules has fallen by 60% and this trend is expected in the future.

FN SYSTEM COMPONENTS

The standard components of photovoltaic systems are FN modules, controllers and battery charge regulators, accumulators or batteries, cables and mounting systems, as well as AC/DC power converters - inverters (autonomous and network). Direct current produced in solar cell or module through the cable leads to the controller. The primary function of the controller is to prevent overcharging the battery, but there are some other roles depending on the specific application. If the battery is not fully charged, electricity is free to go to the battery, where energy is stored for later use. If the system needs to run devices that work on AC, part of the FN system will also be inverters which convert DC to AC electricity. If the FN system is linked to electric power distribution network, the so-called special network inverters that allow synchronization of FN system with the network and restoration of electric power back into the network are used. On that occasion, the network is a medium for electric energy storage instead of batteries. It is the most widespread application of FN system in developed countries today.

The excess energy generated in autonomous FN systems during sunny periods is collected in batteries, and some independent operations, such as, for example, direct pumping of water or running other engines do not require the use of batteries. The water is pumped when the sun is shining and is directly stored in a reservoir located at a higher level for later pumping through effects of gravity. Other FN systems convert DC to AC power and inject excess electricity into the electrical distribution network, while taking energy from the grid during the night, when there is no sunlight. This is an example of the operation of FN systems connected with distribution system network (Figure 3). The three typical configurations of FN system is the autonomous system, the system connected to the distribution network and the hybrid system. The autonomous and hybrid systems can be used independently, so they are not connected to the electrical distribution network and are often used in physically remote areas. FN systems connected with electricity distribution networks are one of the ways to make decentralization of the electrical network. Electrical energy is generated by these systems closer to the locations where there is demand, not only by power plants, nuclear power plants or large hydropower plants. Over time, these systems will reduce the need for increased capacity of transmission and distribution lines.

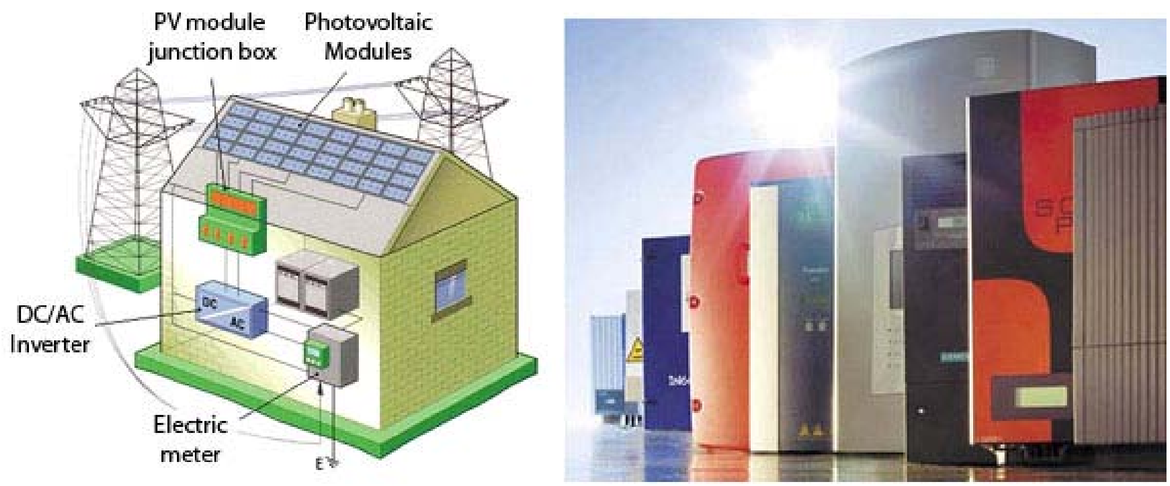

Figure 3. A typical network-connected photovoltaic system and network inverters

FN SYSTEM APPLICATION

Photovoltaic systems are very diverse: they may be less than coins and larger than football fields and can provide power to any device, from clocks to all of the settlements (Fig. 4). With the ease of handling these factors make them especially attractive to a wide range of applications. The recent increase in FN cells production with low prices opened many new markets with a great number of different applications. Applications such as lighting, telecommunications, ventilation, pumping of water, as well as providing electricity for the whole village, especially in remote areas, proved to be competitive and profitable compared to existing technology. In addition, a relatively new application of these systems with very high potential - facade photovoltaic systems (FFNS, or eng. BIPV - building integrated photovoltaics) - has appeared.

