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POTENTIAL OF FEED-IN TARIFF IMPLEMENTATION FOR RESIDENTIAL INTEGRATED PHOTOVOLTAICS-GRID CONNECTED IN INDONESIA'S RESIDENTIAL SECTOR

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ABSTRACT

Grid connected renewable energy technology for urban households, particularly photovoltaics modules, has been utilized increasingly significant in some countries through Feed-in tariff mechanism in a larger sense that the photovoltaics modules are served as centralized power generation. The potential of conducting building integrated photovoltaics-grid connected scheme through Feed-in tariff, which is focused in urban residential sector, is presented in this work. Urban residential of Indonesia along with other relevant data has been selected in the deliberation and analysis as it is provided a common picture of developing countries, where the energy policy and relevant regulation still rely on the subsidy. This work therefore intended to present technical and economical opportunities derived from implementing residential integrated photovoltaics-grid connected scheme in Indonesia's urban household sector.

Key words: photovoltaic, techno-economic, urban households, grid connected

1. INTRODUCTION

Utilization of solar power through photovoltaics modules has became significantly increasing over the decades. The environmental protection issue besides its well developed technology has made the utilization of photovoltaic a viable alternatives to meet electricity demand. Solar photovoltaics is starting to play a substantial role in electricity generation in some countries, especially in European countries. Nevertheless, some leading and emerging market in Asia have taken the same path with that in Europe in terms of the role of photovoltaics as large power generation plant. Solar photovoltaics global capacity has increased quite significantly from only 0.6 GW in 1995 to around 100 GW in 2012 (1). Worldwide, 32.340 GW was installed in 2012 alone, when the photovoltaics sector rose by 23% compared with 2011 (2). Due to its reliable performance and long durability, photovoltaics modules can be either installed stand-alone in the remote rural area or grid connected in the location where electricity is easily accessible such as in the city’s building rooftop or residential provided clean energy with relatively free maintenance over its lifespan (3-5). The Feed-in tariff for photovoltaics individual installation was said the most prevalent support mechanism for renewable energy technologies across Europe (6). Nowadays, many countries classified as emerging Asia and even developing Africa introduce the solar feed-in tariff policy (7-9). Despite of technical and economical potential, installation and utilization of photovoltaics in the developing countries particularly in urban residential sector is still quite uncommon due to lack of supporting regulation and other disadvantage conditions.

Relevant study on the Grid connected photovoltaics system in terms of its impact in residential area can be found in (10). The study is focused on determining the ability of Grid-Connected Photovoltaic systems to reduce total and peak load demand in Saudi Arabia. Performance assessment of grid-connected, building-integrated photovoltaics installation was presented in (11). The study described the design of the installation and system performance data of amorphous silicon PV opearting at prevailing condition. Technical and formal aspect of integrating of photovoltaics in building was discussed in (2). A study intended to provide a simple way for homeowners and developers to explore the financial viability of individual photovoltaics installations was presented in (6). The experimantal results of controlled photovoltaics module for building integrated photovoltaics system was presented in (12). This study intended to improve performance ratio which was caused by partial shadows, temperature effects, inverter losses, thermal losses, and mismatching losses by menas of suitable electronics. Nevertheless, none of aforementioned study and other study explained about technical as well as economical aspect of photovoltaics installation on individual residentials in terms of system's sizing and cost of energy under the Feed-in tariff mechanism.

This paper is therefore focused on the preliminary assessment of technical and economical aspect in terms of system's sizing and life cycle cost i.e. cost of energy and total net present cost during certain photovoltaics project life time installed in individual residential under the implementation of Feed-in tariff. The potential of conducting building integrated photovoltaics-grid connected scheme through Feed-in tariff, which is focused in urban residential sector, is presented. Urban residential of Indonesia along with other relevant data has been selected in the deliberation and analysis as it is provided a common picture of developing countries, where the energy policy and relevant regulation still rely on the subsidy. This paper are organized as follows; application of the photovoltaics modules for household electrification in terms of stand-alone and grid connected type is discussed in the next section followed with brief explanation about household sector as the largest Indonesia's electricity consumer. Preliminary analysis and results in terms of technical and economical point of view is followed subsequently. Barriers and opportunities is elaborated afterwards then the paper ends with conlclusion.

