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COST-BENEFIT COMPARISON OF ON-GRID PHOTOVOLTAIC SYSTEMS IN PANNONIAN PARTS OF CROATIA AND SERBIA

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Subject review
The paper presents detailed comparison of solar energy potentials and cost-benefit analysis of installing photovoltaic power systems in Pannonian parts of Croatia and Serbia. Feed-in tariff systems for incitement of the electricity production from on-grid photovoltaic power systems and the resulting benefits on one side and the current investment and the projected life-time operation and maintenance cost on the other side, have been compared. PVGIS – PhotoVoltaic Geographical Information System have been used for data on solar irradiation and calculation of expected electricity production from PV systems with rated power up to 10 kW, 30 kW, 300 kW and over 300 kW (according to the different feed-in tariffs in Croatia). The results indicate substantial differences in PV markets development in Croatia and Serbia and the necessity to improve feed-in tariffs and legislation in Serbia in order to make the installation of PV systems feasible.

Keywords: *cost-benefit analysis, feed-in tariff system, incentive price, on-grid photovoltaic power systems, renewable energy, solar energy potentials*

Usporedba isplativosti mrežnih fotonaponskih sustava u panonskim dijelovima Hrvatske i Srbije

Pregledni članak
Rad predstavlja detaljnu analizu potencijala sunčeve energije i analizu isplativosti instaliranja fotonaponskih sustava u Panonskim dijelovima Hrvatske i Srbije. Uspoređeni su tarifni sustavi za poticanje proizvodnje iz električne energije pomoću mrežnih fotonaponskih sustava i time rezultirajućom dobiti s jedne strane s trenutnim investicijskim i pretpostavljenim troškovima održavanja i pogona tijekom životnog vijeka s druge strane. PVGIS – PhotoVoltaic Geographical Information System korišten je za podatke o sunčevom zračenju i proračunu očekivane proizvodnje električne energije iz fotonaponskih sustava nazivne snage do 10 kW, 30 kW, 300 kW i preko 300 kW (prema različitim poticajnim tarifama u Hrvatskoj) Rezultati pokazuju značajne razlike u razvoju fotonaponskog tržišta u Hrvatskoj i Srbiji i potrebu daljnjeg poboljšanja sustava poticaja i legislative u Srbiji kako bi se instaliranje fotonaponskih sustava učinilo izvodivim.

Ključne riječi: *analiza isplativosti, mrežni fotonaponski sustavi, obnovljivi izvori energije, poticajna cijena, potencijali sunčeve energije, tarifni sustav*

1 Introduction

Photovoltaic (PV) systems are currently the fastest growing renewable energy technology in the world with average installation increase of over 58 % in the last five years, globally [1]. The demand for photovoltaics worldwide in 2008 was 5,95 GW, which represented a 110 % increase from 2007 [2, 3] thus resulting in rapid PV market development and significant decrease in investment costs of more than 50 % in 2011 worldwide [4, 5]. In order to develop the market an increasing number of countries introduced policy targets for renewables (118 in 2011), feed-in policies (92 in 2011) and/or renewable portfolio quota (71 in early 2012).

The Government of Croatia introduced policy targets and the Tariff system for the production of electricity from renewable energy sources and cogeneration in 2007 and updated the feed-in tariff system in 2012 [6, 7] according to the latest development particularly in the PV market in Croatia, limiting the annual quota for PV system installation and significantly reducing the incentives for large integrated (roof) and all-size non-integrated (ground) PV system.

The Government of the Republic of Serbia introduced the Ordinance on measures of incentives for electricity production using renewable energy sources (RES) and combined heat and power (CHP) production in 2009 [8 ÷ 13] and the update of the feed-in tariffs is to be expected in 2013.

Therefore the authors of the paper working together on the bilateral project for joint scientific and educational framework in the field of renewable energy sources in Pannonian parts of Serbia and Croatia performed the detailed analysis and comparison of solar energy potentials presented in [4] and cost-benefit analysis [14] of installing photovoltaic power systems in Pannonian parts of Croatia and Serbia. Feed-in tariff systems for incitement of the electricity production from on-grid (grid-connected) photovoltaic power systems and the resulting benefits on one side and the current investment, projected operation and maintenance (O&M) cost on the other side, have been compared. According to International Energy agency and Nuclear Energy Agency methodology for calculating levelised (projected) costs of electricity [15,16] environmental (external) cost of CO_2-equivalent is set to zero (although cumulative CO_2-neutrality of PV system in PV cell production could be challenged), while the decommissioning costs are neglected.

PhotoVoltaic Geographical Information System – PVGIS [17] has been used for data on solar irradiation, optimal inclination of the PV modules and calculation of expected electricity production from PV systems with different rated power according to the different feed-in tariffs in Croatian legislation, while Serbian feed-in tariffs are non-sensitive to the rated power of PV system being installed. The results of the cost-benefit analysis for various typical scenarios are presented further on in the paper.

2 Solar energy potential in Croatia and Serbia

During solar system design, one of the main factors is solar radiation data at specific locations. These data imply:

- information on latitude and longitude of observed point/location on the Earth's surface,
- its elevation, slope angle relative to the horizontal plane,
- orientation, location, etc.

Solar database (PVGIS) [17] is supplemented with data on the average state of atmospheric pollution and cloud cover obtained from meteorological satellites. When this database is implemented in the calculations of solar radiation, very precise data on solar radiation can be obtained for each point of the Earth's surface, taking into account even the relief and shadows. Average sum of global irradiation per square meter received by the modules of the given system is shown in Fig. 1.