Figure 4. FN systems applied in telecom, lighting and navigation

FACADE PHOTOVOLTAIC SYSTEMS (FFNS)

All the more current aspect of electricity generation is also the conservation of the environment in which energy is generated and consumed. Solar electricity can contribute to the energy offer and at the same time help in preventing global climate change. Approximately 75% of energy used in the developed world is spent in the cities, of which about 40% is consumed in buildings.

Photovoltaic systems can be embedded in almost any building structure, from bus shelters to large office buildings and even gardens, parks and so on. Although the exact forecast of photovoltaic performance in buildings requires a careful analysis of various factors such as quantity of solar radiation coming to the surface of the building, stability and quality of electrical installation, electrical and distribution networks, etc., it is easily understood that this technology has great potential. Even in climatic conditions that are characterized by moderate sun radiation, the roof of a building of a household is enough to set the photovoltaic system that can provide enough electricity during the year.

Photovoltaic modules and generators are traditionally placed on special supporting structures, but they can also be placed on buildings, or they can become integral parts of buildings (Figure 4). The use of photovoltaic systems can significantly reduce the consumption of electrical energy from power plants. The buildings can even be converted into small manufacturers and distributors of electrical energy that can be of general benefit.

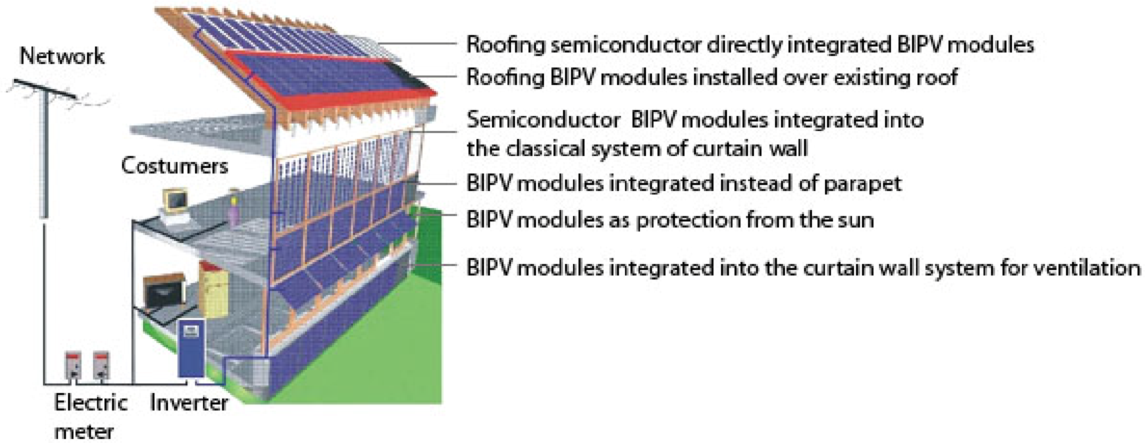

Figure 4. Facade photovoltaic system connected to the electrical distribution network

The problem of architectural integration of photovoltaic technology requires an interdisciplinary approach. This requires not only collaboration and the presence of highly specialized experts in the project team, but also consideration of sensitive issues related to their social, economic and energy aspects. For example, the facade of the building not only has to protect against precipitation and to regulate the heat losses, but it must also regulate the flow of sunlight, provide sound insulation, provide ease of maintenance, and must also meet the architectural and aesthetic criteria (Figure 5).

As the facade photovoltaic modules can replace traditional building materials, difference in cost between the solar elements per unit area and materials that can replace, is of particular importance. So the cost per unit area of facade photovoltaic system, connected to the distribution network, is almost the same as the price of the highest quality materials, such as marble or ornamental stone, and so the additional benefits of FFNS are practically free.