2. INDONESIA'S RESIDENTIAL ELECTRICITY

Electiricity power for all customer sectors including residential is supplied by a state owned electricity company called Perusahaan Listrik Negara or PLN. PLN has been responsible for all process of electricity services, of which comprise of generation, transmission, and distribution. As of 2012, the number of PLN's residential customer was 46.21 million or 92.6% of the total customers. The residential sector consumed 72,130 GWh or 41.45% of the 2012 total national electricity consumption. In Indonesia, PLN's residential customer are divided into three sub-sectors based on their tariff category, since 1999. The "R-1" category are those with connected capacity up to 2,200 VA whereas "R-2" and "R-3" are those with connected capacity up to 6,600 VA and beyond, respectively (13). The "R-1" category was remained in domination with around 90% of electricity consumption among other categories, particularly in the urban region. With the growth of total number of residential customers from 45.83 million at the end of 2011 to 46.21 million at the end of 2012, the electrification ratio reached around 73.37% at the end of 2012 or increased around 2.14% compared to that achieved at the end of 2011 (14).

3. TECHNO-ECONOMIC ANALYSIS

In this study, residential integrated photovoltaics-grid connected is modeled using Hybrid Optimization Model for Electric Renewable (HOMER) version 2.81, developed by the United States National Renewable Energy Laboratory (15). HOMER has been known as one of powerfull tool to conduct techno-economic analysis in terms of system's optimum sizing and system's cost of energy, escpecially for stand-alone renewable energy as well as hybrid based-power generation system supplying AC or DC load as it is used on various relevant study. The selected area is urban area of Surabaya, Indonesia, which has population around 3 million people. Being the second largest city in Indonesia and the capital for East Java Province, Surabaya is located at 7°15' South Latitude and 112°44' East Longitude. In the analysis, the latitude value is used to calculate the average daily radiation from the clearness index and vice-versa.The city can be reached either by means of land transportation form all over direction or about one hour flight from Jakarta, the Indonesia's capital. Part of the map of Indonesia and the location of Surabaya is depicted in Figure 1. Meanwhile, solar resource inputs in terms of monthly averages solar irradiation in kWh/m^2/day is used to calculate the photovoltaics array power for each hour of the year. The monthly averaged daily solar irradiation and corresponding clearness index is presented graphically in Figure 2.

Fig. 1. *Location of Surabaya in the Indonesia archipelago map*

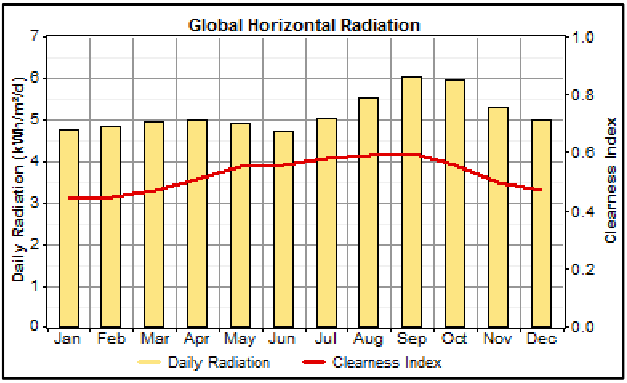

Fig. 2. *The monthly averaged daily solar irradiation and corresponding clearness index of Surabaya*

For the purpose of analysis, three typical residential daily loading pattern model which are representing three residential sub-sector tariff group are considered, i.e. a typical daily loading pattern for residential with 2,200 VA connected capacity, orR1, a a typical daily loading pattern for residential having 3,500 VA connected capacity, or R2, and a a typical daily loading pattern for residential with 6,600 VA connected capacity, or R3. In order to create such patterns, a walkthrough survey has been primarily conducted for several sample houses for each tariff group in urban area of Surabaya. The averaged daily electricity loading curve for R1, R2, and R3 residential sub-sector is shown in Figure 3. The generated loading curve have neglected the seasonal variation as well as weekend loading condition.