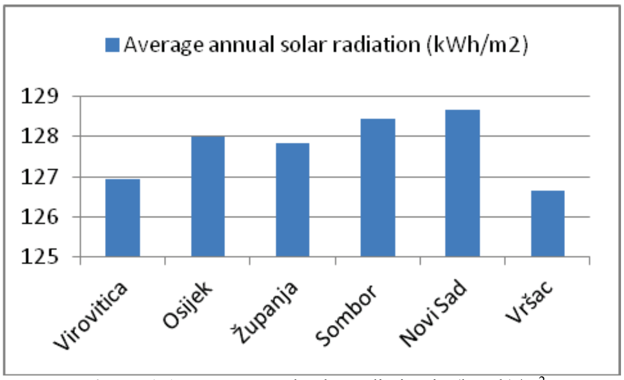

Figure 1 Average annual solar radiation in (kW·h)/m^2

The intensity of solar radiation in Croatia and in Serbia is among the most important ones in Europe. For example, the annual sum of global irradiation is from 1300 kW·h/m^2 in northern Croatia and 1400 kW·h/m^2 in northern Serbia to 1850 kW·h/m^2 in southern Croatia and 1750 kW·h/m^2 in southern Serbia. Possible annual electricity generation by 1 kW$_{peak}$ systems is from 975 kW·h/kW in northern Croatia and 1050 kW·h/kW in northern Serbia to 1375 kW·h/kW in southern Croatia and 1300 kW·h/kW in southern Serbia [4].

The potential of solar energy for the Pannonian part of Croatia and Serbia is shown in Fig. 2. It can be seen that the values of solar radiance in this area range between 1300 kW·h/m^2 and 1700 kW·h/m^2.

Solar radiation has the lowest value in northern and western parts of the Vojvodina Province, and the highest in the southern and eastern part. The other part, which makes up most of the province, has irradiance equal to the average irradiance for the province. Sombor and Vrsac are the regions with the lowest and the highest solar radiation, respectively.

In the Pannonian part of Croatia, the situation is similar to the one in Serbia. The location with highest irradiance is south-eastern part of Slavonia, and the location with the smallest irradiance is north-west part of Slavonia. According to the annual irradiation sum, the Pannonian part of Serbia as well as Croatia is divided into three regions. Three characteristic and representative cities in the Pannonian part of Serbia are chosen and these are Sombor, Novi Sad and Vrsac. In the Pannonian part of Croatia, they are the following: Virovitica, Osijek and Zupanja. Solar radiation has the lowest value in northern and western parts in both regions (Vojvodina Province and Slavonia) and the highest in the southern and eastern part.

Difference between results in previous research is due to different method of solar irradiation estimation in PVGIS system. Previous version used results of direct ground measurement and new method uses satellite images.

The technical potential of solar energy for 1 % of the land area of Croatia is estimated at 830 TW·h/a (3000 PJ/a), or around 10 times of today's primary energy consumption in Croatia, according to the Energy Development Strategy of the Republic of Croatia (Green book) [3]. Assuming that 60 % of that energy is used for thermal energy production and 40 % for electricity production [4]:

- the technical potential of thermal energy from solar collectors and passive use of solar energy (solar architecture) is 175 TW·h/a (630 PJ/a),
- the technical potential of electricity production from photovoltaic systems and solar thermal power plants amounts to around 33 TW·h/a.

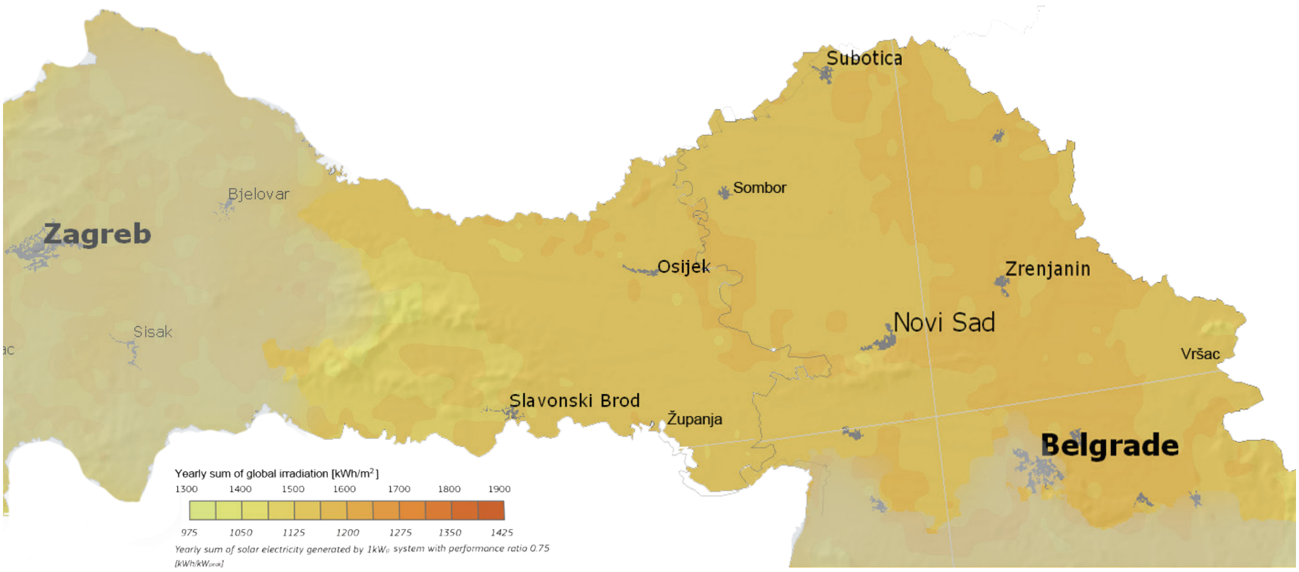

Figure 2 Solar potential in Pannonian part of Croatia and Serbia

The technical potential for the Pannonian part of Croatia can be determined for 1 % of the mainland and with previously mentioned assumptions, taking into account that all projections are given for the Republic of Croatia as a whole [4]. The total area of the Pannonian part of Croatia is 14,258 km^2. The technical potential of solar energy in this territory is 21,9 TW·h/a, with average annual solar radiation of 127,58 kW·h/m^2, and for 1 % of the territory as planned in [4] the technical potential is 219 GW·h/a. The technical potential of solar energy used for thermal energy production is 131 GW·h/a (60 %) and for electricity production it is 87,6 GW·h/a (40 %) [4].

