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Study of PV Powered Air Conditioning for a Classroom of University of Surabaya

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***Abstract*— This paper discusses the interaction between PV and air conditioning and how this can be exploited for a classroom at University of Surabaya campus. A cost analysis of the proposed grid-connected systems are calculated, including total investment, payback period and levelized costs. The most efficient way to connect PVs and air conditioning for a classroom is through a grid connected system. Simulation result shows that a 12 kWp PV system and the new AC units of COP 4,0 gives the LCOE about -3,334 IDR/kWh.**

Keywords—photovoltaic; air conditioning; solar energy; classroom

I. INTRODUCTION

Renewable energy such as solar can reduce the need to burn fossil fuels and in turn reduce the amount of greenhouse gasses being released into the atmosphere. To promote the use of solar energy, new innovative solutions must be created in both engineering and policy. Air conditioners are becoming more common and are a major strain on energy demands especially in tropical climate countries like Indonesia where air conditioning is used all year round. Up to 50% of buildings energy can be from air conditioning in subtropical regions [1].

There are few publications that have looked into the interaction between air conditioners and photovoltaic electricity. Most research conducted had been in other areas such as solar cooling, like absorption and adsorption. Reference [2] reported a work focused on the design and construction of a direct current (DC) air conditioning system integrated with photovoltaic (PV) system. No DC system was constructed but it contained a breakdown of all vital components for both the air conditioner and PV system. Reference [3] uses a different type of cooling technology but provided a detailed insight into the methodology of designing and sizing a solar cooling system. Not all of the steps proposed can be repeated as the design is for a solar absorption cooling system, however it is a good guideline to follow when planning our design process. Reference [4] studied the possibility of using photovoltaic panels to produce electricity that is used to power the compressor of an inverter air conditioning unit, without the use of batteries or any inverter regulators.

The peak times for using air conditioning for classroom activity is during the day when the temperature is the highest. PV's peak times are also during the day when the sun at its strongest. This paper studied the interaction between PV and air conditioning and how this can be exploited for a classroom at University of Surabaya campus. Surabaya is located at the coast on the east side of Java very close to the equator. Surabaya represents a tropical climate, that means the presented system solutions can be adopted to other cities and countries with similar weather.

II. RESEARCH METHOD

Classroom TF 2.2 (apart of Building TF) of faculty of Engineering University of Surabaya was used and simulated in this study. The capacity of the classroom is 100 seats for students. Inside there are three air conditioners, which are operate during class. In the classroom there are three split type Toshiba RAS-18UAX2 air conditioners. Each air conditioner has a running power of 1.87 kW and a cooling capacity of 5.2 kW. The air conditioners currently installed in the classroom are kind of old and have a poor COP of 2.78.

A user behaviour profile gave a detailed view on the internal and external gains of the classroom. The internal gains come from people, electronics, etc. The room's timetable and number of students taking each class were used to get the number of people using the room. The classroom commonly occupied during 07.00 – 18 .30, with a half an hour interval for lunch break during 12.30- 13.30.

Indonesians thumb rule of sizing air conditioners was used by former installer company with 0.5 pk electrical power (paardenkracht Dutch: translated to horse power) per 10 m² of floor. In the classroom there are three 5.2 kW (1.87 kW electrical power) air conditioners. With a factor of 1.36 pk/kWel makes that round 7.6 pk. The classroom is 106 m², therefore it is a bit oversized according to the rule of thumb.

To design a system, an accurate load profile is essential. Data from energy meters, temperature sensors, a user behaviour analysis and weather data were used to determine

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of the cooling load. An energy meter installed in the classroom provides the electrical load needed to power the air conditioner.

The calculations of cooling load for the classroom in this study was made based on the cooling load calculations after VDI 2078 and instructions for simplified cooling load calculations for single air conditioners [5]. The cooling capacity is combination of internal heat gain and external heat gains. The gains here are losses, identified as the heat sources, which needs to be compensated by providing cooling from air conditioners. The internal gains are considered from: people (sensible and latent heat); lighting; electrical appliances (computer, projector, fans of air conditioners). While the external gains for the classroom are: transmission heat losses and ventilation heat losses (cooling and drying outdoor air).

