JET Journal of Energy Technology

JET Volume 9 (2016) p.p. 39-51
Issue 3, October 2016
Typology of article 1.04
www.fe.um.si/en/jet.html

AN OVERVIEW OF REGULATIONS REGARDING PHOTOVOLTAIC SYSTEMS IN SLOVENIA

PREGLED FOTOVOLTAIČNIH SISTEMOV V SLOVENIJI NA PODLAGI NACIONALNIH PREDPISOV

Franc Rihl[R]

Keywords: photovoltaic systems, subsidized prices, feed-in tariff and operative support, LCOE, net metering

Abstract

As a member of the EU, Slovenia has followed European trends encouraging the growth of renewable energy sources and, consequently, photovoltaic systems. Based on the Energy Law and several acts, two kinds of support schemes for PV systems were implemented.

This paper focuses on an overview of this support schemes for the electricity produced, their impact on the spread of production, and analyses the transition to net metering for PV systems in Slovenia.

Povzetek

Slovenija je kot članica Evropske Unije sledila evropskim trendom za spodbujanje rasti obnovljivih virov energije, med njih tudi spada spodbujanje in razvoj fotovoltaičnih sistemov. Na podlagi Energetskega zakona in sprejetih uredb se je v Sloveniji implementiralo dve vrsti finančnih podpor.

Članek se osredotoča na pregled finančnih podpor, njihov vpliv na širjenje PV sistemov in analizo prehoda na neto merjenje električne energije v Sloveniji.

[R] Corresponding author: Franc Rihl, University of Maribor, Energy Conversion Laboratory, Hočevarjev trg 1, SI-8720 Krško, Tel.: +386 40 792 479, E-mail address: franc.rihl1@um.si

1 INTRODUCTION

Photovoltaics is a young scientific discipline, and a younger industry, which is already proving to be a significant contribution to the sustainable supply of electricity, the operation of which does not burden the environment. Photovoltaics is developing into a comprehensive, sustainable, and innovative economic sector, which also offers an excellent opportunity to develop and run advanced RES technologies in Slovenia.

Support schemes were implemented as a result of the sufficient spread of this technology in Slovenia. The main reasons for implementation were high production costs and low electricity prices on the market. Under the schemes, the resulting differences are regulated, so the technology can have a chance to compete with conventional production sources. In 2009, the first national regulation describing support schemes for RES in Slovenia was published. Before that, over 70 PV systems had already been connected to the grid in Slovenia. The values of schemes have been changing recently due to market conditions. In 2016, due to current stagnation, Slovenia introduced a net metering policy, which should result in fostering RES and PV systems.

This article presents the transition from support schemes to net metering for PV systems in Slovenia.

2 NATIONAL REGULATIONS, SUPPORT SCHEMES

In Slovenia, electricity production was supported via two basic supports. According to Article 372 of the Energy Act (EZ-1), support is provided in case the costs of electricity production from RES, including normal market return on invested assets, exceeds the electricity price that can be obtained on the electricity market, *[1]*.

Two types of support were introduced:

- Feed-in tariff – guaranteed purchase of produced and supplied electricity into the public grid electricity at a price set by the government;
- Operational support – support for the real-time operation of the system, *[1]*.

Borzen is a Slovenian electricity market operator. Its principal activity is the implementation of public service obligations relating to the organization of the electricity market, which includes both the organization of the electricity market and the activities of the Centre for RES/CHP Support. The centre administers the electricity feed-in support scheme for RES (renewable energy source) and CHP (high-efficiency cogeneration) power plants, *[2]*.

2.2 Feed-in tariff

In the case of the guaranteed purchase, the Centre for Support assumes the produced electricity from renewable power plants for the price determined in accordance with the decision granting assistance issued by the Energy Agency. Therefore, it is not possible to sell this electricity on the market, and a commercial contract for the sale of this electricity may not be concluded. The renewable power plant is placed in a special balancing group or sub-group established by the Centre for Support (Eco-balance group). The centre regulates the balance of the differences

between the forecasted and realized production (i.e. cover deviations) and pays electricity that is produced and delivered into the public network, *[3]*.

