FACTORS GUIDING THE DEVELOPMENT OF PHOTOVOLTAICS USAGE IN CROATIA

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ABSTRACT

The PV industry is the fastest growing renewables industry in the world. However, that trend seems to bypass Croatia, the country with one of the highest average solar radiations in Europe. The reasons for the slow introduction of PVs in Croatia are multiple, and they vary from legislative barriers to financial incapability to support this rather expensive technology. In 2007 new legislature for renewables was set, including feed in tariffs for PVs. However, the support for PVs is at the moment limited to a total of 1 MWp installed capacity. This limit seems rather low compared to some countries, such as Spain and Germany, where already installed capacity is few hundred megawatts. Nevertheless, taking into account Croatian limited financial resources 1MWp limit seems to be reasonable to some extent. The new Energy Strategy sets ambitious targets for utilisation of solar energy, and for realisation of those targets some changes in legislation will have to be made. With the new legislation, and likelihood that additional changes and simplification will be made as response to requirements of EU *acquis* and new Croatian Energy Strategy, it can be concluded that the PVs and other solar applications will have brighter future under Croatian sun.

KEYWORDS

Photovoltaic energy, solar potential, policy barriers, Croatia

1. INTRODUCTION

"*Even though in 1973, only a few years after the oil shock, Croatia was at the top of the countries, which were just a step behind the USA, and were forming the "leading edge" in solar technologies - with our irrational, illogical and irresponsible development politics we have chased scientist away, we have terminated "unnecessary" research and development programs and discouraged domestic production of equipment, which has, in less than 20 years, put us at the mere bottom of Europe, side by side with Albania[1].*"

Out of all renewable energy sources (RES) in Croatia, solar energy has by far the greatest potential [2]. Most of Croatian coastal areas have 40% more sun than the Middle Europe, and up to 60% more than the Northern Europe [1] (see Figure 1). Despite of lower solar potential, countries that utilize most of the solar energy are those in northern European areas. Croatia had

an early start in solar industry and was researching and investing in photovoltaics (PVs) in 1970s [2]. At that time Croatia was in advantage before many more developed countries. Early start and great solar potential were favourable circumstances for PVs in Croatia. However, solar energy is now barely being utilised.

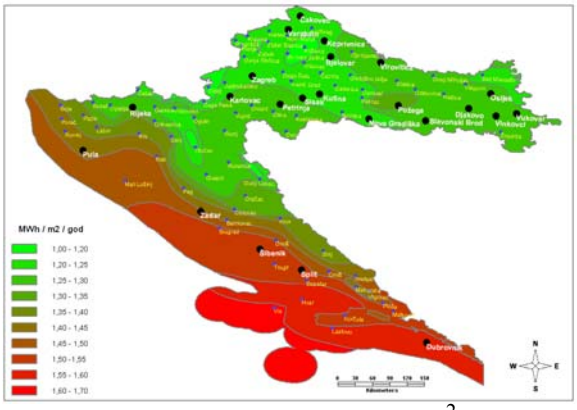

Figure 1. Average annual sums of solar irradiation on each m^2 of horizontal surface in Croatia [6]

Taking favourable circumstances into account it is impossible not to wonder why are PVs almost neglected in Croatia? Why is this great potential not being utilized, especially considering Croatia's dependence on imported energy? Do the reasons lie in the past and/or are these obstacles still present? Is the current energy policy sufficient for fulfilling the desired goals? Will there be a brighter future for Croatian PVs?

All these questions will be discussed in this paper, and current, past and future state of PVs in Croatia will be critically analyzed. The aim is to analyze why there have been so few PVs (as well as other solar applications) in use until now, to assess the current situation and to determine whether there is a basis for future increase of PVs in Croatia.

Namely, PV industry is the fastest growing energy technology in the world [3], and furthermore 2006 and 2007 were the years of a real PV boom worldwide [4]. However, this trend seems to have bypassed Croatia, the country which practically uses sun as a trade-mark. This paper will thus look into possible reasons for under-representation of PVs in Croatia, relevant energy policies and whether the future will offer better prospects.