To predict how the PV systems would perform with new AC air conditioners a new load profile was created this time with a COP of 4.0, which is a typical value for new AC air conditioners. For these values, a design day was also created. The design day load is used from Monday to Friday for annual calculations. For the new air conditioners is the daily load 30.02 kWh and for the current air conditioners 43.20 kWh.

Two size PV systems were simulated in PVsyst. The load used in the simulation is the load from the design day current air conditioners (COP 2.78) and new air conditioners (COP 4.0). Sharp photovoltaic modules manufactured in Indonesia were chosen. Choosing to use locally manufactured modules allows for higher feed in tariff under Indonesian policy. The results from previous study [6] suggested that the north east facing roof (azimuth 135°) had the highest annual irradiation, with a roof tilt of 35°.

A cost analysis of the proposed grid-connected systems are calculated, this includes total investment, payback period and levelized costs. A typical PV grid conected system diagram is shown in Fig. 1 which is also showing algorithm (by arrows) flows of electricity energy to power the airconditioner.

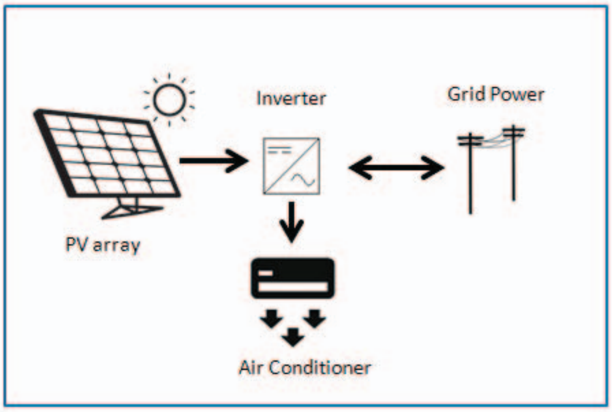

Fig 1. PV grid connected system

III. RESULTS

In Indonesia the average solar irradiation is about 4.8 kWh/m²,day [7]. The weather data needed for analysing and sizing a PV coupled air conditioning system is during the day, as cooling demand for the classroom is only at daytime and solar irradiation of course as well. Therefore, the existing weather data was analysed over daytime from 5:00 to 18:00. The existing University of Surabaya weather station provides the temperature and daytime humidity at its campus. Coldest