Since the projection for Vojvodina Province is not given in the Energy Balance and the Energy Development Strategy of the Republic of Serbia in AP Vojvodina, according to the methodology of the Croatian Strategy (mentioned in the previous paragraph), the technical potential of solar energy with the average annual solar radiation of 127,92 kW·h/m^2 to 1% of the territory of Vojvodina Province (total area of 21,506 km^2) that can be used to produce 330 GW·h/a of energy from solar energy. From this amount, 60 % is attributed to the technical potential of thermal energy production, which is 198 GW·h/a, and 40 % is to be used to produce 132 GW·h/a of electricity.

4 Technical and economical evaluation of a 10 kW PV system

For the purpose of the technical evaluation of the PV project, same sizes of the system are taken with same chosen equipment. Accordingly, crystalline Silicon PV module (mono-crystal) with transformer-less inverter are taken in both cases, along with standard additional equipment: solar type copper cables, aluminium alloy mounting system for tile roof mounting, standard over-current and over-voltage protection installed in electrical cabinet of standard dimensions and IP protection and costs for project design and permits granting are evaluated for each country accordingly.

For the electricity production results from Photovoltaic Geographical Information System (PVGIS) of SOLAREC [17] project are taken. In order to evaluate the project economically feed-in tariff system for the production of electricity from renewable energy sources had to be taken into account since PV systems are mainly used to produce electricity and sell it at incentive price.

Feed-in tariffs (FITs) are more effective than alternative support schemes in promoting renewable energy technologies (RETs). Feed-In-Tariffs provide long-term financial stability for investors in RETs [18]. Feed-In-Tariffs refers to the regulatory minimum guaranteed price per kW·h that an electricity utility has to pay to a private independent producer of renewable power fed into the grid. However, the Feed-In-Tariff can also be the total amount per kW·h received by an independent producer of renewable electricity [19]. Feed-In-Tariffs might be the most appropriate and cost-effective way to support solar energy generation as an attractive alternative to mainstream energy generation systems [20]. The major benefit of Feed-In-Tariffs is that private independent producers receive a long-term, minimum guaranteed price for the electricity they generate. For this reason, Feed-In-Tariffs can provide a certain degree of financial reliability for the producers of renewable electricity, such as solar PV, to soften any future price fluctuations in the energy market. Consequently, it reduces the investment risks of renewable electricity producers and increases their willingness to invest. Although Feed-In-Tariffs have several advantages, they have some drawbacks. For example, a long-term, stable, and higher asking price will negatively affect the actual energy market. Moreover, when the Feed-In-Tariffs price is too high, the pace of renewable energy growth may exceed the goal anticipated by policymakers [21].

Table 1 Part of The Tariff System for the Production of Electricity from Renewable Energy Sources and Cogeneration regarding solar power [6]

Group	Type of the plant	The basic tariff item (C) / EUR/(kW·h)	Corrective coefficient for integrated PV (k1)	The basic tariff item correction Ck=(C×k1)	EUR/(kW·h)	Corrective coefficient for thermal system usage k2	The basic tariff item correction Ck=(C×k1×k2)	EUR/(kW·h)
1.a.1.	Solar power plants with installed capacity up to and including 10 kW	0,14	2,39	2,63	0,35	1,2	3,16	0,42
1.a.2.	Solar power plants with installed capacity exceeding 10 kW up to and including 30 kW	0,14	2,03	2,23	0,3	1,1	2,45	0,33
1.a.3.	Solar power plants with installed capacity exceeding 30 kW	0,14	1,50	1,65	0,22	1,03	1,70	0,23

Table 2 Part of The Decree on measures of incentives for the production of electricity using renewable energy sources and combined production of heat and power regarding solar power [8]

Type of power plant	Stimulating measures - purchase price / EUR/(kW·h)
Power plant on solar irradiance	0,23

Croatian government has developed The Tariff System for the Production of Electricity from Renewable Energy Sources and Cogeneration which part of it is shown in Tab. 1 [6]. Serbian government developed Decree on measures of incentives for the production of electricity using renewable energy sources and combined production of heat and power which part regarding solar power is shown in Tab. 2 [8].

All presented results should be regarded as current average data for PV usage in Croatia and Serbia which are prone to sensitivity analysis due to uncertainties related to:

- Assumed investment cost (different technology suppliers, market development and investment variation over time, variation in quality/price, etc...)

- Assumed operation and maintenance cost (possible changes in average salaries, inflation, GDP, etc...)
- Assumed discount rate (financing of "green projects" in Croatia with lower interest rate, possible changes in economic situation in the countries due to economic crisis/recovery, etc...)

For a 10 kW PV system in Osijek results of electricity production and annual income are shown in Tab. 3. The incentive price which is taken into calculation for Osijek is 0,42 EUR/(kW·h) which is the highest incentive price provided by Croatian Feed-in Tariff system for a roof installed PV system with additional solar water heating system installed on the same cadastral parcel.

For a 10 kW PV system in Novi Sad results of electricity production and annual income are shown in Tab. 4.

The incentive price which is taken into calculation for Novi Sad is 0,23 EUR/(kW·h) which is regular incentive price provided by Serbian legislative.