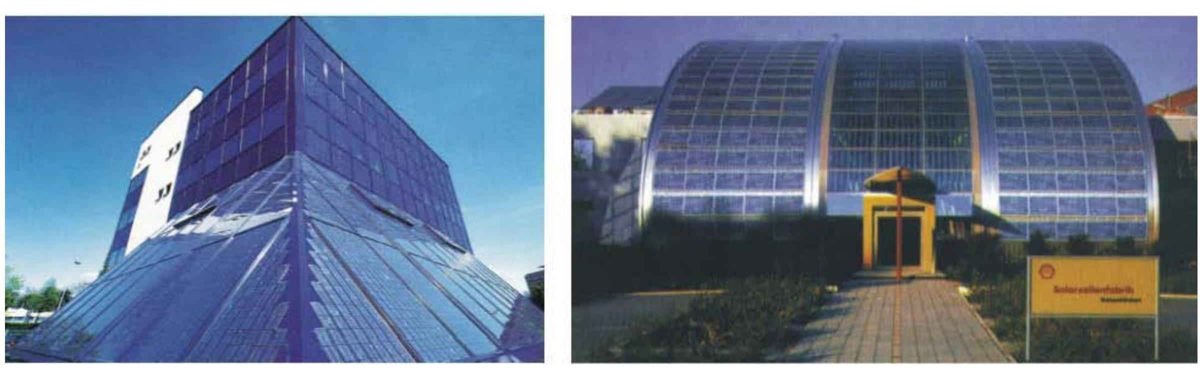

Figure 5. Examples of photovoltaic facade systems

POTENTIAL PHOTOVOLTAIC DEVICE

Solar photovoltaic technology which was previously used mainly in space programs or in remote locations, and thus was marginal and exotic at first, in the last ten years has become the main technology for the production and distribution of electric power in urban areas with the potential to become equally cost competitive to the prices of energy obtained and distributed by conventional technologies. Since 1990 the photovoltaic conversion industry has shown consistent annual economic growth of over 20%, starting from 1997 and over 33% annually. In 2000, the total installed capacity worldwide exceeded 1000MW, and from then until today, the trend growth exceeds 40% annually. In the developing countries more than a million households use electricity produced by photovoltaic systems.

An increasing number of companies and organizations are actively involved in the promotion, development and manufacture of photovoltaic systems. Companies that produce and distribute electric power in cooperation with manufacturers of solar equipment, urban organizations and funds are planning and implementing increasingly large projects gaining the necessary experience, drawing public attention, and at the same time lowering the price of electricity. Market value of photovoltaic industry currently amounts to over $5 billion a year, and it is expected to increase to over $10 billion per year by 2010. Representatives of the photovoltaic solar industry are some of the leading global companies such as Sharp, Mitsubishi, Sanyo, BP, Shell, Kyocera, etc.). At the end of 2009 the total installed photovoltaic capacity worldwide amounted to 15GW, which for almost 50% exceeds predictions made at the beginning of the 21st century. Figure 6 shows the historical development of global cumulative FN capacity by world regions.

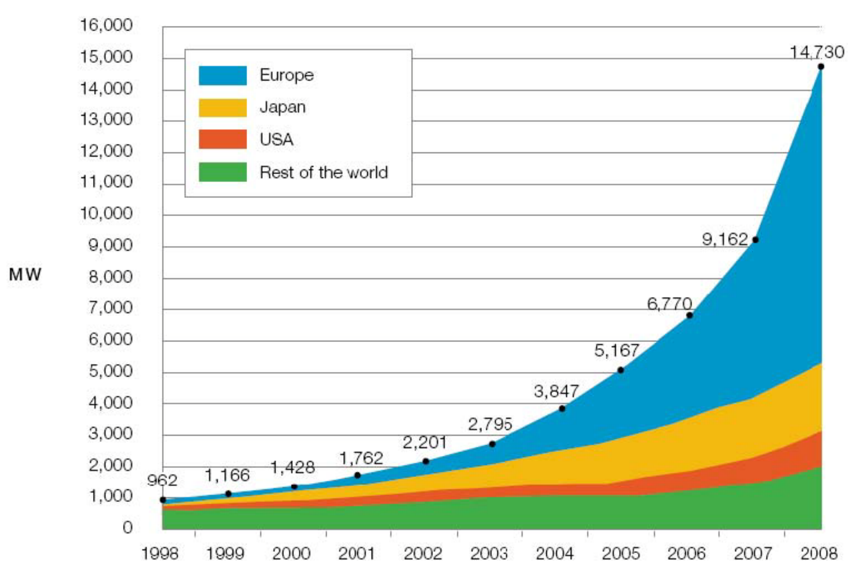

Figure 6. Historical development of global cumulative FN capacity by region

Ten years ago, it was expected that the two most promising applications of FN system would be in the sector of large power plants of several megawatts, connected to the distribution network, and in ten million solar home systems in developing countries. However, the situation is somewhat different today and the market is dominated by urban (residential) FN systems connected to the electricity network. In the period from 2000 to 2005 there was a relative increase of 50% per year in the number of networked solar FN power plants. It is anticipated that residential systems connected to the electricity distribution network will remain a major part of the market by 2010. Moreover, the studies of European photovoltaic industry association (EPIA) and the Greenpeace organization [3] predict that half the capacity of 207GW in 2020 will be systems connected to the electrical distribution network of which 80% will be installed in residential buildings.