For the feed-in tariff, renewable power plants with installed capacities of less than 1 MW are eligible. All producers of renewable energy are usually deemed to have the declaration as long as they use any of the listed RES technologies. The period of eligibility for this support is no more than 15 years, *[3]*.

2.2 Operational support

The producers of renewable energy may decide to directly sell produced electricity on the electricity market, in this case, they are eligible for so-called "Operational support". The Centre for Support will not assume or pay for the produced electricity but only disburse operational support.

The support is intended to replace the difference between the production costs of the renewable power plant and the electricity price on the open market. The suppliers for purchasing electricity produced from renewable energy sources in Slovenia are the following:

- E 3, energetika, ekologija, ekonomija d. o. o.,
- ECE d. o. o.,
- Elektro energija d. o. o.,
- Energija plus d. o. o.,
- GEN-I d. o. o.,
- HSE d. o. o.,
- Petrol d. d.and
- Termoelektrarna Toplarna Ljubljana, [4].

Renewable power plants with installed capacities of less than 125 MW are eligible for operational support. The age of the plant should not exceed 15 years. If a power plant entered the support scheme when it was already in operation, then the duration of the support is reduced by the previous operational time of this power plant, *[1]*, *[3]*.

2.3 The relation between reference costs and subsidized prices for PV systems

The reference costs are the basis for determining the prices for feed-in tariff and operational support in contracts for the provision of support. Slovenia has divided the power plants into three categories:

- up to 50 kWp,
- from 50 kWp to 1 MWp, and
- 1 MWp from up to 10 MWp, *[4]*.

Purchase prices for feed-in tariffs are identical to the reference cost for renewable power plants, and they consist of two parts:

- The fixed part, which is equal to the fixed part of reference costs and does not change throughout the duration of the contract;
- The variable part, which is equal to the variable part of the reference cost, if it is defined. This part is annually or more frequently set according to the published reference price of the fuel used, *[4].*

For renewable power plants for which the variable part of the feed-in tariff is not defined or depends on the amount of electricity produced, just the fixed part should be indicated; the variable part should be ignored, *[4]*. PV systems are an example of this.

Operational support is determined with Equation 2.1, which consists of reference costs minus the reference price of electricity multiplied by factor B, *[4]*.

$$OS = RC - MP \cdot factor\ B \tag{2.1}$$

The reference price of electricity is expected to be the market price of electricity from the Energy Agency's forecast reference market prices of electricity. Factor B reflects the operating characteristics of individual types of renewable power plants, and thereby the quality of the electricity produced, which affects the achieved price of electricity from these production facilities on the electricity market, *[4].*

Reference costs were determined in relation to the competitiveness of electricity production from renewable power plants and their competitiveness on the electricity market, such as production spread, production costs, and efficiency.

Supports have affected the growth in demand and the decrease in production costs for RES systems, especially PV systems, which has led to the reference cost reduction and, consequently, to the downturn of supports. The first announcement of the reference costs reduction for PV systems was made in 2009. In Table 1, the reference cost reductions for PV systems between 2009 and 2014 are shown. The same data are also shown in Figure 1.

Table 1: *Reference cost reductions for PV systems between 2009 and 2014, [4], [5], [6], [7]*

Announced year	Starting year	Reference costs reduction [%]	Regulation
2009	2010	7	Official Gazette of the Republic of Slovenia Act Nr. 37/2009
	2011	14	
	2012	21	
	2013	28	
2010	2011	20	Official Journal of the Republic of Slovenia Act Nr. 94/2009
	2012	30	
	2013	40	
2011	1. 1. 2012 - 30. 6. 2012	30	Official Journal of the Republic of Slovenia Act Nr. 105/2011
	1. 7. 2012 - 31. 12. 2012	40	
2012	1. December 2012	2 (each first of the month)	Official Journal of the Republic of Slovenia Act Nr. 90/2012