For a detailed economical evaluation additional information has to be taken into account. For example, operation and maintenance cost has to be predicted for each country although the activities are the same. This is necessary because economic situations in Croatia and Serbia are different and so is the average income for a specific skilled worker. Taking into account such difference evaluation of the feasibility of the project has to be performed by including information from Statistical Office of each country. So the maintenance cost for Serbia is about 50 % cheaper since this is the difference between average salary in Croatia and Serbia [7, 9]. Since the Serbian PV market is not developed as the Croatian one the prices of the investment equipment are much higher in Serbia. To have the matching equipment the same available distributor is taken for Croatia and Serbia, one which is present on both markets.

Table 3 Electricity production and annual income of a 10 kW PV System in Osijek [4]

Fixed system: inclination=34°, orientation=0° (Optimum at given orientation)						
Month	Avg. daily electricity production from the given system / kW·h	Avg. monthly electricity production from the given system / kW·h	Avg. daily sum of global irradiation per square meter / kW·h/m^2	Avg. sum of global irradiation per square meter / kW·h/m^2	Avg. monthly income for given system (EUR) Roof System	Avg. monthly income for given system (EUR) Roof System with Solar thermal
Jan	14,70	455,00	1,69	52,30	159,25	191,10
Feb	23,80	668,00	2,79	78,20	233,80	280,56
Mar	35,10	1090,00	4,27	132,00	381,50	457,80
Apr	42,60	1280,00	5,34	160,00	448,00	537,60
May	45,70	1420,00	5,90	183,00	497,00	596,40
Jun	46,40	1390,00	6,07	182,00	486,50	583,80
Jul	47,20	1460,00	6,20	192,00	511,00	613,20
Aug	45,70	1420,00	6,00	186,00	497,00	596,40
Sep	37,20	1120,00	4,74	142,00	392,00	470,40
Oct	30,30	939,00	3,74	116,00	328,65	394,38
Nov	19,20	576,00	2,26	67,80	201,60	241,92
Dec	12,10	375,00	1,39	43,00	131,25	157,50
Annual average	33,4	1 020,00	4,21	128,00	355,63	426,76
Total for year	12 200,00		1 540,00		4 267,55	5 121,06

Table 4 Electricity production and annual income of a 10 kW PV System in Novi Sad [4]

Fixed system: inclination=34°, orientation=0° (Optimum at given orientation)					
Month	Avg. daily electricity production from the given system / kW·h	Avg. monthly electricity production from the given system / kW·h	Avg. daily sum of global irradiation per square meter / kW·h/m^2	Avg. sum of global irradiation per square meter / kW·h/m^2	Avg. monthly income for given system (EUR) Roof System
Jan	14,70	455,00	1,69	52,30	104,65
Feb	23,80	668,00	2,79	78,20	153,64
Mar	35,10	1090,00	4,27	132,00	250,70
Apr	42,60	1280,00	5,34	160,00	294,40
May	45,70	1420,00	5,90	183,00	326,60
Jun	46,40	1390,00	6,07	182,00	319,70
Jul	47,20	1460,00	6,20	192,00	335,80
Aug	45,70	1420,00	6,00	186,00	326,60
Sep	37,20	1120,00	4,74	142,00	257,60
Oct	30,30	939,00	3,74	116,00	215,97
Nov	19,20	576,00	2,26	67,80	132,48
Dec	12,10	375,00	1,39	43,00	86,25
Annual average	33,4	1 020,00	4,21	128,00	233,70
Total for year	12 200,00		1 540,00		2 804,39

When all this is calculated there is still one major issue that has to be predicted in the economic model. That is the lifetime of installed equipment. Since PV modules are guaranteed to have a lifetime of 25 years they are not the issue, but the inverter, which is guaranteed for only 5 years has to be predicted for a replacement. This replacement is scheduled to be after 7 working years since the time period in the economic evaluation is 14 years.

Results of the economic evaluation and simulation for period of 14 years are given in Fig. 3.

Detailed economic indicators for a 10 kW project in Osijek are given in Tab. 5. Own interest rate is taken from the Croatian National Bank [22].

Detailed economic indicators for a 10 kW project in Novi Sad are given in Tab. 6. Own interest rate is taken from the Serbian National Bank [23].