2. CURRENT SITUATION RELATED TO PV TECHNOLOGY IN CROATIA

2.1 Croatian solar potential

When it comes to solar energy, Croatia could hardly wish for a better geographical position – coastal region of Croatia has solar radiation as the sunniest parts of Europe, Greece and southern Spain [1]. The comparison of solar radiation in Croatia and in Europe is given in Table 1. Figure 1 shows average annual sums of solar irradiation on each m^2 of horizontal surface in Croatia. Solar radiation reaches almost 2000 kWh/m^2 per year on the optimally inclined surfaces at some southern islands [5a].

Table 1. Solar radiation at horizontal surfaces for different parts of Croatia and Europe [5]

Location	Yearly average (kWh/m2day)
Croatia (southern coastal area)	5,0 – 5,2
Croatia (northern coastal area)	4,2 – 4,6

Croatia (continental area)	3,4 – 4,2
Middle Europe (Germany, France)	3,2 – 3,3
Northern Europe (The Netherlands, UK, Sweden)	2,8 – 3,0
South Europe (Greece, south of Spain)	4,4 – 5,6

2.2 Energy demand

Total primary energy production in Croatia in 2006 was equal to 208.76 PJ, while total primary energy consumption was 410.56 PJ [7]. Clearly, this indicates Croatian dependence on imported energy sources, primarily petroleum products, but also electricity import, which is increasing significantly. With constantly growing primary energy demand (average growth rate in the last five years of 2.2%), and rapid growth of energy imports (annual growth rate of 5.6%), Croatian energy self-supply is increasingly insufficient. Hence, security of energy supply is seriously endangered.

Furthermore, there is also a pressure to reduce green house gas emissions and to increase sustainability. Clean energy and preservation of environment are also crucial for tourism – Croatia's main industry. By increasing the share of RES in energy mix, Croatia would decrease its dependency on imports and simultaneously preserve its main natural assets, on which Croatia's tourism depends.

2.2 Current use of PVs and other solar applications in meeting energy demand

Even though Croatian solar potential is significant, it is still barely used for PV, or other solar, installations. Currently in Croatia PV systems are mainly used for powering road signals, telecommunication and radio diffusion systems, light house and naval buoys, distance measurement systems and similar applications. In 2006 there was 49.96 kW of installed power capacity with yearly electricity production of 49.13 MWh [8]. In addition to that, so far there has been only one grid connected PV system of 7.4 kW, and the power it produces is delivered to the Croatian Power Utility's (HEP) grid. Since 2007, new legislation is in force that regulates relations between independent power producer and utility power grid, i.e. RES producers are entitled to receive incentive price for electricity delivered to the grid. More detailed explanation of the new legislature will be given in the following Chapter 3. Considering introduction of the incentives and the multiple benefits solar energy presents – increased sustainability and decreased dependency on imports – currently installed PVs capacity seems rather insignificant.

It is also interesting to mention other solar applications, i.e. solar thermal systems or concentrated solar power plants. The neglect of solar energy in Croatia is shown also in the fact that currently there are no reliable data in Croatian energy statistics on installed thermal capacities of solar collectors. Also, some alternative techniques, such as concentrated solar thermal, are not in use at all at the moment.

2.3 Past and present experiences with the PV technology

Research and use of solar energy have had a long tradition in Croatia. They started in the early 1970s, while Croatia was still a part of former Yugoslavia. During the following decade there was a great interest in the field, especially in projects for domestic hot water heating which peaked in the 1980s [7].