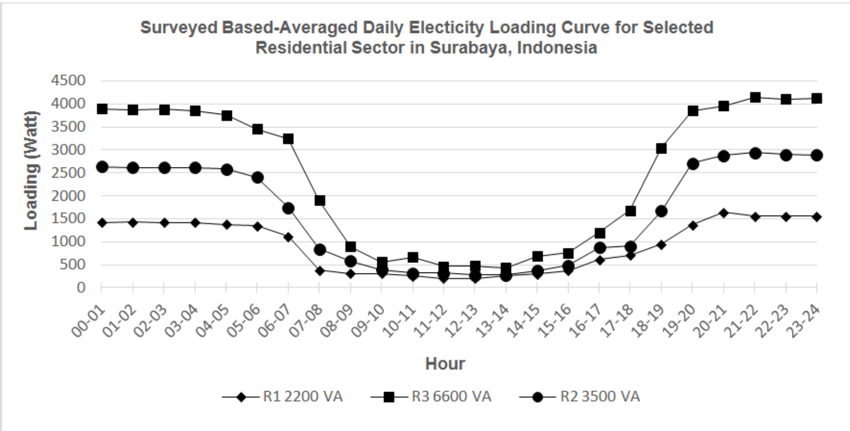

Fig. 3. *The survey based-averaged daily electricity loading curve for R1, R2, and R3 residential sector in Surabaya, Indonesia*

The simulation is then conducted considering several scenarios taken into account the possible number of photovoltaics array installed in the rooftop of the house. Important parameters of which predetermined in the HOMER simulation are given in Table 1. Under the Feed-in Tariff mechanism, the system parameter consists of system components and cost, grid power price and sell back rate, which is required since the photovoltaics is integratedly-grid connected, and system loading condition.

Table 1. Some important technical and economic simulation system parameters

System Parameter	Value
Maximum photovoltaics installed capacity	1.5 kWp for R1-2,200 VA; 2.5 kWp for R2-3,500 VA; 4 kWp for R3-6,600 VA
Photovoltaics rated output per module	100 Wp
Photovoltaics purchasing and replacement cost per module	USD 225 and USD 180
Photovoltaics lifetime	20 years
Photovoltaics derating factor	20%
Tracking system	n/a
Converter rated output	1.5 kW for R1 2,200 VA; 2.5 kW for R2-3,500 VA; 4 kW for R3-6,600 VA
Converter purchasing and replacement cost per kW rated output	USD 150
Converter lifetime	10 years
Converter’s inverter and rectifier efficiency	90% and 85%
Battery’s nominal capacity and voltage	200 Ah, 2.4 kWh, 12 Volt (6FM200D)
Battery’s purchasing and replacement cost incl. charge controller	USD 650
Grid power price	USD 0.1 per kWh
Sell back rate (Feed-in Tariff)	USD 0.1 – USD 0.3 per kWh
Annual real interest rate	6%
System fixed capital cost	USD 300 – USD 500
Minimum renewable fraction	10%
Project lifetime	20 years

The maximum photovoltaics rated output is limited up to predetermined value as presenetd in Table 1 due to the size limitation of the rooftop of Indonesian residential building. Grid power price is defined as averaged value of electricity price. Although the real electricity price for residential sector in Indonesia is keep on increasing in 2013, accounted for a total increase of 15% per year. It is seen relatively low particularly if the analysis is conducted in USD rate. System fixed capital cost covers photovoltaics installation, cabling procurement and installation, commisioning, and contractor fee. It may vary over the houses power connected capacity, ranges from USD 300 for R1-2,200 VA to USD 500 for R3-6,600 VA. The sell back rate i.e. the feed-in tariff, which is not yet regulated, is assumed to be USD 0.1 to USD 0.3 per kWh. Grid power price as well as the sell back rate is aplicable either weekday or weekend. The somewhat high rate is applicable since it is quite common for utility to purchase electricity in a higher price, compared to that they sell, from the renewable sources. The Indonesian state utility company planned to purchase electricity from large solar generation stations under a Feed-in tariff mechanism at USD 0.25 to USD 30 per kWh, as to comply with recent regulation issued by government. In addition, the minimum renewable fraction is imposed in the simulation in order to allow supply from photovoltaics as well. Here, a distinct control scheme in terms of how photovoltaics dispatch electricity in a minimum of 10% house's required energy is applied by HOMER. Figure 4 depicts a HOMER system architecture for household with 2,200 VA power connected capacity whereas the remaining model for R2 and R3 are similar except a difference appeared on daily energy requirement.