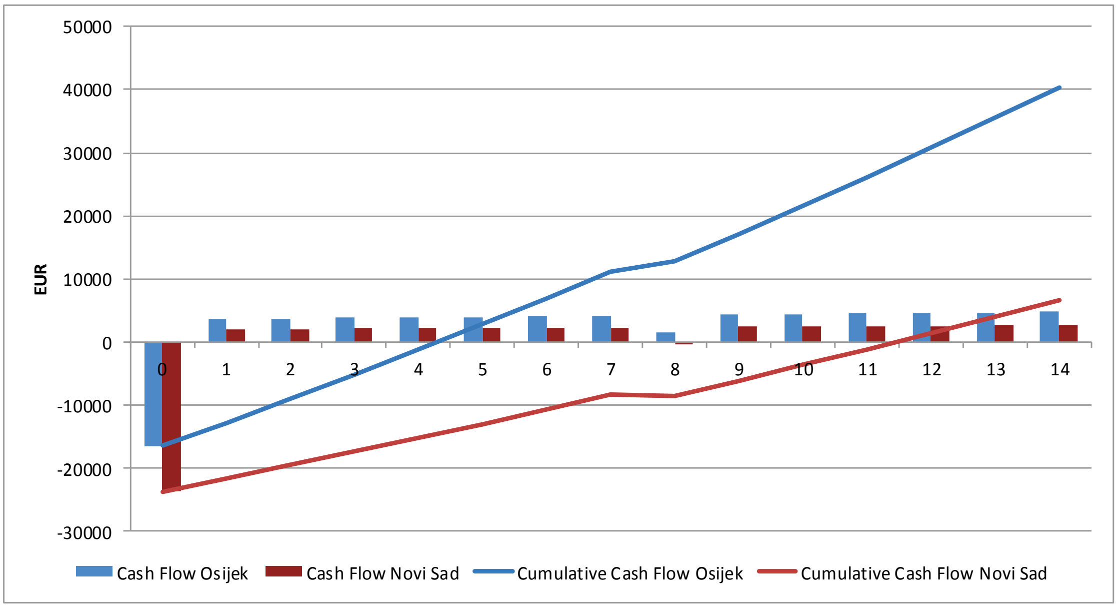

Figure 3 Economical evaluation of 10 kW PV System in Osijek and Novi Sad

Table 5 Detailed economic indicators for a 10 kW PV System in Osijek

Investment:	16 400,00 EUR
Equity:	16 400,00 EUR
Own interest rate:	8,00 %
Interest rate of Own share	0,00 %
NPV:	34 079,52 EUR
IRR Operative Income:	21,89 %
IRR Cash Flow:	20,98 %
NPV Equity	56 783,13 EUR
Difference NPV Equity - Equity:	40 383,13 EUR
Difference NPV - Investment	17 679,52 EUR

Table 6 Detailed economic indicators for a 10 kW PV System in Novi Sad

Investment:	23 458,56 EUR
Equity:	23 458,56 EUR
Own interest rate:	11,25 %
Interest rate of Own share	0,00 %
NPV:	15 668,05 EUR
IRR Operative Income:	8,73 %
IRR Cash Flow:	7,10 %
NPV Equity	30 370,10 EUR
Difference NPV Equity - Equity:	6 911,54 EUR
Difference NPV - Investment	−7 790,51 EUR

As presented in Fig. 3 initial investment in 10 kW PV system is slightly bigger in Serbia since the PV market is not fully developed so the prices are not competitive. That, along with the relatively low incentive price, makes the Serbian case on a benefit margin. Payback period for a 10 kW PV system in Novi Sad is almost 12 years. In Croatian case the PV market is more developed and the investment prices are more similar to the prices in EU countries, so the initial investment is lower. Stimulating prices in the feed-in Tariff system are creditable for significantly lower payback period which in the Osijek case is around 4 years.

The basic criteria for accepting the investment project is that a difference between NPV and investment is greater than 0. In this scenario for Novi Sad this is not the case so this investment will be rejected by that criteria since the total net income is lower than the investment itself.

4 Technical and economical evaluation of a 30 kW PV system

By contacting the same distributor in both countries, prices for the same equipment could be found, irrelevant of system size. For a 30 kW system prices of modules are slightly lower since the distributor approved discount on quantity. By applying these new values into economic model a new feasibility evaluation can be made. In the evaluation one has to take into account an incentive price drop in Croatian feed-in tariff system. New price per produced kW·h is 0,33 EUR for a system between 10 and 30 kW. Parameters of operation and maintenance are made equally as in previous case. Feasibility evaluation for a 30 kW PV system in Osijek gave results as shown in Tab. 7.

Feasibility evaluation for a 30 kW PV system in Novi Sad gave results as shown in Tab. 8.

Like in previous case, this project for Novi Sad also is not suitable for investment since its net income is lower than the investment itself.

Results of the economic evaluation and simulation for period of 14 years are given in Fig. 4.

Table 7 Detailed economic indicators for a 30 kW PV System in Osijek

Investment:	47 100,00 EUR
Equity:	47 100,00 EUR
Own interest rate:	8,00 %
Interest rate of Own share	0,00 %
NPV:	88 048,99 EUR
IRR Operative Income:	19,16 %
IRR Cash Flow:	18,22 %
NPV Equity	146 472,60 EUR
Difference NPV Equity - Equity:	99 372,60 EUR
Difference NPV - Investment	40 948,99 EUR

Table 8 Detailed economic indicators for a 30kW PV System in Novi Sad

Investment:	62 850,24 EUR
Equity:	62 850,24 EUR
Own interest rate:	11,25 %
Interest rate of Own share	0,00 %
NPV:	52 240,57 EUR
IRR Operative Income:	11,65 %
IRR Cash Flow:	10,34 %
NPV Equity	103 001,36 EUR
Difference NPV Equity - Equity:	40 151,12 EUR
Difference NPV - Investment	–10 609,67 EUR