During the five-year period, from 1981 to 1986, the Ruđer Bošković Institute coordinated a project under which first computer programs for solar heating calculations were developed. After this research period, researchers from the same Institute have initiated technology transfer from USA (from Chronar Ltd.) to Croatia, which resulted with founding of a PV module factory in 1987 [7]. The factory (which today operates under the name Solar Cells Ltd.) started operating in 1989 and at that time, with capacity of approximately 1 MW, was among 20 largest factories in the world [9].
Until 1991, when Solar Cells Ltd. bought the remainder of shares from Chronar Ltd., the company was jointly owned by those two founders. It is interesting to note that factory's production capacity remained the same until present. Even though the company is constantly operating since its founding, it will be necessary to modernize its production [10].
In 2000 new company, Solaris was funded. Its production started with 0.5 MWp and by 2006 reached 3.3 MWp. There are plans to further increase production capacity, so that in 2008 it would produce 20 MWp [7]. At the same time Ruđer Bošković Institute remains leading research institution in the field of experimental PVs and they continue collaboration with the company. Besides Solaris, in 2007 a new company Solvis was formed and started producing solar cells in 2008 [11].
When it comes to industry for production of complementary equipment, such as electronic converters and other mechanical and/or electronic parts, Croatia has good foundation in companies such as Končar Group and institutes such as Ruđer Bošković. Thus, if PV utilisation rate in Croatia would increase, domestic industry could benefit directly from production of PVs, as well as from production in other related industries.
PV industry in Croatia had a boom in 1970s and 1980s thanks to the great support from the government, and perhaps it could be presumed that the industry would have further developed, if it weren't for the political crisis during the 1990s (war in Croatia began in 1991). In the new circumstances, after independency, priorities were changed and investment in new expensive technologies, such as PVs, was put on a hold.
Even though at the beginning of Croatian experiences with solar technologies the government was in favour of promoting this new technology, the situation has changed. The research programs were terminated, industry growth was slowed down, and basically Croatia remained at the same level where it was in 1970s. During the period of change, the conventional energy sources became cheaper, but even more crucial were the economic, political and infrastructural changes, which were the result of several years of wartime. It also can be presumed that the solar boom was stopped mainly due to the insufficient and inadequate legislative, as well as high investment costs for PV technology. Solar energy could have played a significant role in Croatia's energy supply today, if technology was cheaper and policy was better defined.

3. PVs IN CROATIAN ENERGY POLICY

3.1 Legislative framework

During the last 10 years Croatia has developed its policy and moved from the state of nonexistent energy policy to a point where most of its legislation is aligned with the EU *acquis*.
The first post-war reforms in Croatian energy sector had started in 1997 with the introduction of National Energy Programs (NEPs). One of the NEPs was the Croatian Solar Energy Utilisation Program (SUNEN), whose aim was to research and promote usage of solar energy in Croatia. In 1998, the Energy Sector Development Strategy was designed. The part of reform that will probably be crucial for future of PVs in Croatia began in 2001, when Croatian Parliament

adopted a new legislative framework for the energy sector. The new legislative was created through the following acts (only those relevant for PVs are mentioned):

- The Energy Act
- The Electricity Market Act
- Energy Activities Regulation Act

The aforementioned laws were further amended in 2004 and in 2007 in order to incorporate the requirements of EU directives in them [11b]. Furthermore, the secondary legislation (coming from The Energy Act and The Electricity Market Act, see Figure 2) for RES was passed and became effective on July 1st, 2007.

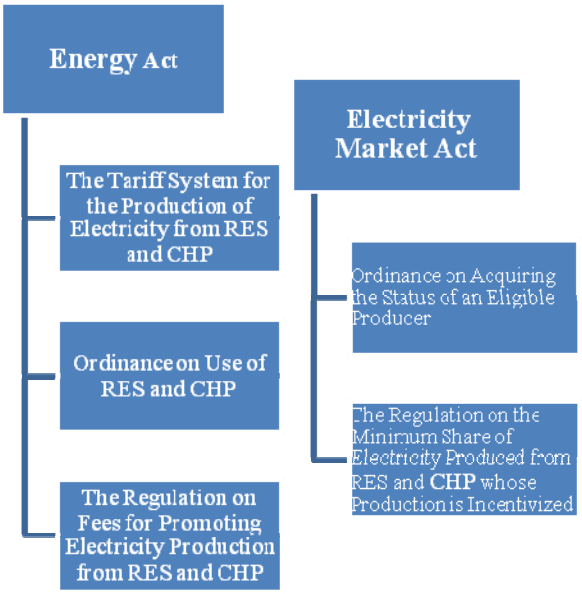

Figure 2. Croatian energy and RES legislation

The Tariff System determines the right of eligible electricity producer for the incentive prices, which the market operator pays for the electricity produced from RES and cogeneration (since irrelevant for the PVs, cogeneration will further not be mentioned) and delivered to the grid. The Tariff System determines guaranteed incentive prices. For solar electricity the incentive prices are as follows:

- Solar power plants with installed power up to and including 10 kW: 3.40 HRK/kWh (0.45 €/kWh)
- Solar power plants with installed power exceeding 10 kW and up to including 30kW: 3.00 HRK/kWh (0.39 €/kWh)
- Solar power plants with installed power exceeding 30kW: 2.10 HRK/kWh (0.27 €/kWh)

Note: The currency rate used for conversion is taken on 20th March 2009

It has to be noted that initially the correction factor for the above given tariff items was introduced in order to give higher incentives for projects that use domestic equipment and manpower. The correction factor was set in order to promote domestic production and to encourage foreign investors to cooperate with Croatian companies. Even though domestic industry still isn't fully prepared for demand coming from the RES sector, Croatia has strong electrical and mechanical industry which could play a significant role in the future RES activities.

The correction factor and existing basis in industry could have given the opportunity for revival of PV industry. However, it is almost certain that this correction factor will be abandoned as result of pressure from European Commission made within the EU accession negotiations, due to the potential distortion of market competition.
The right for incentives can be obtained, if the energy subject has been given the status of eligible producer and has a power purchase agreement with the market operator. The process of obtaining status of eligible producer is complicated and time consuming (Figure 3). This extensive and complicated process is the same for all applicants, independently of the type of RES object. Thus, even the small scale PVs to be put on household rooftops, must go through this timely process as well.

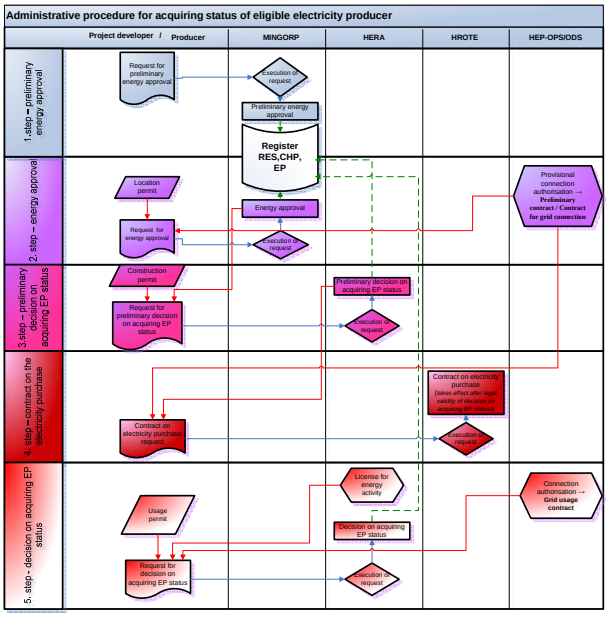

Figure 3. Procedure for obtaining status of eligible producer

The market operator will be making purchase agreements with eligible producers until the total planned electricity production from RES reaches the minimum set by the Regulation on the Minimum Share. The national target is set to 5.8% of RES electricity in total electricity consumption by 2010, excluding large-scale hydro power plants with installed power exceeding 10 MW. The Croatian RES share, excluding large-scale hydro, was approximately 1 % in 2006, while in 2007 was even less because of worse hydrological conditions and related lower electricity production from small hydro power plants as well as because of the lack of new installed RES capacities (Figure 4).

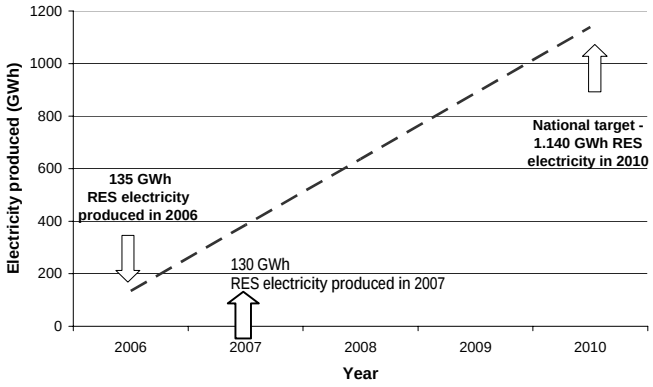

Figure 4. RES electricity production in 2006 and 2007 and national target for 2010

It is important to note that the solar facilities are considered for incentivising only up to total installed power of 1 MW [11c]. Namely, the total of 1 MW installed power in solar power plants is the limit by which the market operator will be making power purchase agreements with the eligible producers of solar electricity. Once this limit is reached, the investors in solar electricity applications will not be able to receive the incentive price for electricity they produce. This limit could be a significant barrier for the future development of PVs in Croatia.