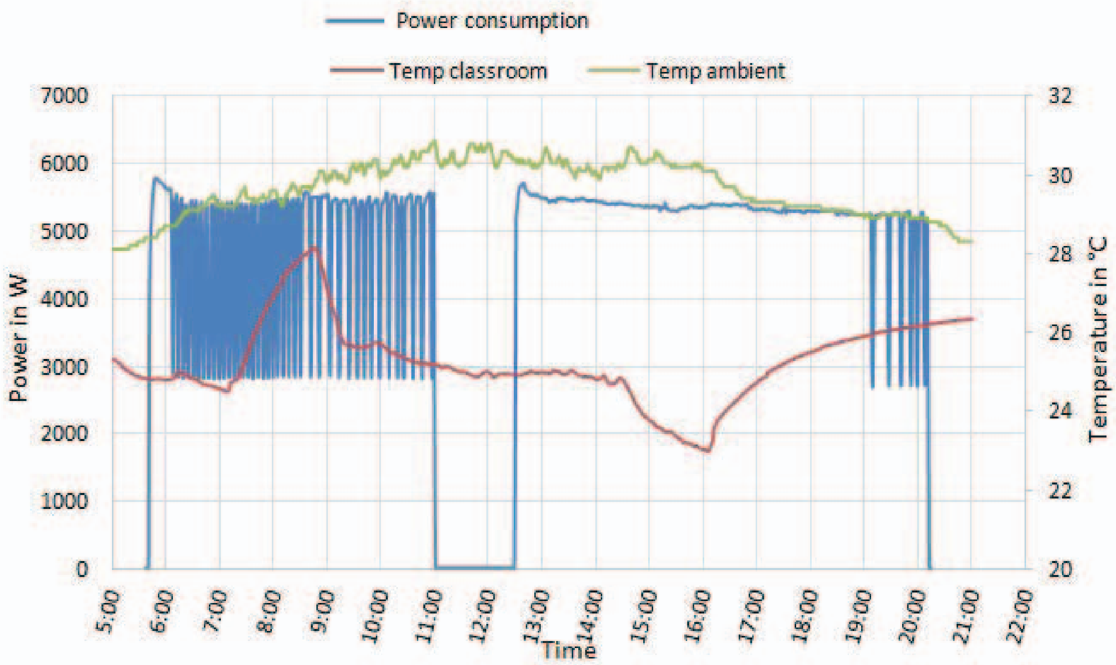

Fig 2. Air conditioner consumption compared to temperature

months are January to August with below 28 °C and the hottest months are October and November with around 31 °C. Global solar radiation and temperature in Surabaya is shown in Fig 3. The daytime humidity is with 60 to 80 % in average also very high around the year. During the dry season (July to October) it is in general less humid than during the rainy season (November to June).

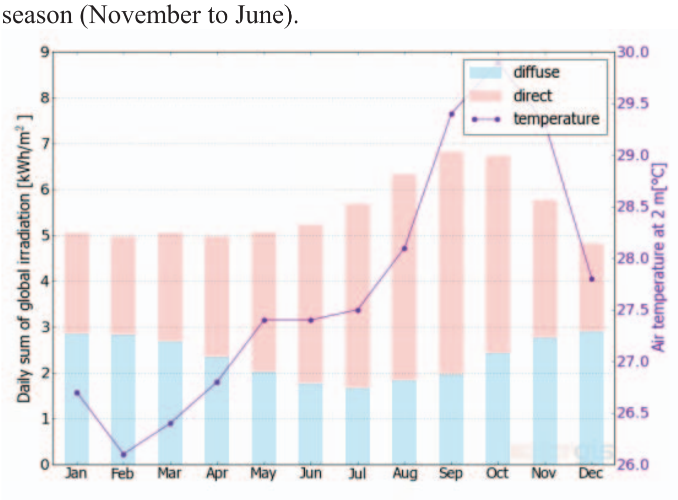

Fig 3. Global solar radiation and temperature in Surabaya

Referring to comfort zone in dependence of temperature and humidity [8] room temperatures in Surabaya should be in between 18 and 24 °C dependent on the humidity. The optimal relative humidity is in between 35 and 70 %. In addition, people feel higher temperatures more comfortable with a lower humidity than with a higher humidity. The further the air conditions are out of that zone the more uncomfortable it is for people. But the temperature difference between inside and outside should not exceed 6 K for health reasons [9]. With a daily average temperature of 28 to 31 °C, Surabaya's temperature is much higher than the comfort zone.

A. Existing Air Conditioners Power Consumption

Figure 2 shows measurement results from the existing classroom air conditioners. The power is cumulative values for the three air conditioners

The figure also shows the classroom temperature and the ambient temperature. At 05:30 air conditioner is switched on. The blurred lines in the consumption are when one of the air conditioners is cycling on and off. There is a rise in temperature of 2 °C which could be explained by the large number of students attending this class (87 students). Mid-day the air conditioner is switched off for an hour during lunch break. The air conditioner then runs continually until 20:00. The running times of the air conditioner were much longer than expected so for the purpose of this test only values from 07:30 to 17:30 were used.

B. PVSyst Simulations

Table 1 shows the main parameters for both the 8 kW and 12 kW grid connected PV systems, to simulate of supplying air conditioners both with COP 4.0 and COP 2.78. Sharp photovoltaic modules manufactured in Indonesia were chosen. These modules contain more than 40 % local components, so that a high feed in tariff of 0.27 USD/kWh can be assumed.