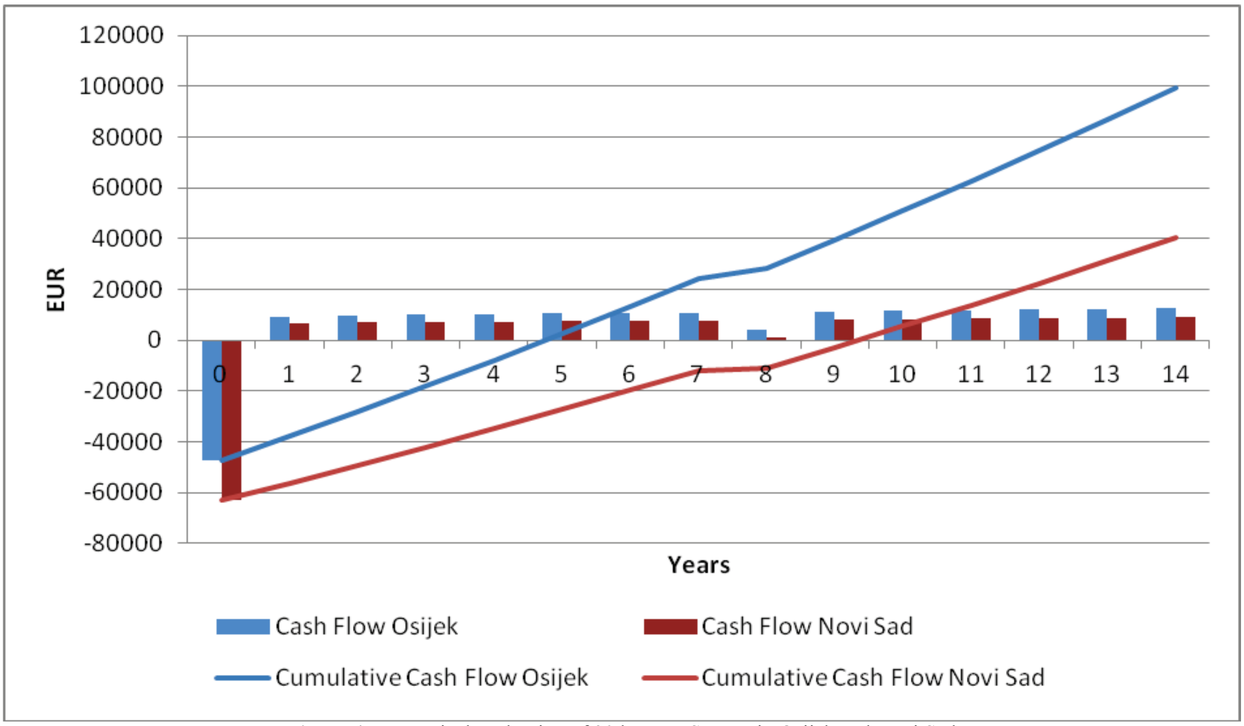

Figure 4 Economical evaluation of 30 kW PV System in Osijek and Novi Sad

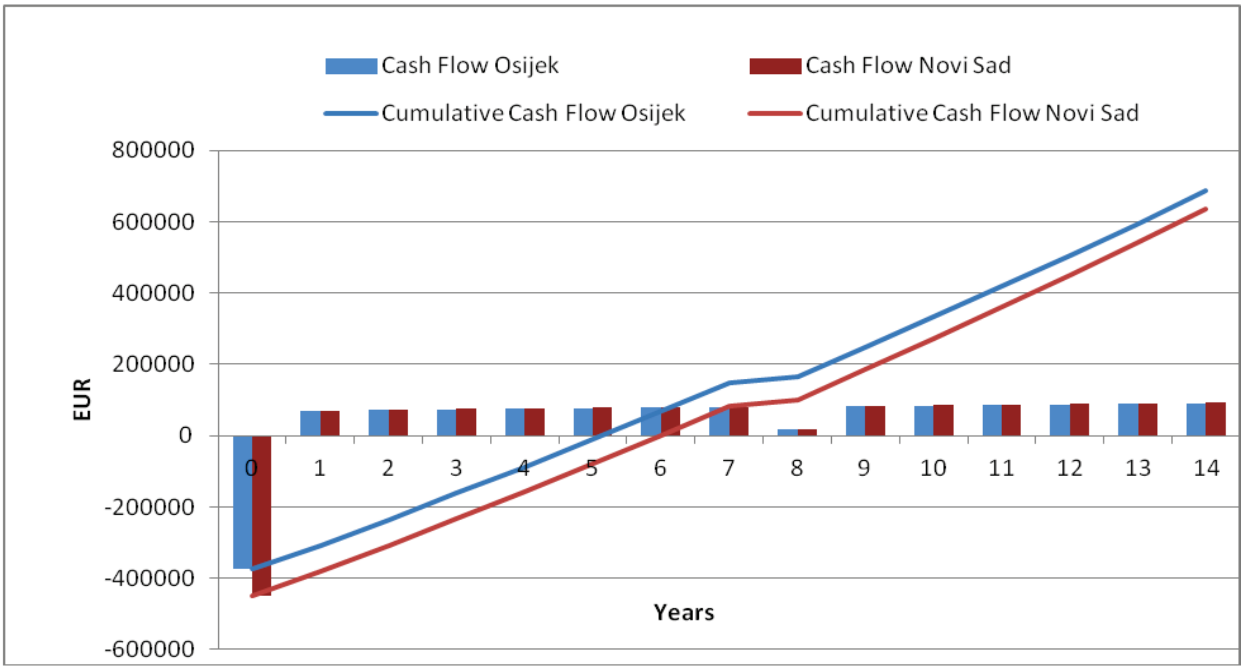

Figure 5 Economical evaluation of 300 kW PV System in Osijek and Novi Sad

As presented in Fig. 4 initial investment for a 30 kW system is still slightly bigger in Serbia since the PV market is not fully developed. Incentive price is the same irrelevant to size of a PV system, which makes two cumulative cash flow lines closer together, since in Croatian feed-in tariff system prices drop as size of PV system increases. Payback period for a 30 kW PV system in Novi Sad is almost 10 years. In Croatian case the feed-in Tariff system with still higher prices than in Novi Sad is creditable for significantly lower payback period which in this case is around 5 years.

As shown in Fig. 5 initial investment for a 300 kW system is still slightly bigger in Serbia, but the difference is quite lower in this scenario. Incentive price is still the same irrelevant to size of a PV system, which makes two cumulative cash flow lines more closer together, since in Croatian feed-in tariff system price for a 300 kW system is the same as in Serbia. Payback period for a 300 kW PV system in Novi Sad is 6 years and in Croatia the payback period is 5 years.

5 Technical and economical evaluation of a 300 kW PV system

A 300 kW PV System is a boundary case in Croatia for a roof installation since Croatian legislative allows a maximum of 300 kW to be built on a roof on a single cadastral parcel. Like in previous, 30 kW, case, distributor once again approved a significant discount on major equipment for such system. Incentive price dropped in Croatia and for a 300 kW (everything larger than 30 kW) it is 0,23 EUR/(kW·h). In Serbia, since there is no corrective factor, the price is still the same. Feasibility evaluation for a 300 kW PV system in Osijek gave results as shown in Tab. 9.