3.2 Legal and administrative barriers for further development of PVs

"*Only in regulated conditions of clearly defined relations, defined prices in the system and the timeframe for energy purchasing and with removal of all administrative barriers could RES sector exist [11d].*"

Even though there were significant changes in Croatian legislation and the new legislation does provide better support for PVs, there were almost no changes in the amount of the installed power in PV systems since introduction of new by-laws. It seems that out of all the RES, particularly PVs are facing the greatest obstacles.

To illustrate the investor's point of view, the example of company HEP - Renewable Energy Sources Ltd will be taken. This company is a daughter company of the national utility in Croatia, founded in 2006 with the purpose of grouping and supporting RES. So far mostly due to difficulties with legislation and the 1 MW total cap for PVs, the company did not start any of solar projects and focus has been put on wind and geothermal energy, which at the moment are more profitable and easier to invest in. When it comes to PVs, the company is at the moment solely researching the options and the market. The same opinion is shared by many potentially interested small investors, who would be interested to put PVs on their rooftops, but they find the complicated process to be a big obstacle.

As aforementioned, the biggest barriers for PVs in Croatia were specific national circumstances (war), high investment costs and lack of relevant legislative, which remained the main barrier until the introduction of the Tariff System. After the introduction of the Tariff System, main barriers remaining are high costs and those of procedural/administrative nature. It is stated that

natural and legal entities have the right of obtaining the status of eligible producer, but it is still uncertain what the natural entity in this case exactly would mean. The problem occurs since natural entities cannot deliver or issue bills, and if electricity is produced and sold, bills need to be delivered to the market operator. It is also not completely clear whether it is necessary to be a craftsman[1] in order to be able to produce electricity, since according to the Law on craft [12] it is necessary to be a craftsman, if one wants to produce and sell any product, thus energy including (firstly it was suggested that only legal entities would be able to produce energy, second proposal was that it would be sufficient to have a craft business and now it is being considered that maybe a new classification would be allowed in the form of a home business).

Process of registering and licensing is dependent on multiple bodies, i.e. procedural parts from Figure 4 are in jurisdiction of different institutions: Ministry of Economy, Labour and Entrepreneurship, Ministry of Environmental Protection, Physical Planning and Construction, Croatian Energy Regulatory Agency and Market Operator. The 'one-stop-shop' for issuing all licences does not exist, not even for small applications, like PVs usually are. Unlike in countries such as i.e. Austria, where for small scale PVs the whole application can be made online, and the status is obtained in the matter of weeks, the process in Croatia is still likely to take more than a year in all cases.

The other barrier for PV boom is the 1 MW total cap. Because of the low cap potential investors are facing the risk that they will finish the project after the cap is reached although they have applied before that occurred. Thus, they would lose the opportunity to become eligible producers, and the cost-effectives of the project would be severely changed. The justification for such a small cap is in expensive technology - since Croatia as a buyer is too poor, it makes difficult to bear such a great expenditures. Additionally, the idea was to start with introduction of small PV systems (up to 10 kW) to gain experience, for which 1 MW total limit would be reasonable.

This cap was set because Croatia is far behind with utilisation of all renewables and at the same time there is a financial limitation, so firstly cheaper technologies should be invested in. PV technology on a large scale is still too expensive for Croatian budget and to collect funds for incentives, electricity prices would have to be further increased, and any further increase would not be possible at the moment. Considering the current state of practically nonexistent PV systems in Croatia, it would be reasonable to reach the 1 MW cap before questioning whether it was set too low. Croatia needs experience and the aim of new legislation was to push progress and gain experience. Government is planning to be flexible once the technology becomes cheaper and/or cap is reached. On the other hand, if the cap was set higher, bigger investors, would probably show more interest. For example, a company from Germany was interested in building a 180 MWp PV system. However, at the moment Croatia would not have sufficient funding to incentivise even one installation of this size.