Photovoltaic industry is increasingly present in national energy strategies of more and more countries. The regional distribution of FN market in the world and in Europe is shown in Figure 7.

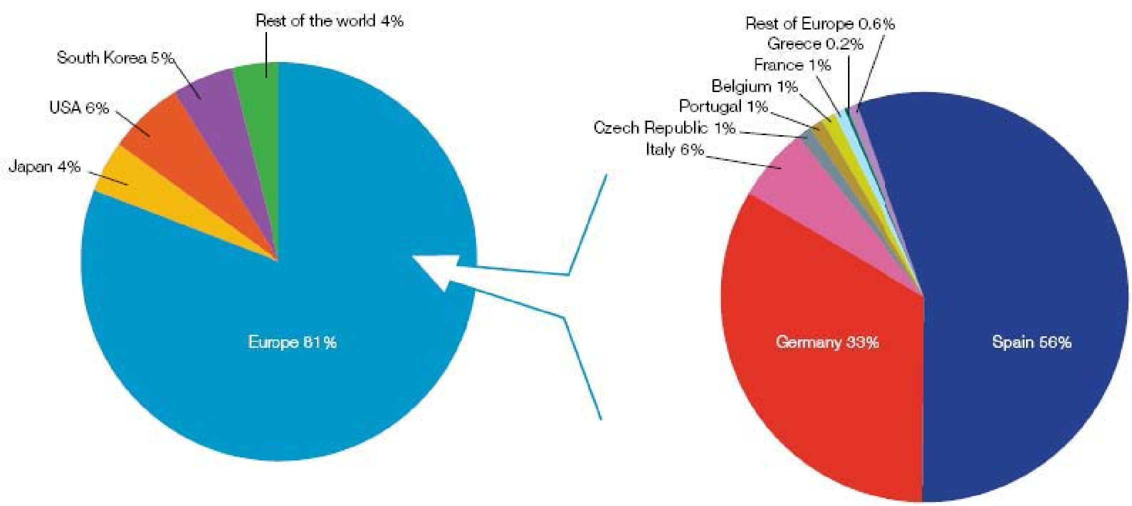

Figure 7. The regional distribution of FN market in 2008 (left) and market distribution in Europe (right) at the end of 2008 [3].

So, for example, the Japanese Ministry of Economy, Trade and Industry (METI), is planning to install photovoltaic power systems of almost 5GW by 2020, and it is anticipated that up to 2030 these capacities should increase to 82.8 GW. It is expected that during the same period the price of 3kW power should be reduced from $3/W to $1.5/W.

Germany provides illustrative example by adopting far-reaching law ("eng. feed in-tarrif") about RES state stimulants by which starting from 1 January 2000 N networked system owners are paid compensation of €0.51 (initially 99 pfennigs) per each kilowatt-hour of generated energy in the period of 20-25 years. Every year, the price will gradually be reduced until the total capacity does not reach a value of 1000MW (this value was increased from 350MW in mid 2002). It proved that this approach had a strong incentive for increasing the number of installed FN systems around the country.

The aim of the European Union was that, by 2010, the total capacity of installed FN systems should reach 3GW, but the goal was reached already in 2006, so that the total capacity at the end of 2008 amounted to 9.5 GW, which is over three times more than planned. Although the EPIA (European Photovoltaic Industry Association) predicted that this goal could be achieved provided that the module cost were reduced below 2€/W, which would cause prices of complete FN systems to be between €2.75 and 3€/W.

Since 1995 the U.S. industry of FN system has been showing an annual growth of 30%, and total installed capacity has reached 350MW. An important incentive for the FN market was made in 1997 when the then-President Clinton announced "The initiative for a million solar roofs" which is aimed at reducing the use of fossil fuels by installing one million solar systems by 2010.

Large multinational companies are organizing special business branches for solar FN systems (BP, Shell, etc.). On the other hand, groups that are fighting to preserve the natural environment, such as Greenpeace, actively promote the use of FN in order to increase demand and reduce prices.