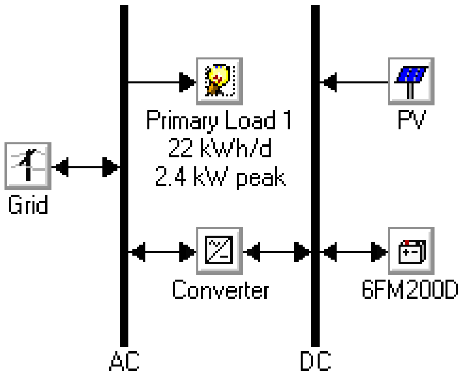

Fig. 4. *HOMER system architecture for household with 2,200 VA power connected capacity*

HOMER simulates the system operation by performing energy balance calculations for each hour over a year. HOMER compares the electricity demand in that particular hour to the energy that the generation system can supply, and calculates the flows of energy of the system. The economic parameters such as initial cost (IC), operating and maintenance cost (OMC), total net present cost (Total NPC), and cost of energy (COE) are calculated for each alternative system (16). The software performs calculation to obtain the size of the search space that is the set of all systems over which HOMER searches (17). The search space is defined by specifying the sizes and quantities of the different system components in the Sizes to consider tables in the search space window. In the optimization process, every system configuration in the search space is simulated and the feasible ones are displayed in a table, sorted by net present cost.

4. RESULT AND DISCUSSION

Based on the predetermined conditions and constrains, simulations are carried out for each tariff group with respect to various sellback rate, which represents the possible amount of feed-in tariff. Either optimictic or pesimistic scenarios of feed-in tariff implementation is reflected in the proposed amount of sellback rate. Figure 5 to Figure 7 shows HOMER simulation result in terms of photovoltaics optimal sizing along with their incured life cycle cost with respect to corresponding sellback rate, for R1 to R3 system, respectively. From the simulation, the higher the sellback rate, i.e. the amount of feed-in tariff, the more photovoltaics modules are sugested to be installed, resulting in a lower cost of energy over the project lifetime. Although the initial capital required could be consequently higher, the operational cost as well as the total net present cost would be substantially decreased. The system performed a shortage free condition with all demand could be fullfiled, provided no battery is required in these cases. It could be theoriticaly possible as long as the grid supply are secured over the year.

Rate 1 Sellback ($/kWh)	PV (kW)	6FM200D	Conv. (kW)	Grid (kW)	Initial Capital	Operating Cost ($/yr)	Total NPC	COE ($/kWh)	Ren. Frac.
0.100	0.7		1.0	1000	$ 2,025	718	$ 10,266	0.108	0.12
0.150	0.7		1.0	1000	$ 2,025	707	$ 10,133	0.106	0.12
0.200	1.5		1.0	1000	$ 3,825	508	$ 9,648	0.092	0.22
0.250	1.5		1.0	1000	$ 3,825	455	$ 9,048	0.087	0.22
0.300	1.5		1.0	1000	$ 3,825	403	$ 8,448	0.081	0.22

Fig. 5. *HOMER optimization result in terms of sizing and cost of the R1-2,200 VA system*

Rate 1 Sellback ($/kWh)						PV (kW)	6FM200D	Conv. (kW)	Grid (kW)	Initial Capital	Operating Cost ($/yr)	Total NPC	COE ($/kWh)	Ren. Frac.
0.100						1.1		1.0	1000	$ 3,025	1,273	$ 17,631	0.105	0.10
0.150						1.1		1.0	1000	$ 3,025	1,250	$ 17,368	0.104	0.10
0.200						2.5		2.0	1000	$ 6,325	893	$ 16,568	0.090	0.21
0.250						2.5		2.0	1000	$ 6,325	795	$ 15,439	0.083	0.21
0.300						2.5		2.0	1000	$ 6,325	696	$ 14,311	0.077	0.21

Fig. 6. *HOMER optimization result in terms of sizing and cost of the R2-3,500 VA system*