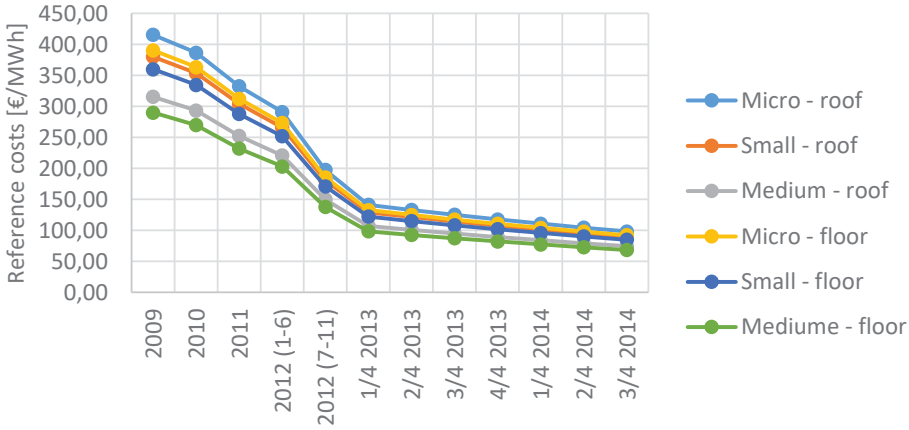

Figure 1: *Reference costs for PV systems in Slovenia,* [3]

3 SPREAD OF PV SYSTEMS REGARDING SUBSIDIZED PRICES

Despite the fact that the first supports were paid in 2009, 73 PV power plants were already operating in Slovenia. From Figure 2, we can observe that the first payoff of supports led to a steep increase in PV power plant construction. This mainly happened because reference costs were at their peak value that year, and the relation between them and production costs was extremely high; this presented a business opportunity. The spread of PV systems continued until 2012, when the yearly installed capacity was at peak value. After that it began to decline, *[8]*. The main reason for this decline was the adoption of regulations that contained the reference costs reduction (Table 1).

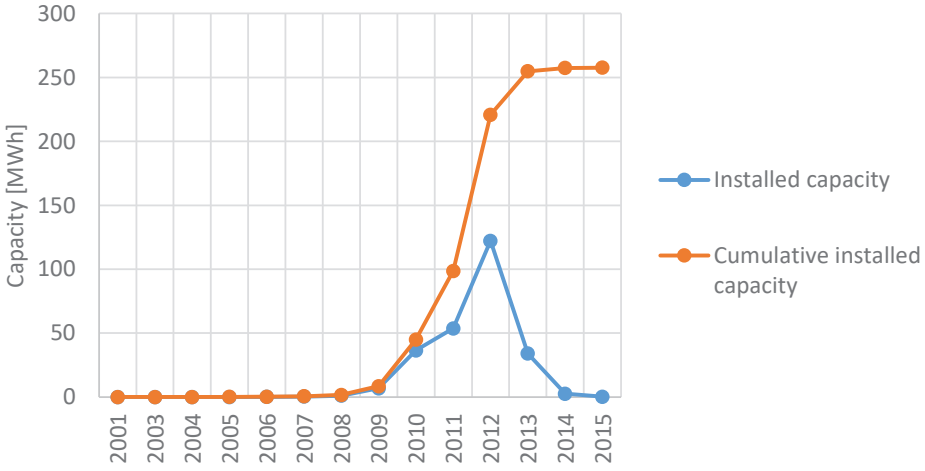

Figure 2: *Installed and cumulative installed capacity of PV systems in Slovenia, [8]*

In 2015, 3,367 PV power plants with a total installed capacity of just over 250 MW were in operation. Small PV power plants dominated with a share of over 83%, which can be seen from Table 2, *[8].*

Table 2: *Number of installed PV systems by categories for 2015, [8]*

Category	Micro	Small	Medium	Total
Number of PV systems	2798	569	0	3367
Percentage share	83.10	16.90	0	100

As shown in Figure 2, photovoltaics in Slovenia is nearly in stagnation, as support schemes are at their lowest value, or they are not in use anymore because of low production costs and electricity price on the electricity market. This depends on the RES used.