[1] [1] ***Craft business*** refers to independent and permanent performance of allowed economic activities on the part of physical entities for the purpose of acquiring profit on the basis of production, commerce or provision of services in the market. Craft business may be run by a company engaged in one or more activities, provided it does not perform such activities in an industrial manner.

It seems that both domestic and foreign investors are interested in investing in RES[2], and thus would be interested in PVs if the conditions were suitable, but the question remains how to bring their interest with the demanding administration and the small cap.

3.3 Questioning the 1 MW total cap

Successful models worldwide have shown that when right policies are chosen RES markets can develop rapidly [13]. Furthermore, the RES market is developing and it is the fastest growing in the energy sector [14]. Croatia has developed its RES policy but, as aforementioned, some issues still remain to be discussed. Strategically, Croatia seems to have chosen the right policy option, which should result in increase in PVs. The policy options that have shown to be successful in Europe (Austria, Germany and Spain all have similar systems to those introduced in Croatia) are guaranteed purchase of electricity from RES and feed-in tariffs, both of which have became effective in Croatia [2]. Countries with those systems have had a remarkable success with increase of PV installed power and industry.

Figure 6 shows how PVs have had a relatively slow start Germany, but with the introduction of feed-in laws the growth became rapid. It is interesting to note that only with the first policy that Germany had introduced for promotion of PVs (1000 rooftops) Croatian limit would already have been exceeded (Figure 5). And even without thinking in terms of introducing any such program, it is easy to perceive where 1 MW stands on the 1 to 200 MW scale. As aforementioned, this kind of limitation could push away potential foreign investors and at the same time the domestic industry is not getting the reason to kick off. Further comparison can be made with Spain. Spain has a new feed-in law since June 2006, which has set the target for PV market to 371 MW by 2010 [15]. However, installed capacity for PVs in Spain has already reached 1500 MW [16]. The growth rate for PVs in Spain is so rapid that the government is considering lowering the cap to 500 MW.

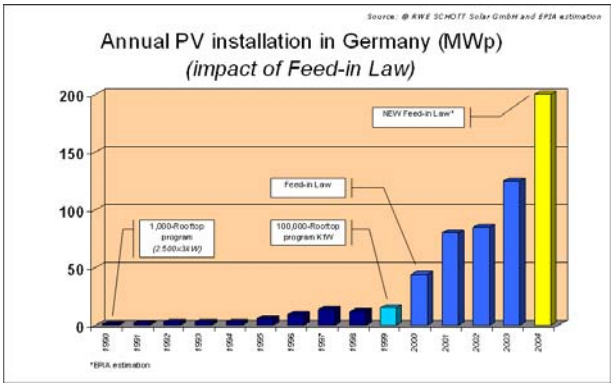

Figure 5. Impact of Feed-in laws and other policies on PV growth in Germany [7]

[2] Survey was conducted by Croatian independent business paper in 2005 with aim to determine if Croatian companies and foreign investors (Nordic) have interest tin investing in renewable energy. The survey was sent to 400 companies which participated at the conference „Nordic Days Conference 2005“ in Zagreb,, and 128 companies had replied. The results have shown that more than 50% of the companies would like to invest in RES but they don't think Croatia is investing sufficiently in renewable technology (76%). Some of other obstacles noted by survey participants were that foreign investors are facing difficulties because there is „too much politics playing in the background“ (32%) and the laws are poorly elaborated (27.9%) [7]

Never the less, again it has to be noted that Spanish and German example cannot be fully compared with Croatian because their circumstances are different. These countries are more developed than Croatia, and have bigger industry, available funding and different laws.

3.4 The role of solar energy in the new Croatian energy strategy

In October 2008, Green paper on Croatian Energy Strategy (in further text: the Strategy) was released for public consultation. The Strategy sets the following targets for the utilisation of solar energy in Croatia [5]:

- By 2020 installation of solar thermal systems should reach today's per capita installations of Germany and Greece (target: 0.225 m^2 of installed solar thermal collectors per capita);
- Installed capacity of PV systems should reach current Spain's per capita installed capacity by 2020 (target: 11.71 W per capita) and Germany's by 2030 (target: over 45 W per capita).