FN modules currently cost is around €2.5 - 3.5€/W, and complete systems are installed at a price of 4-6€/W, depending on the size and type of system [4]. Produced with a typical annual force of between 750 kWh and 1500 kWh per installed kW, the cost of solar power is obtained of 20 to 40 ¢€/kWh (euro cents per kilowatt-hour). The constant increase of production capacity with a steady research progress and development enables reliable prediction of the cost lower than 2€/W in 2010. It is expected that the price of the cheapest FN system consisting of thin-FN modules (a-Si, CdTe and CIGS technologies) is about l,7€/W, which would mean that the price of photovoltaic generated electricity is less than 10¢€/kWh. This would equate or lower the price of electricity obtained from the FN installation below the price of electricity supplied from the traditional power plants.

CONDITIONS AND DEVELOPMENT OF FN TECHNOLOGIES IN THE EUROPEAN UNION AND SERBIA

In order to place the potential of FN technology in Serbia in the appropriate context, it is necessary to consider the situation of this industry in the European Union. The European Commission in 2001 set a goal to the European Union to increase the use of renewable energy sources, which means the share of electricity from RES in total electricity consumption in the EU being 22.1% in 2010. Accordingly, all member states have committed to increase electricity generated from RES for a certain percentage for each country. In this respect proper incentive mechanisms aimed at investors were established in the form of incentive purchase price (Eng. feed-in tariff). The same committee in 2007 set the goal for the share of RES in total energy consumption in the EU until 2020 is 20%, while each country is left with a choice of which types of renewable energy sources will generate the goal. Between 2003 and 2008 the installation of FN in the EU increased by ten times and reached 9.5GW of total capacity at the end of 2008 [3]. Out of that 5.3GW was installed in Germany, and 3.4GW in Spain, which means that in Germany there is more than half of European capacity. Figure 8 presents comparative European FN capacities connected to distribution network in 2001 and 2008. It is important to note that the total installed capacities do not correspond to the natural resources of solar radiation, because, for example, the average value of global radiation on the territory of Germany is equal to the European average, and, as mentioned earlier, much smaller than the values for Serbia. Since 1999 Germany and Spain have recorded the highest number of investments in production capacity of solar cells and modules. These two countries have made the most functional and stable legal conditions for natural and legal persons who invest in FN systems and "green" technology.

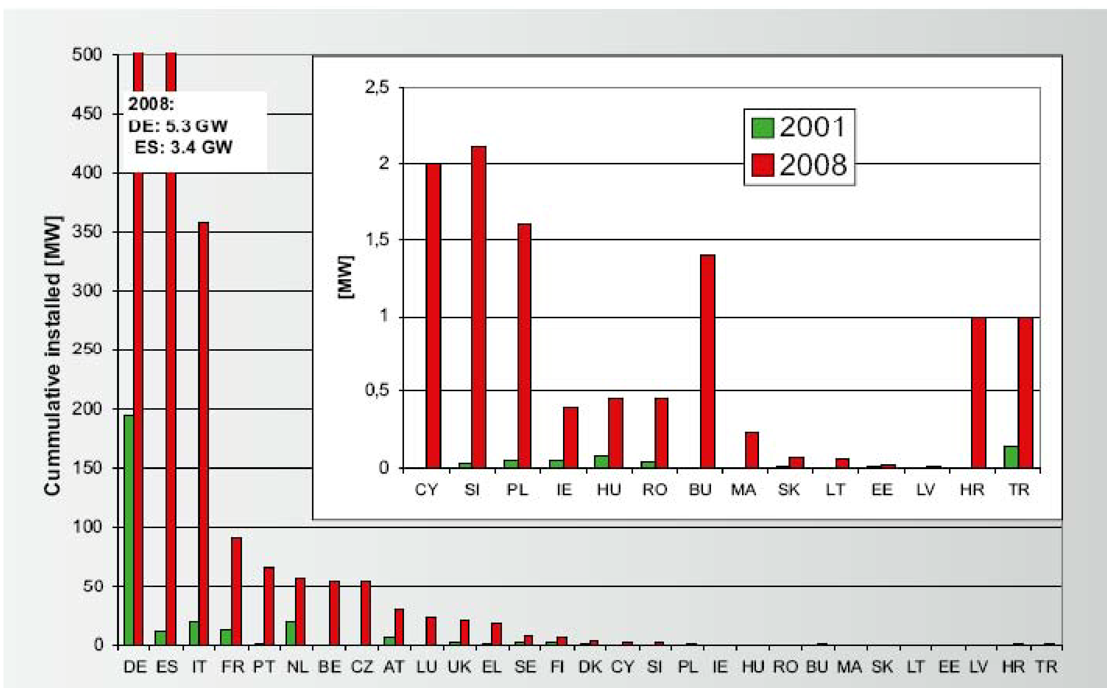

Figure 8. Total European FN capacities connected with the distribution network at the end of 2008, compared with the situation in 2001.