Perhaps the proper solution for this stagnation phase is properly set net metering regulation. With this, the re-growth of PV systems can be achieved.

4 NET METERING

Net metering (or net energy metering (NEM)) allows consumers that generate some or all of their own electricity to use that electricity anytime, instead of when it is generated. This is particularly important for wind and solar energy production, which are non-dispatchable. Net metering policies can vary significantly by country and by state or province. Most net metering laws involve monthly or annual roll over of kWh credits, a small connection fee, require payment of deficits (i.e. normal electric bill), and settlement of any residual credit. Thus, a net metering policy involves the electrical grid being used as a type of virtual accumulation pool, which is used for storing the generated electricity. Unlike a feed-in tariff, which requires two meters, net metering uses a single, bi-directional meter and can measure the current flowing in two directions. Net metering can be implemented solely as an accounting procedure, and requires no special metering, or even any prior arrangement or notification. Net metering is an enabling policy designed to foster private investment in renewable energy, *[9].*

Net metering usually becomes effective when electricity prices on the market are higher than the production costs of electricity from solar energy. For that reason, the movement of electricity prices on the market must be known, and the production cost of electricity produced by a power plant must be evaluated. To do this properly, the "Levelized Cost of Energy" (LCOE), which is one of the utility industry's primary metrics for the cost of electricity produced by a generator, is calculated.

4.1 LCOE

The LCOE is the price at which electricity must be generated from a specific source to break even over the lifetime of the project. It is an economic assessment of the cost of the energy-generating system, including all the costs over its lifetime: initial investment, operations, and maintenance, the cost of fuel, and the cost of capital. It can be calculated with a single formula. There are many different formulas for calculating LCOE, and one of them is shown in Equation 4.1, *[10].*

$$LCOE = \frac{\sum_{t=1}^{n} \frac{I_t + M_t + F_t}{(1+r)^t}}{\sum_{t=1}^{n} \frac{E_t}{(1+r)^t}} \tag{4.1}$$

where I_t are investment expenditures in year t, M_t are the operations and maintenance expenditures in year t, F_t are fuel expenditures in year t (zero for PV systems), E_t is electricity generation in year t, r is discount rate, and n is investment period considered in years.

It is an economic assessment of the cost of the energy-generating system including all costs over its lifetime:

- initial investment,
- operations and maintenance,
- cost of fuel,
- cost of capital, *[14].*

Typically, LCOE is calculated over 20 to 40 years of the project's lifetime. It is given in the units of currency per kilowatt-hour (€/kWh).

The biggest impact on the calculation of LCOE for PV systems are from the investment costs. Operating and maintenance costs are much lower in comparison to investment costs; fuel costs practically do not exist. This means that the LCOE depends essentially on the investment costs, which are mostly the costs of purchasing solar modules.

The PV industry has experienced a compound annual growth rate of over 50% over the last 10 years, accompanied by a four-fold reduction of costs. This is directly linked to solar module prices which are shown in Figure 3. It is noteworthy that prices have practically halved in the last five years. The price decrease has influenced high demand and enlarging the production capability of solar modules in various markets, which resulted in increased competitiveness, *[8]*, *[13]*.