Table 9 Detailed economic indicators for a 300 kW PV System in Osijek

Investment:	375 000,00 EUR
Equity:	375 000,00 EUR
Own interest rate:	8,00 %
Interest rate of Own share	0,00 %
NPV:	646 635,11 EUR
IRR Operative Income:	17,20 %
IRR Cash Flow:	16,01 %
NPV Equity	1 062 840,00 EUR
Difference NPV Equity - Equity:	687 840,00 EUR
Difference NPV - Investment	271 635,11 EUR

Feasibility evaluation for a 300 kW PV system in Novi Sad gave results as shown in Tab. 10.

Table 10 Detailed economic indicators for a 300 kW PV System in Novi Sad

Investment:	450 000,00 EUR
Equity:	450 000,00 EUR
Own interest rate:	11,25 %
Interest rate of Own share	0,00 %
NPV:	545 969,53 EUR
IRR Operative Income:	17,67 %
IRR Cash Flow:	16,51 %
NPV Equity	1 085 424,98 EUR
Difference NPV Equity - Equity:	635 424,98 EUR
Difference NPV - Investment	95 969,53 EUR

Results of the economic evaluation and simulation for period of 14 years are given in Fig. 5.

6 Technical and economical evaluation of a 500 kW PV system

Economic model in this case shows better payback conditions for a PV system in Novi Sad. This is due to the lack of scale-factor according to rated power of PV system so the incentive price is still the same in Serbian case irrelevant of the fact that 500 kW is considered a large system.

Distributor of the PV equipment once again approved a significant discount on quantity so these new prices were taken into account for feasibility evaluation. Croatian incentive prices are now much lower since system this big can be only ground-mounted and the price according to Tariff system is 0,147 EUR/(kW·h).

Feasibility evaluation for a 500 kW PV system in Osijek gave results as shown in Tab. 11.

Table 11 Detailed economic indicators for a 500kW PV System in Osijek

Investment:	625 000,00 EUR
Equity:	625 000,00 EUR
Own interest rate:	8,00 %
Interest rate of Own share	0,00 %
NPV:	698 054,73 EUR
IRR Operative Income:	8,12 %
IRR Cash Flow:	6,31 %
NPV Equity	1 109 562,74 EUR
Difference NPV Equity - Equity:	484 562,74 EUR
Difference NPV - Investment	73 054,73 EUR

Feasibility evaluation for a 500kW PV system in Novi Sad gave results as shown in Tab. 12.

Table 12 Detailed economic indicators for a 500 kW PV System in Novi Sad

Investment:	690 000,00 EUR
Equity:	690 000,00 EUR
Own interest rate:	11,25%
Interest rate of Own share	0,00%
NPV:	911 694,68 EUR
IRR Operative Income:	17,72%
IRR Cash Flow:	16,56%
NPV Equity	1 812 712,74 EUR
Difference NPV Equity - Equity:	1 122 712,74 EUR
Difference NPV - Investment	221 694,68 EUR

Results of the economic evaluation and simulation for period of 14 years are given in Fig. 8

In this case the PV system in Novi Sad gave better feasibility result for the first time. This is because Croatian Tariff system is made to emphasize small-scale integrated PV systems and the incentive price for a ground-mounted large-scale system is quite lower.

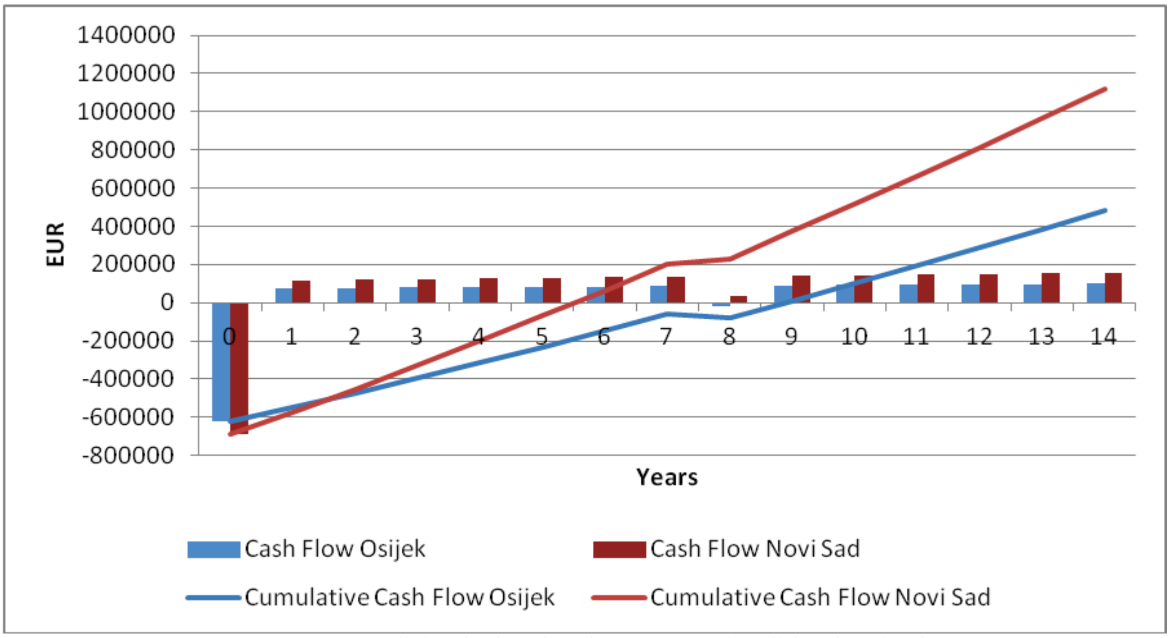

Figure 6 Economical evaluation of 500 kW PV System in Osijek and Novi Sad

7 Conclusion

Croatia and Serbia have huge potentials in using all solar technologies thanks to their geographical and climate circumstances. Both countries have incentive tariff schemes for electricity produced from PV systems but the market is much more developed in Croatia due to the higher tariffs particularly for small-scale building integrated PV systems, resulting also in lower specific investment cost.