The timeline for target achievement is divided into three stages, and the Strategy emphasizes that in the first phase the activities should be focused on promotion of solar thermal systems, progressing later onto the PVs. First phase ends in 2010, and one its objectives is to redefine the standpoint on PVs and to expand the incentive cap over 1 MWp. The first phase should also result in removal of administrative barriers. The second phase (2010-2020) should result in achieving targets for both solar thermal and PV installed capacity. By the end of the third phase in 2030, if the initial targets were met, Strategy predicts that Croatia should be ranked as 4^{th} in Europe by the installed solar thermal capacity per capita, and should have more than 45 W per capita in installed PV capacity. The total installed PV capacity in 2020 should reach 46 MWp, and increase to impressive 252 MWp in 2030.

It seems that in case the Strategy's targets are achieved, the PVs together with other solar applications would surely play a more significant role in Croatian energy supply. Such an increase in installed capacity could prove to be fruitful ground for both, domestic industry development and for foreign investments in Croatian power supply.

4. CONCLUSION

RES have specific market position and thus significant governmental efforts are necessary for creating possibilities for introduction of new technologies such as PVs. Most of the barriers that PVs in Croatia have faced in the past are now to some extent addressed, as a result of new legislative, and in addition to that PV costs are now one tenth of what they were in 1980s, with further reductions to be expected [14]. Furthermore, not only did the policies and legislation framework change, but the companies, both domestic and foreign, show interest in investing in the technology.

The biggest barriers were costs and nonexistent relevant laws, inadequate policy and no support. Even though the new legislation is in place, there was no significant and fast increase in either PV industry or the amount of installed PV systems. The reasons to the slow progress in the PV sector are likely to be slow administrative procedure and possibly the 1 MW cap. It is hard to estimate whether 1 MW cap will prove to be an additional turn off for PV investors, or if it really is better to start in small steps. Regardless of what the result will be, the fact remains that Croatia

at the moment does not have funding to incentivise much more than 1 MW installed power in PVs at their current cost.

As abovementioned, procedure for completing all the paperwork for acquiring the status of eligible producer seems somewhat like a mission impossible, especially for households that might be interesting in putting PVs on their rooftops. Considering the fact that the PV is a fast growing industry worldwide, and that the trend still bypasses Croatia despite its solar potential, it could be concluded that the reasons for slow development of PVs lie mainly in the administrative procedure. Consultations with investors interested in PVs showed that they find the procedure too complicated and too long, and that their investments thus turn to be of questionable profitability [17].

The situation is similar for all renewables, and investors mainly agree that the procedure and the related administrative requirements are the main barriers for fast introduction of renewables in Croatian power system. Namely, since 2007 over 250 requests for RES or cogeneration plants have been recorded in the Registry of RES and CHP projects, kept by the Ministry of Economy, Labour and Entrepreneurship. However, at the beginning of 2009 there are only five eligible producers operating in Croatia and with five producers more the Market Operator has concluded power purchase agreements based on the Preliminary Decision on Acquiring the Status of Eligible Producer [18]. Unless the procedure gets simplified soon, there is a possibility that the renewable target of 5.8% electricity production from RES in 2010 will not be met, especially since, according to the latest available energy statistics, this share is currently approximately 1%.

The PVs could play important role in Croatia, both through the development of Croatian PV industry, and from the contribution PV systems could have for meeting electricity demand and simultaneously having a visible role in meeting Croatian renewable target. However, the remains of the “old system”, which are still showing in many segments (such as laws on finances, taxes or craft, weak collaboration on legal issues between institutions) need to be adjusted to the requirements of today’s legislation. Furthermore, if the PVs are to play a significant role in Croatian power system, the cap must be set to a significantly higher level than is the current 1MW. PVs will only play an important role in Croatian renewable mix if the cap is higher and the administrative procedure is simplified.

The restructuring of energy sector and the introduction of new legislation as well as new targets set by the new Energy Strategy draft should be a fruitful ground for the future development of PVs. However, that is only likely to happen once the procedure is simplified and speed-up. Nevertheless, it can be concluded that maybe it isn’t all as gloomy as it might seem. A lot of work has been done, and chances are that PVs will find their place under the Croatian sun.

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