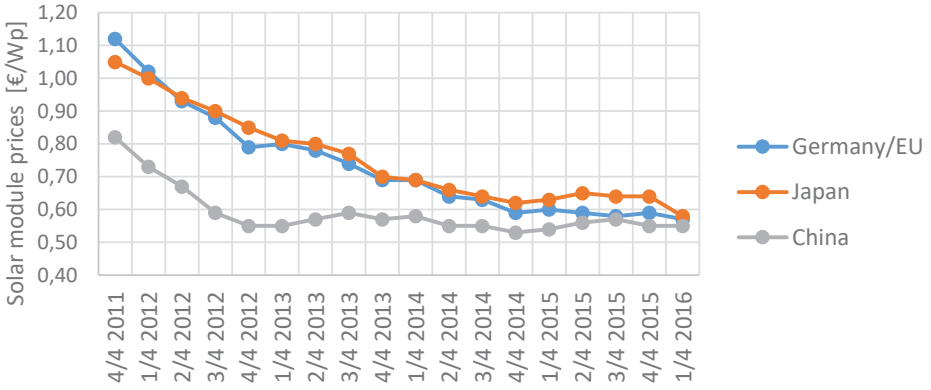

Figure 3: *Average net prices for crystalline modules, [13]*

JRC has produced a series of PV electricity price maps, which combine a standard model for the leveled cost of electricity (LCOE) with the geographically dependent PV performance data from its PVGIS software system *[3, 4]*. The calculated LCOE values are then compared with the retail electricity prices in the Member States, of which Slovenia is one, *[10].* Table 3 summarizes the parameter values used in 2012, 2013 and 2014 for LCOE calculations.

Table 3: *Parameter values used in the LCOE calculation, [10]*

Parameter	**Values**		
	2012	**2013**	**2014**
I_t	2300	1700	1400
r	5%	5%	5%
n	20	20	20
M_t	1%	1%	1%
E_t	From JRC's PV-GIS on-line tool	From JRC's PV-GIS on-line tool	From JRC's PV-GIS on-line tool

According to the calculated LCOE data from 2013, Slovenia has already reached grid parity. This is shown in Figure 5.

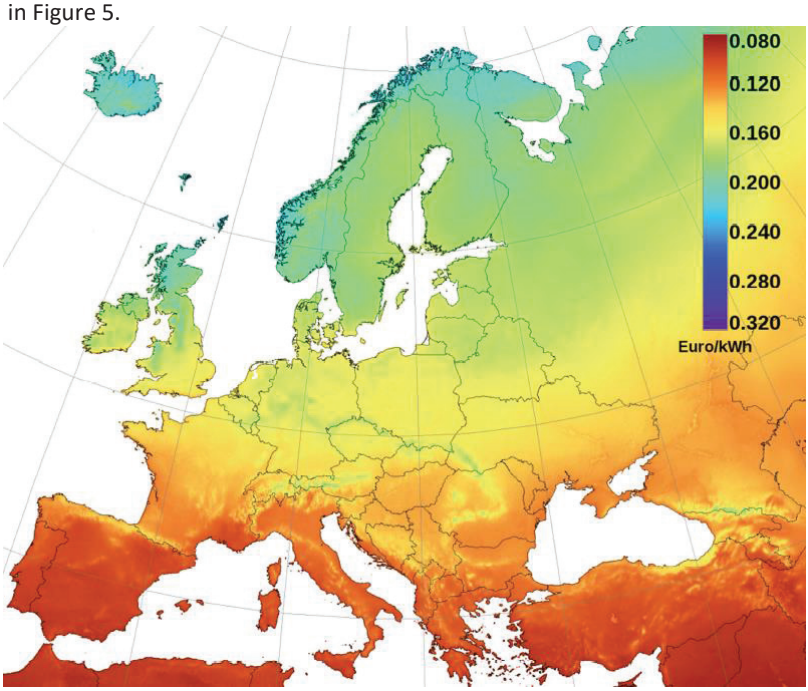

Figure 4: *Distribution of the leveled cost of PV electricity in Europe for 2013, [10]*

4.2 Electricity market prices

As already stated, the prices of electricity have a key role in achieving the proper environment for the successful integration of net metering; they must be below the calculated LCOE.

Electricity market prices in Slovenia have been practically constant over the previous seven years, which can be observed from Figure 4. The increase in prices was just a few percentage points, so it can be concluded that electricity prices in the future will not affect the net metering, as much as the prices of solar modules will.