In general, with average data used in analysis in this paper the payback period in Croatia is between 4 and 6 years (within 14-year contract) while in Serbia it is between 6 and 12 years (within 12-year contract) depending on the PV system installed power.

Meanwhile, for large scale system (over 300 kW) the payback period is shorter in Serbia (approx. 5,5 years) than in Croatia (approx. 9 years) due to non-sensitive Serbian feed-in tariffs to the rated power of PV system being installed.

Acknowledgments

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The Role of Thermal Science in Meeting Societal Challenges

Heat transfer, a major academic discipline originating from seminal studies of thermal non-equilibrium phenomena, has grown to include the science of transport phenomena for ions, electrons, and chemical species. Thus it deals with essential fundamentals such as energy, materials, food and water, and also with a range of technologies that support modern lifestyles. Heat transfer is now a vitally important field, as scientists and engineers face difficult challenges: development of cutting-edge technologies for highly efficient energy systems, massive information/ communication equipment, high-value-added manufacturing, and comfortable living environments, to name just a few. Due to its enormous scope and impact, heat transfer is often called "thermal science."

The International Heat Transfer Conference (IHTC), nicknamed the "Heat Transfer Olympic," is the world's premier conference for scientists and engineers in the heat and mass transfer research community, who convene every four year to exchange the latest information. Previous conferences have greatly enhanced mutual exchanges of knowledge and experience, and nurtured new and/or interdisciplinary research areas. Future conferences should realize an increasingly important mission: to foster international cooperation and facilitate the exchange of ideas among colleagues in order to solve urgent problems and improve peoples' lives in the years ahead.

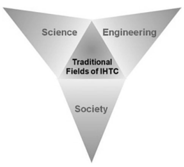
To pursue these aims, we invite forward-looking scientists, engineers, and researchers from all over the world to attend the Fifteenth International Heat Transfer Conference (IHTC-15) in Kyoto, Japan, August 10 to 15, 2014. In addition to exploring traditional research areas, IHTC-15 asks an important question so that we may better serve society: "What is the role of thermal science in meeting societal challenges?" Clearly, we face major issues such as ensuring sustainable development, healthy ageing, sufficient food for all, and economic growth, and we need to develop scientific and technological solutions. To do this, we should shape our current and future roles more concretely, and start to formulate an interdisciplinary framework for collaboration among colleagues active across a wider range of physical, life, and information sciences.

IHTC-15 will provide participants with unique opportunities for exchanging new knowledge, and facilitate intensive discussions throughout the conference period. We hope that IHTC-15 becomes a model for future IHTCs, and magnifies the scope of contributions made by the international community of thermal science professionals for the benefit and welfare of people everywhere.

History of IHTC

1	1951	London Atlantic City	United Kingdom United States
2	1961 1962	Boulder London	United States United Kingdom
3	1966	Chicago	United States
4	1970	Paris Versailles	France
5	1974	Tokyo	Japan
6	1978	Toronto	Canada
7	1982	München	Germany
8	1986	San Francisco	United States
9	1990	Jerusalem	Israel
10	1994	Brighton	United Kingdom
11	1998	Kyongju	Korea
12	2002	Grenoble	France
13	2006	Sydney	Australia
14	2010	Washington	United States
15	**2014**	**Kyoto**	**Japan**
16	2018	Beijing	China

Keywords of IHTC-15



In addition to the traditional keywords employed in the previous IHTCs, their extensions to deeper and wider relevance to science, engineering and society will be highly desired; essential keywords required to pioneer a new field for human society will be welcome.

Paper Submission

Abstracts for possible paper presentation at IHTC-15 should be submitted on-line at the IHTC-15 web page. They will be reviewed in two steps at the initiative of regional International Scientific Committee (ISC) members. Once an abstract has been accepted, the full-length manuscript will be requested by the due date. It is then reviewed by reviewers assigned by the regional ISC members. The copyright transfer form is requested to fill out upon acceptance of the full-length manuscript and prior to submittal of the final manuscript. For each accepted manuscript, at least one paid registrant is required to ensure that the manuscript appears properly in the conference proceedings. The accepted and presented manuscript will be archived in the newly established IHTC Digital Library after the conference.

Important Dates (tentative)

Abstract submission: August 31, 2013
Notification to abstract acceptance: September, 2013
Full paper submission: November, 2013
Notification to full paper acceptance: April, 2014
Submission of the final manuscript: May, 2014

Special Features of IHTC-15

1. Oral presentations only
All contributed papers are to be presented in parallel oral sessions.

2. IHTC Digital Library (IDL)
The AIHTC and Begell House have agreed to establish the IHTC Digital Library (IDL). The IDL is an online archival library featured with interactive web interface and advanced search engine for the use of active researchers and engineers. It will be composed of the past and future Proceedings of the International Heat Transfer Conferences under the auspices of the AIHTC Thus, all papers presented will be uploaded and included in the IDL after IHTC-15.

3. Awards
Following memorial awards/medals are to bestowed and memorial lectures will be presented
The William Begell Medal
The Max Jakob Memorial Award
The Luikov Medal
The Nukiyama Memorial Award

4. Kyoto in Midsummer

Do not miss a special traditional event, Gozan (Five Mountains) Fire Festival, starting at 8 pm on 16 August

immediately after

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