Figure 4 shows the power output for both the 8 kW and 12 kW systems in comparison to the air conditioner consumption with COP 2.78. The Figure gives a direct comparison of the two systems. The daily output for the 8 kW system is 28.28 kWh and 44.74 kWh for the 12 kW system. The consumption of the air conditioner is 43.20 kWh. For both systems grid backup power is needed in the morning and the evening. There are also times that both systems feed into the grid with 3.36 kWh for the 8 kW system and 11.96 kWh for the 12 kW system. The solar fraction shows the percentage of air conditioner power supplied by the PV system. The solar fraction values were 57% for the 8 kW system and 76% for the 12 kW system.

Table II gives a summary of the results from the simulation of the 8 kW and 12 kW systems for the air conditioners. The yearly solar fraction for the 8.0 kW system is 60% for the current COP 2,78 and 72% for the COP 4,0 respectively. For the 12 kW system the solar fraction is 75% with the old AC and 81% for the new AC.

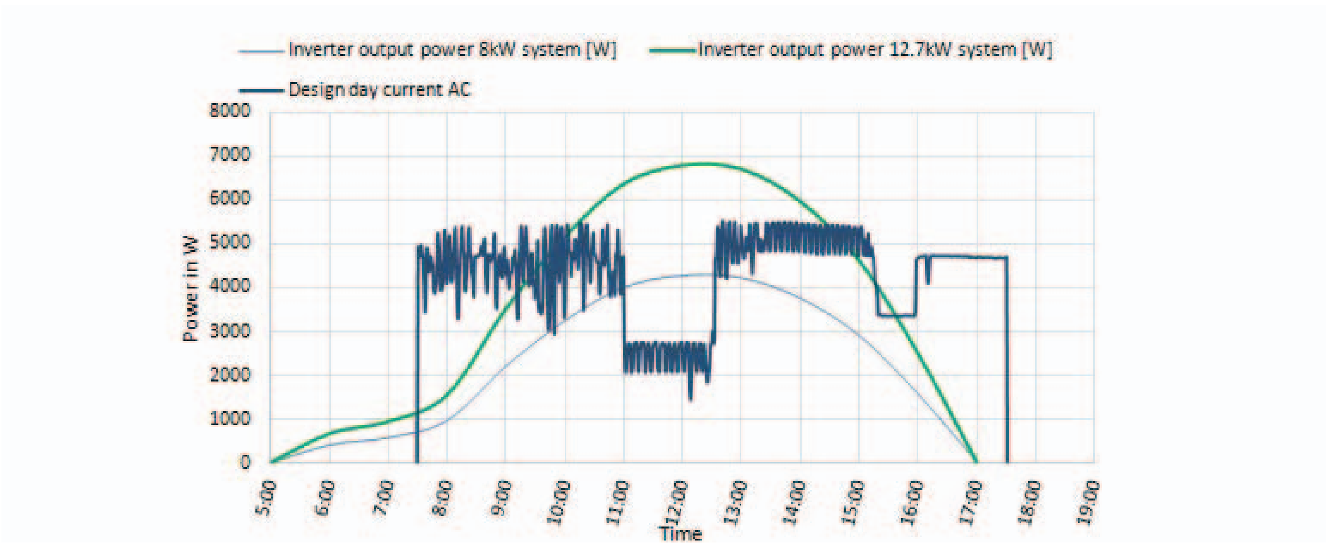

Fig 4. Power output of PV System in comparison to air conditioning load

TABLE I
PV SIMULATION PARAMETERS

Photovoltaic panels	**12 kWp**	**8 kWp**
PV Field Orientation	tilt 35° azimuth 135°	tilt 35° azimuth 135°
PV Manufacturer and Model	Sharp R245A6	Sharp R245A6
PV Technology	Si-poly	Si-poly
Nominal Power	245 Wp	245 Wp
Array global power Nominal (STC)	12.74 kWp	8.09 kWp
At operating conditions (50°C)	11.38 kWp	7.22 kWp
Total number of PV modules	52	33
Total area Module area	85.4 m2	54.2 m2
Manufacturer and Model	StecaGrid 3010	StecaGrid 2300
Operating Voltage	125-500 V	125-500 V
Nb. of inverters	4 units	3 units
Unit Nominal Power	3 kWac	2.30 kWac
Total Nominal Power	12 kWac	6.9 kWac
System Production Produced Energy	17.59 MWh/year	11.12 MWh/year
Performance Ratio PR	81.50 %	81.20 %

A. Financial Analysis

A cost analysis of the proposed systems was calculated, including total investment, payback period and levelized costs. Results for the 8 kW and 12 kW PV systems are given for both the current air conditioners with a COP of 2.78 and the new proposed air conditioners with a COP of 4.0. In May 2015, Indonesian's inflation rate was 6.79 %. The inflation rate forecast for 2020, 2030 and 2050 is projected to be 7.63, 7.54 and 7.56 % respectively [10], hence 7,5% was assumed in this calculation.