Rate 1 Sellback ($/kWh)						PV (kW)	6FM200D	Conv. (kW)	Grid (kW)	Initial Capital	Operating Cost ($/yr)	Total NPC	COE ($/kWh)	Ren. Frac.
0.100						1.7		1.0	1000	$ 4,275	1,935	$ 26,473	0.105	0.10
0.150						1.7		1.5	1000	$ 4,350	1,896	$ 26,101	0.103	0.10
0.200						4.0		3.0	1000	$ 9,750	1,317	$ 24,860	0.088	0.22
0.250						4.0		3.0	1000	$ 9,750	1,162	$ 23,082	0.082	0.22
0.300						4.0		3.0	1000	$ 9,750	1,007	$ 21,304	0.076	0.22

Fig. 7. *HOMER optimization result in terms of sizing and cost of the R3-6,600 VA system*

Figure 8 to 10 shows the proportion of monthly average electricity production by grid and photovoltaics for R1 to R3 with respect to a USD 0.1/kWh sellback rate and corresponding optimal photovoltaics sizing. We can see that the relatively high proportion from solar energy is achieved on August, September and October due to consecutively three month high in daily solar radiation.

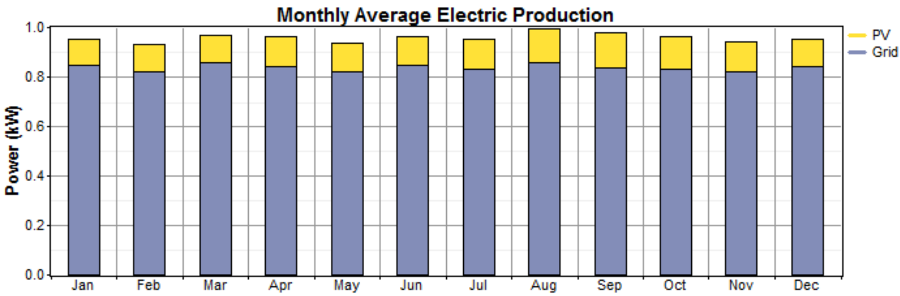

Fig. 8. *R1-2,200 VA monthly average electricity production with 0.7 kW photovoltaics installed capacity*

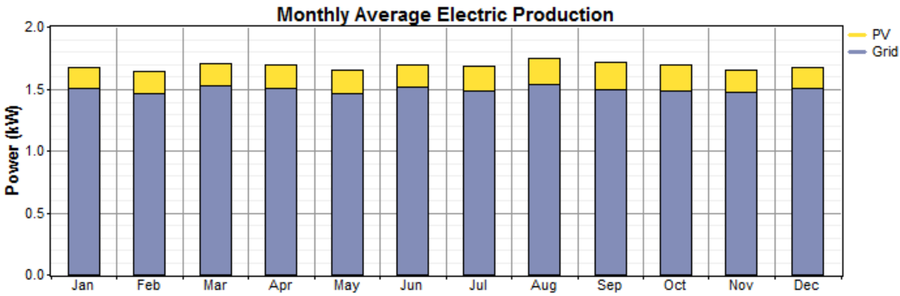

Fig. 9. *R2-3,500 VA monthly average electricity production with 1.1 kW photovoltaics installed capacity*

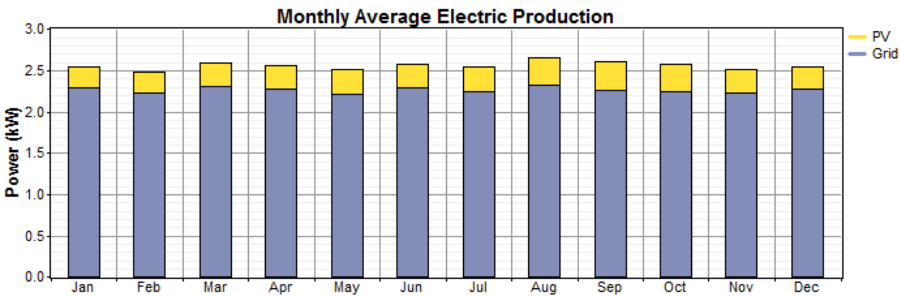

Fig. 10. *R3-6,600 VA monthly average electricity production with 1.7 kW photovoltaics installed capacity*

Table 2 to 4 presents the annual energy production and consumption for R1 to R3, respectively. We can see that if higher sellback rate is applied, the photovoltaics electricity production as well as electricity sell to the grid is increased. Below USD 0.2/kWh rate, the fraction of electricity sell into the grid is around 22% of the total electricity produced by the photovoltaics modules. On the other hand, applying the sellback rate on USD 0.2-0.3 would increase the fraction in a range of 46-53%. This condition is also affecting an increasing renewable energy fraction of around 22% of the total electricity generated by the combined source, over all system.