Based on the studies of Greenpeace and EPIA each MW in the manufacture of solar devices opens 10 new positions, while 33 jobs per MW open during the installation of the system [5]. 3-4 new jobs are created in the sales and indirect distribution, and 1-2 places open in the research sector. Based on the latest data the number of employees in the European FN industry has far exceeded 100.000 in 2008. Electrical energy from the FN systems, in addition to the opening of a large number of vacancies, also has other positive effects on economy. First, increased FN installation reduces the dependence of EU on energy imports. In particular, it is estimated that the increase in prices of crude oil is 10$/barrel, from 50$/barrel to 60$ per barrel, reducing GNP (gross national income) in the EU for 41.9 million from 2005 to 2007 [6]. It is obvious that the new increase in prices would worsen the current situation, and some economic analysts say that the economic crisis of 2008-2009 was caused by rapid increase in crude oil prices since 2003, culminating in July 2008. [7]. Second, electrical energy from FN systems is typically produced in times of greatest demand, which in economic terminology corresponds to periods when the price of electricity is the greatest. On the other hand, FN electricity generation is the best at extremely high temperature when, for example, the hydropower plant efficiency is reduced due to reduced water supply. During extremely hot weather in July 2006, the prices on European Electricity Exchange (EEX) were higher than the cost of injection (feed-in tariffs) in Germany.

Constant increase in production capacity of FN solar cells and modules has an important role in relation to the large market for these products in rural areas of Asia, Africa and South America, where still about 2 billion people lack access to electricity. It is of strategic importance for Europe to win and keep this market, not only because of the possibilities of job creation, but also to maintain the leading position in the world in this industry.

Plan that European installation capacity by the end of 2010 should reach 3GW of electric energy produced by FN technology became obsolete as early as in 2006. A similar increase was also retained in the period 2001 - 2008, and it is expected that by 2010 FN electricity net share in the European electricity production will be 0.5%. The impressive growth and sustainability of the trend requires reliable and stable political conditions in order to facilitate and ensure profitable investment in FN technology. Figure 9 represents the expected development of FN market (under the regulatory initiative) until 2013 [8].

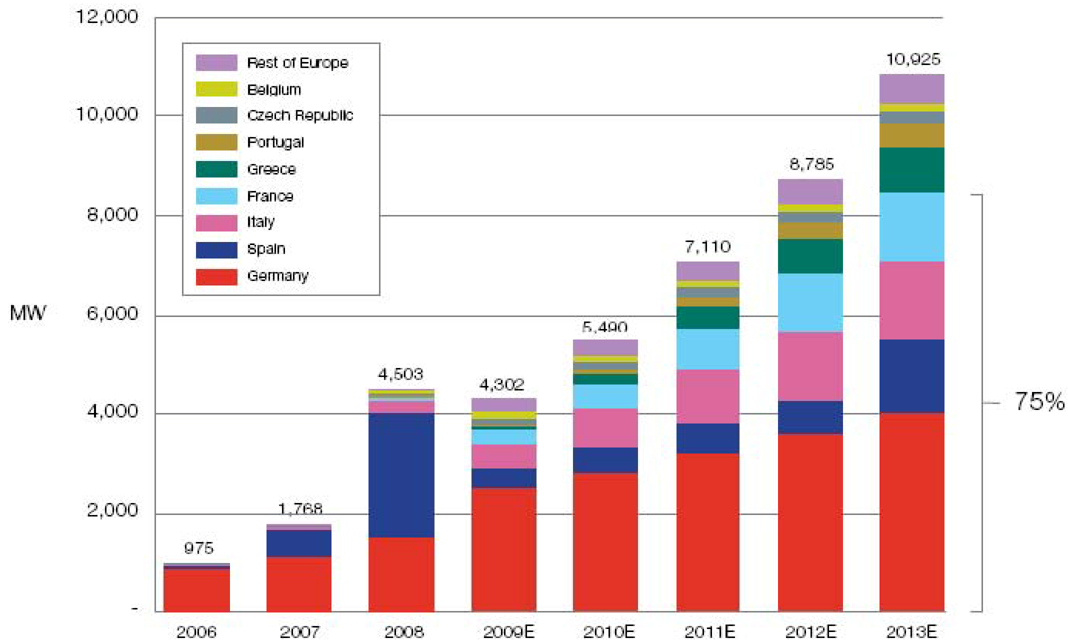

Figure 9. Expected regulatory encouraged development of European FN market by 2013