TABLE II
PV SIMULATION RESULTS

COP	**System**	**Inverter output [kWh]**	**Grid backup [kWh]**	**Feed in [kWh]**	**Load [kWh] Design day**
2.78	8.0 kW	28.28	18.30	3.36	43.20
	12.7 kW	44.74	10.40	11.96	43.20
4.0	8.0 kW	28.28	8.00	6.25	30.02
	12.7 kW	44.74	5.22	19.93	30.02

Calculation shows that a total initial investment of 132.11m IDR (million Indonesian Rupiah) for the 8 kW system and 211.43m IDR for the 12 kW system is required. The component includes module costs and mounting, inverter costs, installation and shipping, total project costs. Margin for engineering and profit, and total investment (without 20 % TAX). VAT has not been included because the University can deduct the tax. The specific PV price for polycrystalline modules from South East Asia is currently 0.48 €/Wp [11]. With an exchange rate of 14400 IDR per Euro (25.05.2015) is the specific PV price than 6900 IDR/Wp.

The electricity price of the state owned grid operator in Indonesia is about 1500 IDR/kWh. By using modules manufactured in Indonesia, it entitles the university to get the high feed in tariff, which is assumed to 3600 IDR/kWh. This high feed in tariff makes Indonesia unique where the feed in tariff is more than double the price of electricity. This is an effort by the government to encourage the installation of grid connected PV. Even though it would make economic sense to put all produced electricity into the grid, for the purpose of this project priority will be given to powering the air conditioner first. Without any assistance from PV, the electric bill would be 17.00 m IDR. By using a PV system, the money made from the feed in tariff would mean the university would get paid instead of having to an electric bill. Using the 8 kW system the university would receive 8.75 m IDR for the first year. This would be 28.42 m IDR for the 12 kW system.. The money earned with a PV system will be constant over the years as the feed in tariff stays also constant. With increasing electricity costs the profit with a PV system decreases each year. The consumption of the new air conditioners (COP 4,0) is lower than the current ones, this gives a lower electric bill and a higher feed into the grid. For the 8 kW and 12 kW systems, 16.20 m IDR and 37.99 m IDR respectively, can be made for the first year.

The payback period is a calculation of how long it takes to recoup the investment of the project. After this time the project will become profitable. Payback periods for the different systems are shown in Table 3.

Without having a PV system, the average yearly electricity costs for powering the current air conditioners would be 43.00 m IDR. A PV system lowers these costs greatly. With the 12 kW system, the annual electricity costs would come down to 10.60 m IDR in average. If excess energy is sold to the grid operator these costs go down again to minus 22.01 m IDR. New, more efficient air conditioners reduce the energy used and with it the electricity costs to even lower cost.

TABLE III
PAYBACK PERIOD IN YEARS WITH 7 % INFLATION RATE

System		Payback period	
		with Feed in tariff	without Feed in tariff
8 kW	COP 2.78	5.0 years	10.0 years
	COP 4.0	4.8 years	11.0 years
12.7 kW	COP 2.78	4.7 years	11.9 years
	COP 4.0	4.3 years	14.0 years

IV. DISCUSSIONS

The classroom was the site the PV system should be designed for. An analysis of the classroom air conditioner consumption, internal and ambient temperatures were recorded and analyzed. Based on the test results from the home office system two different size systems were proposed and simulated using PV syst.