Table 2. Electricity consumption and production for R1-2,200 VA

R1-2,200 VA							
Sellback rate (USD/kWh)	PV sizing (kWp)	PV production (kWh/year)	Grid purchases (kWh/year)	Grid sales (kWh/year)	Grid net purchase (kWh/year)	Load Served (kWh/year)	RE fraction
0.1	0.7	1,061	7,342	231	7,111	8,067	0.12
0.15	0.7	1,061	7,342	231	7,111	8,067	0.12
0.2	1.5	2,274	7,096	1,046	6,050	8,067	0.22
0.25	1.5	2,274	7,096	1,046	6,050	8,067	0.22
0.3	1.5	2,274	7,096	1,046	6,050	8,067	0.22

Table 3. Electricity consumption and production for R2-3,500 VA

R2-3,500 VA							
Sellback rate (USD/kWh)	PV sizing (kWp)	PV production (kWh/year)	Grid purchases (kWh/year)	Grid sales (kWh/year)	Grid net purchase (kWh/year)	Load Served (kWh/year)	RE fraction
0.1	1.1	1,668	13,120	459	12,661	14,162	0.1
0.15	1.1	1,668	13,120	459	12,661	14,162	0.1
0.2	2.5	3,790	12,721	1,968	10,753	14,162	0.21
0.25	2.5	3,790	12,721	1,968	10,753	14,162	0.21
0.3	2.5	3,790	12,721	1,968	10,753	14,162	0.21

Table 4. Electricity consumption and production for R3-6,600 VA

R3-6,600 VA							
Sellback rate (USD/kWh)	PV sizing (kWp)	PV production (kWh/year)	Grid purchases (kWh/year)	Grid sales (kWh/year)	Grid net purchase (kWh/year)	Load Served (kWh/year)	RE fraction
0.1	1.7	2,577	19,829	549	19,280	21,498	0.1
0.15	1.7	2,577	19,829	650	19,179	21,498	0.1
0.2	4.0	6,064	19,155	3,100	16,055	21,498	0.22
0.25	4.0	6,064	19,155	3,100	16,055	21,498	0.22
0.3	4.0	6,064	19,155	3,100	16,055	21,498	0.22

Figure 11 to 13 shows sensitivity analysis graph of photovoltaics capacity versus sellback rate superimposed to the cost of energy for each tariff group.

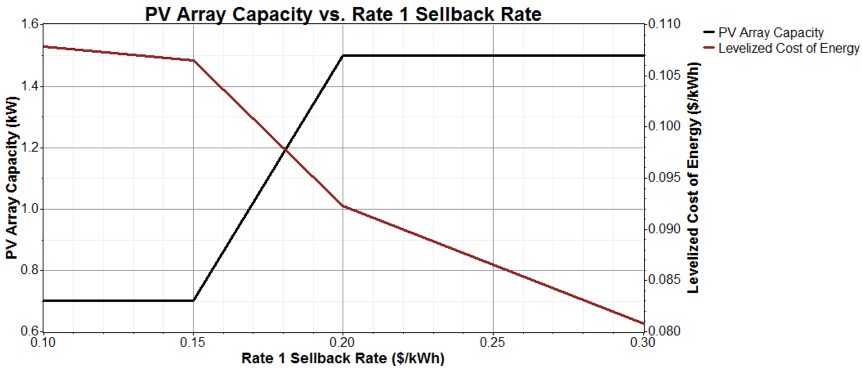

Fig. 11. *Sensitivity analysis graph of photovoltaics capacity vs sellback rate superimposed to cost of energy for R1-2,200 VA*