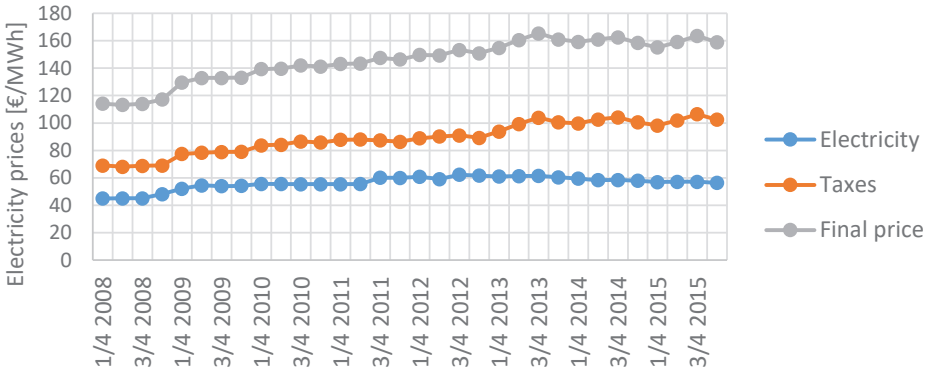

Figure 5: *Average electricity prices for households,* [12]

4.3 The net metering regulation in Slovenia

In January 2016, net metering regulation was adopted for the electricity produced from RES. The regulation sets out the conditions for self-sufficiency, the accounting method, the annual limit of renewable power plants, the way of reporting on the measures implementation and the method for calculating the electricity produced from renewable power plants, *[14], [15].* The conditions under which devices are eligible for net metering regulation are the same as they were in the feed-in tariff and operational support with one exception: net metering uses a single, bi-directional meter for measuring the power.

The maximum installed capacity for power plants is 11 kVA; it means that apparent power has to be considered in planning, so active and reactive power also have to be taken into consideration. For the calculation of the electricity consumption, the difference between the used and produced active power in a given billing period (normally the current calendar year) is taken into account. If a power plant has a positive balance at the end of the period, then the difference is transferred free of charge to the ownership of the power supplier. Otherwise, when the electricity consumed is greater than that produced, the difference is accounted at current electricity prices on the market. Therefore, the best option is to plan the size of the renewable power plant as close to the predicted household electricity consumption or just a little lower, in addition to not having any costs with the free transferring of extra produced electricity to the power supplier.

The maximum total rated power of connected devices for self-sufficiency to the grid in the calendar year is 7 MVA for households and 3 MVA for SMEs. The amount of the network charges for using the electrical network is determined when signing the contract with the selected system operators. The user of the net metering device must pay to the system operator for the following items for the usage of the electrical network on a monthly basis:

- Network charge,
- The contribution of RES and CHP, *[14]*, *[15].*

For the implementation of the net metering in Slovenia, the following distribution system operators are eligible:

- Elektro Ljubljana,
- Elektro Maribor,
- Elektro Gorenjska,
- Elektro Primorska, and
- Elektro Celje, [3].

5 CONCLUSION

Slovenia has followed European trends for encouraging the spread of RES and especially PV systems by introducing financial support schemes. In the beginning, supports were extremely high due to high production costs from RES in comparison to conventional sources. These grants were quickly utilized, which has led to the great annual growth of PV systems as shown in Figure 2.

Decreasing solar module prices on the global market, due to the massive enlargement of demand and consequently, production facilities, resulted in a decrease of supports. The decrease was happening until production costs from renewable power plants became level with the price of electricity on the market. This meant that the withdrawal of supports slowed the spread of PV systems and that a new way had to be found to again encourage the spread of such systems. The adopted net metering regulation was found to be a good solution for this matter.

According to the content of the adopted regulation, restriction of the size and the annual number of connected PV systems, we cannot expect a major change in the spread of such systems in Slovenia. The ratio between the price of electricity and the production cost is still too low to expect that the regulation would drastically affect the spread of PV systems.