The co-efficient of performance (COP) of the old air conditioners is 2.7 and the suggested new air conditioners have a COP of 4. Changing to the new air conditioners has a significant impact on the solar fraction used of the PV systems. The 8.0 kW system increased from 60 % to 72 % and the 12.0 kW increased from 75 % to 81 %. The feed in values are also high this can be explained by the weekend numbers. Assuming there is no school or work during the weekend the produced electricity is fed into the grid..

Considering a project lifetime of 25 years the results are very encouraging with a payback period of 5 years or under for all systems with Feed in tariff. The payback period is quite similar for all systems, because the 12 kW system produces much more electricity but the project costs are also much higher, while the 8 kW system produces less electricity, the project costs are also lower. Once the payback period is completed the 12 kW system would become more profitable. A calculation without any feed in tariff shows a payback period of 10 to 14 years. The feed in tariff is not necessary for this project to be profitable. Many countries have lower feed in tariffs than Indonesia but a similar project could be successful there also. In all calculations without feed in tariff, excess energy is not considered. This excess energy is fed into the grid for free or could be used within the University to lower the electricity use. If this excess energy could be used the payback period would decrease. The majority of the excess electricity produced is during the weekend because the classroom is not in use. For this electricity to be useful further study would have to be done to investigate how much electricity is used during weekends in the university.

The levelized cost of energy (LCOE) represents a per-kilowatt value of electricity used over the project lifetime (25 years). Using the feed in tariff, the 12 kW PV system and the new AC units the LCOE is -3,334 IDR/kWh. This is a very profitable system and a good result for the project. Even the worst case scenario 8 kW PV, current AC and no feed in tariff has a LCOE of 1,981 IDR/kWh, which is more than half that of without PV (3,795 IDR/kWh). The projects profitability is dependent on the level of initial investment made. If the University is willing to invest in the 12 kW PV system and new air conditioning units the levelized cost of energy will be lower. However, if there is no possible feed in tariff the project size will reach a limit. The levelized cost for the 12 kW PV system using new COP 4,0 air conditioners is higher than the 8 kW system. This means the 12 kW system is oversized and the 8 kW system should be chosen.

The next step for the project would be to bid for a feed in tariff with the proposed 12.0 kW system. If the bid is unsuccessful then the 8 kW system should be installed. These changes are all very good but in reality the cost of initial investment usually has a big influence on the project. With a total investment of 132.11m IDR for the 8 kW system and 211.43m IDR for the 12 kW system a budget for the project must also be decided before continuing.

One way to reduce the cooling load of the room is to get new air conditioners with a higher COP and a lower electrical consumption. Another way to reduce the cooling load is to look at the culture of air conditioner use and thermal comfort levels. Many studies have been conducted analysing thermal comfort levels and the potential for energy reduction with regard to air conditioning. While this type of study was not possible during this work, personal observations showed that energy conservation for air conditioning was not an issue. In many places like schools, shops, cinemas and restaurants air conditioners are sometimes set very low at 17°C to 19 °C with people wearing sweaters and jackets because it's too cold. Reference [12] showed that there is no loss in thermal comfort with a 2 °C increase (from 25 °C to 27 °C) as long as a higher air flow rate was present. Reference [13] found that 34.4% reduction in energy use in buildings is possible by increasing the set temperature by 2 °C based on buildings in Taiwan. For Indonesia to become more energy efficient these concepts and mentality must be taken into consideration.

V. Conclusions

The study showed that the collaboration between photovoltaics and air conditioning for a classroom is evident with an average of 94 % of PV electricity produced during the class hours of 07:30 to 17:30. The best way to connect PVs and air conditioning is through a grid connected system. With an average solar irradiation of about 4.8 kWh/m²/day together with a high feed in tariff, Indonesia is an attractive prospect for solar energy. Simulations showed getting a higher solar fraction than 80 % for the air conditioners will produce a high amount of excess electricity. Surabaya represents a tropical climate, that means the presented system solutions can be adopted to other cities and countries with similar weather.

References

[1] K. F. Fong, C. K. Lee, and T. T. Chow, "Comparative study of solar cooling systems with building-integrated solar collectors for use in sub-tropical regions like Hong Kong," *Appl. Energy*, vol. 90, no. 1, pp. 189–195, Feb. 2012.