RESEARCH RELATED TO FN TECHNOLOGY

In addition to 27 national research and development program, the European Union has also been funding research (DG RTD) and development projects (DG TREN) within the FP program (Framework Program) since 1980 [11]. Funds for these projects are an important incentive for European agenda in FN technologies. A large number of research groups, ranging from small research groups at Universities to the teams of major research centers, are included in the program that includes research related to FN, from semiconductor materials to industrial optimization processes. During the 6-th FP program a platform for the FN technology was established [9], which aimed to mobilize all researchers who agree to the long-term European research programs related to FN technology. The platform has developed European Strategic agenda for FN research over the next ten years in order to retain the leadership role of Europe in FN industry [10]. A special role in the new FP 7 program, which began in 2007 and lasts to 2013, is given to the basic research related to FN technologies [12]. It is anticipated that, with technological development, the price of FN electricity which is connected to the distribution network should be between 0.10 and 0.25€/kWh, compared to the current price ranging between 0.25 and 0.65 €/kWh, depending on solar radiation and local conditions on the market. It is expected that the results of research and development should enable reduced consumption of materials, higher efficiency of solar devices and improvement of production processes based on compliance with environmental standards and cycles.

SITUATION WITH FN TECHNOLOGY IN SERBIA

Use and development of FN technology in the EU may represent a stimulus, but also a framework within which Serbia could use its climatic resources, research and industrial potential for faster adaptation to European standards and inclusion in development plans and programs. Similar approach should be adopted for other renewable energy sources.

During the 21st century, Serbia will have to implement energy-wise strategy that will include several innovative measures for efficient use of energy, renewable energy capacity boom and use of fossil fuels with the observance of high environmental norms in order to preserve the natural environment and climatic conditions. Despite the large long-term potential, photovoltaic technology will initially play a supporting role, but its contribution will constantly grow, both in urban and most remote places in Serbia. Installation potential for FN systems by 2012. amount to about 20MW. Plans and strategies for the development of European FN technology should be a signpost to local scientific and political public that should support all activities in research, technological, user and political domain in order to provide faster and more efficient integration into European programs. On the other hand, because of lack of energy efficiency in Serbia, extremely unfavorable economic situation and unstable price of fossil fuels, also frequent increase in electricity prices, the implementation of FN technology should start as soon as possible, using the creation of appropriate development strategies in accordance with the European plans, of course, depending on how much current economic opportunities allow that.

FN industry boom in the world with the increase of production capacity and a positive political climate in countries such as Germany, Spain, USA and Japan (as well as China, Italy, Korea, Greece etc.) are promising good prospects for photovoltaic technologies in Serbia. However, FN industry requires suitable and stable political conditions in Serbia for a constant and sustainable development. Rapid or sudden changes in the terms and amounts of subsidy and political attitudes may bring into question the positive development trend. Taking into account the current importance of FN technology, their long-term potential and the time required to develop this technology, development and application of these technologies fully justify and encourage public support and subsidies. Additionally, FN industry can significantly contribute to the country's economy by opening new jobs, as well as the development of small and medium enterprises.

In the area of basic and applied research a few very successful projects financed by the Ministry of Science and Technology Development (MSTD) relate to research in the field of nano-materials. These projects are indirectly related to FN technology, and could easily fit or create cooperation with European projects related to FN research and development, and to use the results of the research to connect local development centers with European industry. We should not forget that one of European objectives is to win he huge market in Asia, Africa, and South America, and even a small share of Serbia in cooperation with European industrial centers would mean a lot both for the local industry and economy. We should especially favor the projects of technological development related to the connection of FN systems with distribution networks in light of the huge expansion of the already developed methods of electricity production in Europe, in countries with less favorable climate conditions than Serbia. It is interesting that in the previous year, and even now, there have been no such projects funded by a ministry in Serbia.

RECOMMENDATIONS

Since Serbia is in the group of countries whose energy consumption, particularly electricity, is not too rational, it is necessary to increase interest in renewable energy sources (RES) and allow educating people about the importance and benefits of energy efficiency and using solar energy. We should emphasize the economic aspect, but also the impact on the preservation of the natural environment. Programs of this type could be organized and coordinated at the national level, but also by the relevant academic institutions, as well as by nonprofit and other organizations.