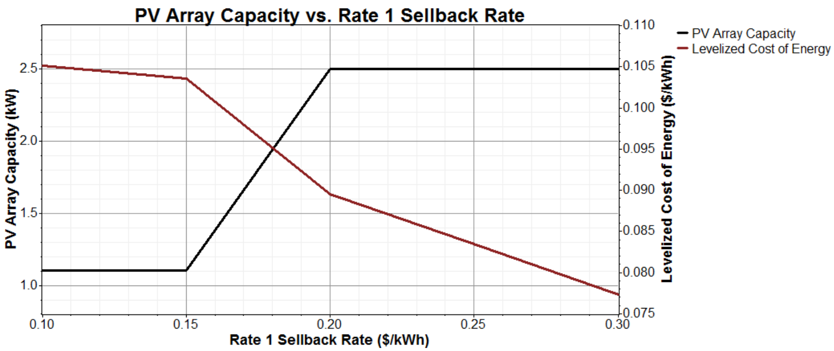

Fig. 12. *Sensitivity analysis graph of photovoltaics capacity vs sellback rate superimposed to cost of energy for R2-3,500 VA*

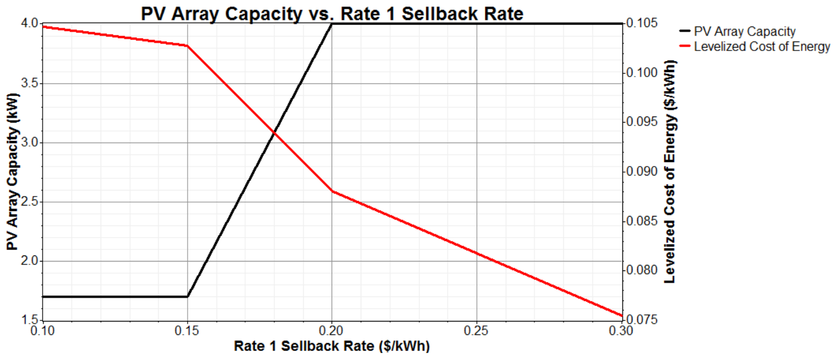

Fig. 13. *Sensitivity analysis graph of photovoltaics capacity vs sellback rate superimposed to cost of energy for R3-6,600 VA*

From Figure 11, we can see that the levelized cost of energy of USD 0.098/kWh could be achieved by having 1.2 kW photovoltaics array installed capacity under a sellback rate of USD 0.18/kWh. Similarly, for R2 and R3 cases, the cost of energy that could be obtained are USD 0.095/kWh and USD 0.094/kWh, respectively, provided 1.95 kWp and 3.1 kWp photovoltaics array installed under a sellback rate of USD 0.18/kWh. From this case study, we can infer that all tariff group could possibly obtain lower cost of energy compared to that achieved by the load having a sole connection into the grid without a photovoltaics supply. The interesting finding include the same sellback rate for all tariff group as well as similar cost of energy provided different photovoltaics installed capacity.

Besides, the feed-in tariff mechanism is quite interesting as it provides additional advantages, such as earning money or net metering from selling electricity into the grid and increasing energy self sufficiency and security for the house up to certain extend. However, some supporting regulations are needed to make the feed-in tariff program for residential sector come into work. Up to now, the feed-in tariff regulation still in the early stage of its introduction in Indonesia as the solar power feed-in tariff and new solar power purchase producers are recently introduced under the regulation of MEMR No. 17, 2013 (18). The purpose of the regultion is to stipulate among other things: (i) new procedures for purchase of power from solar photovoltaic power projects in Indonesia which require developers to bid in capacity quota tenders; and (ii) feed-in-tariff for solar photovoltaic power projects at the cap of USD 0.25/kWh, or USD 0.30/kWh if the photovoltaic module contains 40% or more local components. However, the regulation is applicable for considerably large solar power plant generation only. In the case of residential-photovoltaics integrated-grid connected, the regulations could be of that combination between fiscall incentives and energy price policy, of which proposing to encourage the deployment of photovoltaics modules among domestic dan residential sector on the voluntary basis. The energy price subsidy, on the other hand, can be converted into a kind of subsidy to support photovoltaics modules procurement and deployment while other possible mechanisms are yet opened to be discussed to bring the residential photovoltaics integrated-grid connected, which is relatively expensive in initial capital into the implementation under the feed-in tariff.