[2] I. Daut, M. Adzrie, M. Irwanto, P. Ibrahim, and M. Fitra, "Solar Powered Air Conditioning System," *Energy Procedia*, vol. 36, pp. 444–453, 2013.

[3] T. Tsoutsos, E. Aloumpi, Z. Gkouskos, and M. Karagiorgas, "Design of a solar absorption cooling system in a Greek hospital," *Energy Build.*, vol. 42, no. 2, pp. 265–272, Feb. 2010.

[4] F. J. Aguilar, P. V. Quiles, and S. Aledo, "Operation and Energy Efficiency of a Hybrid Air Conditioner Simultaneously Connected to the Grid and to Photovoltaic Panels," *Energy Procedia*, vol. 48, pp. 768–777, 2014.

[5] "Zeitschriftenartikel: Ueberschlaegige Bestimmung der Kuehllast. Zur Auswahl von Einzelklimageraeten – Fraunhofer IRB – baufachinforma tion.de." [Online]. Available: https://www.baufachinformation.de/zeitschrift/%C3%9Cberschl%C3%A4gige-Bestimmung-der-K%C3%BChllast/2004099000346. [Accessed: 01-Jul-2015].

[6] "UPPSATSER.SE: Solar Energy assessment based on weather station data for direct site monitoring in Indonesia." [Online]. Available: http://www.uppsatser.se/uppsats/71cb56a39e/. [Accessed: 01-Jul-2015].

[7] T. Guide, "Power in Indonesia," 2013.

[8] "Grundlagen: Luftfeuchte und Gesundheit." [Online]. Available: http://www.cci-dialog.de/branchenticker/2013/kw05/04/grundlagen_luftfeuchte_und_gesundheit.html?backLink=/branchenticker/?date=31.01.2013. [Accessed: 01-Jul-2015].
[9] "Schaden Klimaanlagen der Gesundheit? | Apotheken Umschau." [Online]. Available: http://www.apotheken-umschau.de/Umwelt/Schaden-Klimaanlagen-der-Gesundheit-124241.html. [Accessed: 01-Jul-2015].
[10] "Indonesia Inflation Rate | 1997-2015 | Data | Chart | Calendar | Forecast." [Online]. Available: http://www.tradingeconomics.com/indonesia/inflation-cpi. [Accessed: 30-Jun-2015].
[11] "PVX spot market price index solar PV modules."
[12] Q. J. Kwong, N. M. Adam, and B. B. Sahari, "Thermal comfort assessment and potential for energy efficiency enhancement in modern tropical buildings: A review," *Energy Build.*, vol. 68, pp. 547–557, Jan. 2014.
[13] K. H. Yang and C. H. Su, "An approach to building energy savings using the PMV index," *Build. Environ.*, vol. 32, no. 1, pp. 25–30, Jan. 1997.

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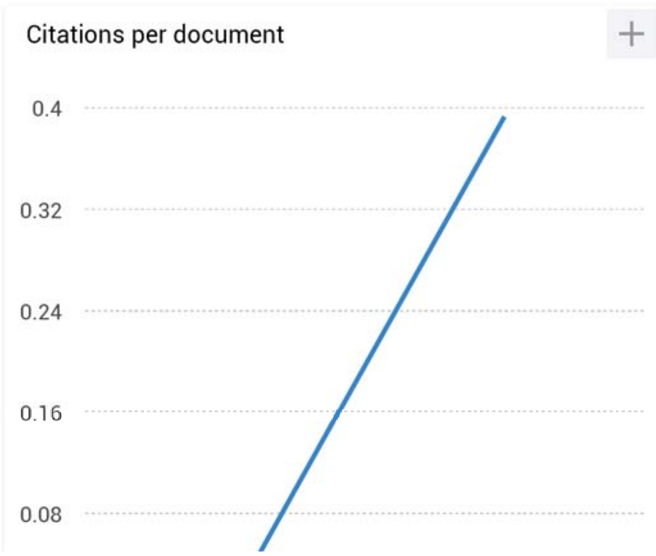