One disadvantage is that fees for using the electrical network as an “accumulation pool” are not clearly set; consequently, distribution system operators are at least partially adversely affected. In contrast, electric utilities are required to buy produced power, even though it generally would cost them less to produce the electricity themselves or to buy the power on the wholesale market from other electricity providers, *[16].*

In the end, we can say that this regulation is set without taking into account the knowledge of electrical providers and operators of PV systems. Furthermore, the maximum total rated power of connected devices for self-sufficiency to the grid in the calendar year is too limited in regards to what potential owners of PV systems could contribute in the field of RES.

References

[1] **Government of the Republic of Slovenia:** *Official Journal of the Republic of Slovenia, Act Nr. 17/2014,* Energy Act – Slovenia, Ljubljana 2014

[2] **F. Pranjić**: *Review of energy regulations on solar energy (pv) in Slovenia and Austria*, JET volume 7, 2014

[3] Borzen, organizator trga z električno energijo, d.o.o.

[4] **Government of the Republic of Slovenia:** *Official Journal of the Republic of Slovenia Act Nr. 37-2009*, Ljubljana 2009

[5] **Government of the Republic of Slovenia:** *Official Journal of the Republic of Slovenia Act Nr. 94/2010,* Ljubljana 2010

[6] **Government of the Republic of Slovenia:** *Official Journal of the Republic of Slovenia Act Nr. 105/2011,* Ljubljana 2011

[7] **Government of the Republic of Slovenia:** *Official Journal of the Republic of Slovenia Act Nr. 90/2012,* Government of the Republic of Slovenia, Ljubljana 2012

[8] **UL FE, LPVO:** *PV portal, Slovenski portal za fotovoltaiko* [online]. Available: http://pv.fe.uni-lj.si/Welcome.aspx (10. 8. 2016)

[9] **Wikipedia:** *Net metering*, The Free Encyclopedia [online]. Available at: https: // en.wikipedia.org/wiki/Net_metering (15. 8. 2016)

[10] **H. Ossenbrink, T. Huld, A. Jäger Waldau, N. Taylor**: *Photovoltaic Electricity Cost Maps*, Annual Report 2013, Joint Research Centre (JRC), 2013

[11] **Wikipedia:** *Capital recovery factor*, The Free Encyclopedia [online]. Available: https://en.wikipedia.org/w/index.php?title=Levelised_energy_cost&oldid=365220846 (15. 8. 2016)

[12] **Ministry of Infrastructure, Government of the Republic of Slovenia, The Energy Directorate:** *Electricity prices* [online]. Available at: http://www.energetika-portal.si/statistika/statisticna-podrocja/elektricna-energija-cene/ (30. 7. 2016)

[13] **Pv magazine:** *pvXchange module price index* [online]. Available: http://www.pv-magazine.com/investors/module-price-index/#axzz49Jp3NaVt (20. 8. 2016)

[14] **Public Hearing Notice:** *Net metering regulation for RES* [online]. Available: http://www.enerson.si/scripts/download.php?file=/data/upload/Predlog_uredbe_ samooskrba_z_EE_jun_2015.pdf (18. 8. 2016)

[15] **Government of the Republic of Slovenia:** *Official Journal of the Republic of Slovenia Act Nr. 97/2015*, Ljubljana 2015

[16] **Edison Electric Institute (EEI):** *Solar Energy and Net metering* [online]. Available: http://www.eei.org/issuesandpolicy/generation/NetMetering/Documents/Straight%20Talk%20About%20Net%20Metering.pdf (22. 8. 2016)

Nomenclature

(Symbols)	(Symbol meaning)
PV	Photovoltaic
RES	Renewable Energy Sources
OS	Operational support
RC	Reference costs
MP	The reference price of electricity
LCOE	Levelized Cost of Energy
I_t	Investment expenditures in year t
M_t	Operations and maintenance expenditures in year t
F_t	Fuel expenditures in year t, which is zero for photovoltaic electricity
E_t	Electricity generation in the year t
r	Discount rate
n	Investment period considered in years
r	discount rate (cost of capital)
CHP	Combined Heat and Power