5. CONCLUSION

The preliminary assessment in terms of technical and economical aspect of feed-in tariff potential for residential sector is presented in this work. The mechanism is focuced on the implementation of residential integrated photovoltaics-grid connected in the urban residential sector in Indonesia. From the simulation, it is found that the feed-in tariff mechanism could be potentially technically and economically viable as the cost of energy can be relatively lower that achieved by the conventional condition with support by a proven photovoltaics technology. The next callenge is deal with the relevant policy and regulation that is needed to encourage the utilization of such system under the feed-in tariff mechanism.

REFERENCES

1. J.L. Sawin (2013). Renewables 2013 Global Status Report. REN21 Secretariat, Paris, France. http://www.ren21.net. Date accessed: October 15, 2013.

2. T. Schuetze (2013). Integration of Photovoltaics in Buildings-Support Policies Addressing Technical and Formal Aspects. Energies, 6, 2982-3001.
3. T. James, A. Goodrich, M. Woodhouse, R. Margolis, and S. Ong (2011). Building-Integrated Photovoltaics (BIPV) in the Residential Sector: An Analysis of Installed Rooftop System Prices. NREL Technical Report-6A20-53103, Colorado, United States.
4. L.Y. Seng, G. Lalchand, G.M. Sow (2008). Economical, environmental and technical analysis of building integrated photovoltaic systems in Malaysia. Energy Policy 36 (6), 2130–2142.
5. T. Meyer (2004). Photovoltaic Energy: Stand-Alone and Grid-Connected System. Reference Module in Earth Systems and Environmental Sciences, 35-46.
6. J. Hart (Photovoltaic Installations in the Domestic Sector: A Model of the Environmental and Economic Implications of the Proposed UK Feed-in Tariff Scheme. http:// *www.iema.net/system/files/jessica20hart.pdf.* Date accessed: October 7, 2013.
7. PV-Magazine.com. Feed-in tariffs (FITs). http://www.pv-magazine.com/services/feed-in-tariffs/feed-in-tariffs-for-various-countries/ Date accessed: October 8, 2013.
8. W.Y. Teoh, S.Y. Khu, C.W. Tan, I.H. Hii, and K.W. Cheu (2012). Technoeconomic and Carbon Emission Analysis for a Grid-Connected Photovoltaic System in Malacca. ISRN Renewable Energy 2012, 1-8.
9. D. Lavansiri (2013). Updates on the Feed-in Tariff Scheme in Thailand. http://www.engerati.com/on-demand/updates-feed-tariff-scheme-thailand/2415. Accessed on: October 23, 2013.
10. R.A. Shalwala and J.A.M. Bleijs (2009). Impact of Grid-Connected PV systems in residential areas in Saudi Arabia. Proceeding of the 44th Universities Power Engineering Conference (UPEC), 1-4 September 2009. Glasgow, Scotland.

11. R. Ruther, M.M. Dacoregio (2000). Performance assessment of a 2 kWp grid-connected, building-integrated, amorphous silicon photovoltaic installation in Brazil. Progress in Photovoltaics: Research and Applications, 8 (2), 257-266.
12. S. Ubertini and U Desideri (2003). Performance Estimation and Experimental Measurements of a Photovoltaic Roof. Renewable Energy, 28, 1833-1850.
13. Y. Tanoto and M. Praptiningsih (2013). Factors decomposition of Indonesia's Household Electricity Consumption. Engineering Journal, 17 (2), 19-28.
14. S. Corporate (2013). PLN Statistics 2012. PT. PLN (Persero), Jakarta, Indonesia.
15. T. Lambert, P.G. Gilman, and P. Lilienthal (2006). Micropower System Modeling with HOMER. http://www.pspb.org/e21/media/HOMERModelingInformation.pdf. Date accessed: April 12, 2008.
16. Y. Tanoto, M. Santoso, C. Massay (2013). Off Grid Fully Renewable Energy with Free Capacity Shortage for Remote Electrification. The Proceeding of 7th IEEE International Power Engineering and Optimization Conference, 3-4 June 2013, Langkawi, Malaysia.
17. A.M.A. Haidar, P.N. John, and M. Shawal (2010). Optimal Configuration Assessment of Renewable Energy in Malaysia. Renewable Energy, 36, 881-888.
18. The Minister of Energy and Mineral Resource Reg. 17/2013 (2013). Introduction of Solar Power Feed-In-Tariff and New Solar Power Purchase Procedures In Indonesia. Jakarta, Indonesia.