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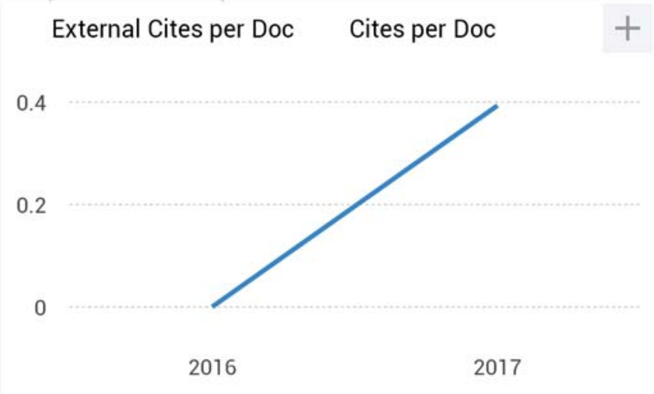

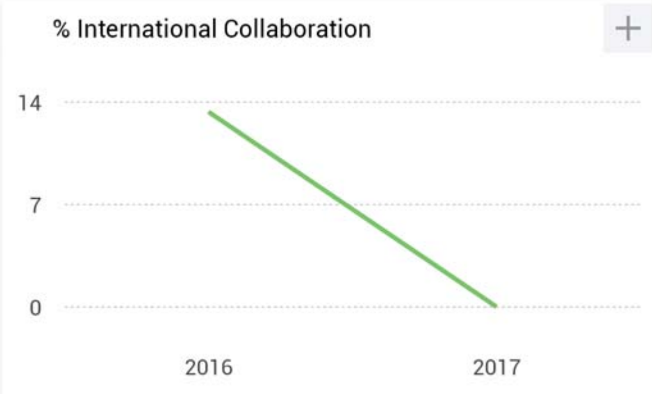

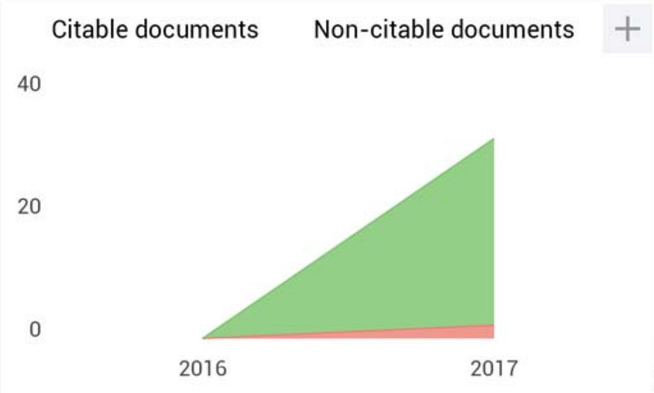

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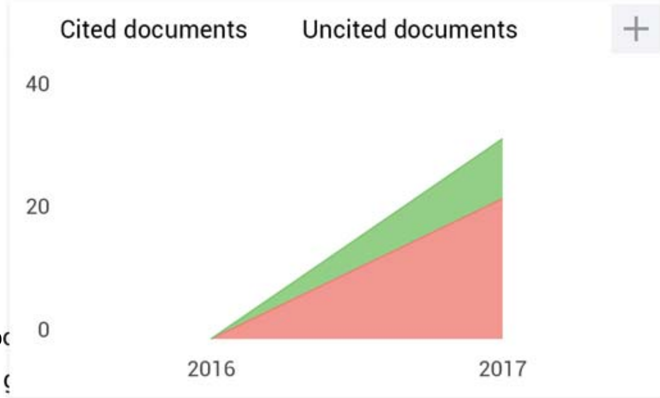

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Study of PV powered air conditioning for a classroom of University of Surabaya (Conference Paper)

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Abstract

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This paper discusses the interaction between PV and air conditioning and how this can be exploited for a classroom at University of Surabaya campus. A cost analysis of the proposed grid-connected systems are calculated, including total investment, payback period and levelized costs. The most efficient way to connect PVs and air conditioning for a classroom is through a grid connected system. Simulation result shows that a 12 kWp