The energy policy of Serbia was promoted in the Energy Law in 2004. Its aim is to, in contemporary circumstances and in accordance with the policy of joining the European Union, establish qualitatively new conditions, business operation and development of energy production sectors and consumer sectors. Accordingly in 2005 the "Long-term development strategy of Serbian energy sector by 2015" was adopted, and in 2007 "Program to achieve the strategy by 2012”, which sets strategic goals that will apply in the period up to 2030. Important progress is the adoption of Ordinance on incentive measures for electricity by using RES [13], which is applied from 1 January 2010 to 31 December 2012, and which prescribes measures of incentives to produce electricity using renewable energy sources and for the purchase of that energy, i.e. cost injection (feed-in tariffs). On the basis of this regulation the purchase price for FN solar energy is 23¢€/kWh, for 12 years. By comparison, the highest guaranteed purchase price of injection in Europe is 54¢€/kWh in Germany, and surrounding countries either do not have proper legal regulations (such as Romania and Bulgaria), or have much lower redemption price (as Hungary, 10¢€/kWh). Of the former Yugoslavia, the price in Slovenia is 37¢€/kWh, while in Croatia it is 46¢€/kWh. Until 2004 FN market in Slovenia was very poorly developed, but since 2005 it has constantly increased 100% annually, and sustainable growth is expected by the end of 2010, when slower growth is expected due to saturation of the relatively small market. We hope that a similar situation will be repeated in Serbia, starting from 2012, due to redemption price which, by that time, will be at the level of Slovenia until 2004. Given the intense economic, trade and political ties with Slovenia, Slovenian experience should be taken advantage of for the rapid development of FN market in Serbia.

The next step should be legislation on rational energy consumption, as well as amendments to energy law in order to adapt it to European requirements and standards, as well as the standards to which Serbia was committed by signing the Agreement on Energy Union of European countries. We should also mention here the production and delivery of plans for implementation of the Directive of the European Commission in 2001 and 2007 on the increasing of use of RES. As part of these activities a fund for energy efficiency could be formed that would help more rational use of all forms of energy, especially electricity.

Of great importance would be the reactivation of a network of meteorological stations which until 1991 continuously measured solar radiation, which would allow analysis of radiation climatology at the level of the entire territory of Serbia and determine the level of quality of the areas that are potentially favorable for converting solar energy into electricity [2]. The construction of new stations for monitoring the solar radiation is certainly relevant, especially in urban areas, for effective implementation of facade FN. In line with this suggestion is the establishment of the corresponding center for the solar radiation, which would establish a national standard for secondary and working etalons for solar radiation in order to harmonize the calibration of appropriate instruments.

It is necessary to encourage research institutions to organize research projects whose program includes basic and applied research whose results can be used in FN technology. This is primarily related to research on research and development of nano-materials, and projects aimed at efficient use of FN systems and their integration into distribution electro-energy system.

The general public should be informed as soon as possible with the content of new regulations on preferential electric energy producers and incentive purchase prices for the electric energy produced from FN system. We should emphasize that the stimulating price allows each investor with preferential status to, in the period of 12-15 years, receive back all invested assets in the FN systems, including operating costs, i.e. maintenance costs incurred in the same period. Incentives purchase price does not depend on time of day or year when electrical energy is produced. Simplifying the administrative and technical requirements for linking households to electricity distribution network is necessary in order to faster increase the number of FN users, as well as the popularization of this technology. Consequently, it is necessary to establish in appropriate institutions well trained and educated staff who not only know the new technology, but also monitor the development of FN systems and new European standards in this area.

Already in the next few years architectural plans and construction solutions for new buildings in urban areas should use facade FN devices, and a similar practice would be applied in the renovation of the old. Therefore, facade FN modules should become mandatory part of building materials such as, for example, windows or doors. The appearance of even a small number of these modern systems in buildings in urban areas would be the best promotion for FN technology and encourage faster implementation in construction industry, but also in households. Certainly this trend would also require appropriate technical regulations and necessary standardization. Monitoring energy efficiency in buildings with FN technology should be available to the public through the Internet, as well as information about energy needs and consumption compared to standard buildings, and the accompanying economic effects. With well-planned and effective policy of using renewable energy sources the use of FN technology would be highly beneficial and cost-effective.

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