Household energy in the Philippines

Study of solar energy to reduce household expenses

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1 Introduction

The Philippines is a country of 7107 islands in Southeast Asia, in the Western Pacific Ocean. It has an area of 300,000 km^2 and a population of 107.7 million (July 2014 est.).[1]

The selling price of electricity in the Philippines is among the highest in the world and the electricity cost constitutes a substantial part of household expenses, especially in the lower and middle income households. Due to the tropical hot humid climate, many households are dependent on electricity to power fans and air-conditioning units to cope with the high temperatures.

The generation of electricity in the Philippines is almost entirely based on imported fossil fuels, which is not a sustainable solution. This paper will therefore study the feasibility of using solar energy as an alternative source of energy for households. There are two widespread systems for harnessing solar energy-photovoltaic (PV) and solar thermal system. The focus of this study is on PV system, because of its more universal use.

[1] CIA, 2015

2 Overview of the energy sector in the Philippines

Energy production

Visconti (2012) writes that the Philippines have the second highest electricity rates in Southeast Asia and some of the highest in the world. It is pointed out that the rates in comparable countries in the region, such as Indonesia, Thailand and Malaysia are less than half of that in the Philippines. The main reasons for the high rates are:

- Absence of government subsidy
- Lack of competition
- Reliance on imported fossil fuels
- Challenging geography, including many small islands, mountains, etc
- Inefficient plants, which require frequent maintenance and back-up generators

In the 1970's the Philippines' government was working on two major projects to ensure that the rising demand will be met in the coming decades - the Chico River Hydroelectric Plant and the Bataan Nuclear Power Plant. These plants, which would have been clean and cheap energy producers, were very controversial and got abolished after the People Power Revolution in 1986. Subsequently the energy market has been gradually privatized. The regular brownouts in the 80's and 90's drove the country into crisis and an immediate solution was found in building oil-fuelled plants, which produce energy at a very high cost.[2] Aside from hydro and geothermal energy, other renewable sources have a very small share in the power generation today.

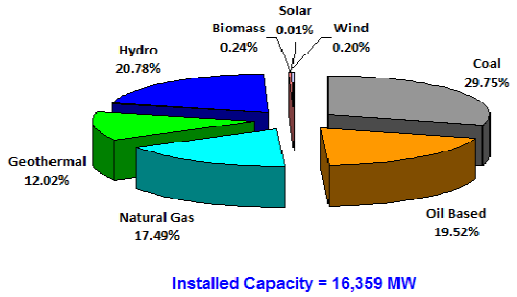

Chart 1. Installed Capacity in 2010 by fuel type in Philippines[3]

[2] Magno, 2011
[3] Department of Energy, 2010

Household energy consumption

According to Philippine Statistics Authority (2013), electricity is the most used source of energy by households, about 87% of households used electricity in 2011. Other fuels include wood, charcoal, liquefied petroleum gas (LPG) and kerosene. By type of appliances, electricity is most commonly used for lighting (85% of households that use electricity), TV (75%), cooling fan (65%), flat iron (46%), refrigerator (41%), radio (34%), washing machine (29%), videoke (26%), cooking (20%), computer (15%), air conditioning unit (9%) and water heater (4%).[4]

Based on a survey from 2004, the largest consumers of energy in an average household are refrigerators (28% of the electricity used), cooling devices (28%, out of which air conditioning 15% and cooling fan 13%), recreational appliances (19%) and lighting (11%). It is also worth noting that households with air conditioning use 12 times more energy on cooling than those who only use fans.[5]

An average Filipino household uses 211 kWh of electricity per month.[6] The high electricity prices make it a major expense in the household budget. As the price of energy keeps rising, many Filipino families are forced to reallocate their spending from other basic necessities, such as food and education. Magno (2011) labels this phenomenon as ‘energy poverty’.

Moreover, energy deficiency is predicted during the summer months, from March to May, when consumption is at its peak due to the need for cooling. This is also a period when generating capacity of hydropower plants will be reduced due to dry season and other plants will undergo planned maintenance works, resulting in reduced supply of electricity. Thus the Department of Energy warns 2-7 hour rotating brownouts for many regions in 2015,[7] which will disrupt the daily lives of millions of people in the Philippines.

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[4] Philippine Statistics Authority, 2013
[5] Philippine Statistics Authority, 2005
[6] Wooton, 2013
[7] Diokno, 2015

Solar photovoltaic technology

Solar PV is one of the fastest growing energy technologies today. Its current share in energy production is still very small, around 0.1%,[8] but it has a huge potential to provide the world with clean energy. The cost-benefit ratio of PV still depends largely on the individual country's legislation and subsidies, however, as the technology advances, it becomes both cheaper to install and more efficient, thus becoming more and more viable alternative. So far the PV market has been dominated by a few countries, such as Germany, USA and Japan.

The PV technology uses semiconductors that convert sunlight into direct current electricity. It can be divided into two main categories- crystalline silicon and thin film technologies. This study will focus on crystalline silicon, which has been developed further and is thereby more efficient and affordable. Crystalline silicon accounts for 85-90% of the installed solar energy production capacity today.[9]

3 Arguments for using solar energy in the Philippines

Climate analysis for Metro Manila

According to the climate data of Metro Manila (Table 1), the solar radiation is above 15 MJ/m^{2}day almost throughout the whole year. This makes the it a very suitable location for harvesting solar energy. Furthermore, there is most radiation in the period from March to June, which coincides with the hottest period and thereby also the peak of electricity consumption, due to the need of cooling. It can also provide an independent energy source for households during brownouts, which are likely to occur in that period. Therefore it makes good sense to utilize the solar energy in the Philippines.

[8] Varnäs, Fahnestock, et al, 2012
[9] Varnäs, Fahnestock, et al, 2012

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Sunshine													
real	6.0	7.0	7.5	9.0	7.0	5.0	4.0	4.0	4.0	5.0	5.0	5.0	hours/day
max.	11.2	11.5	11.9	12.4	12.7	12.9	12.8	12.5	12.1	11.6	11.3	11.1	hours/day
%	54%	61%	63%	73%	55%	39%	31%	32%	33%	43%	44%	45%	
Radiation	14.9	17.4	20.9	22.5	20.2	19.9	17.4	15.1	16.9	15.4	15.4	14.7	MJ/m²day
Temperature													
Mean Max	29.9	30.3	31.7	33.0	32.7	31.2	30.4	30.0	29.7	30.7	30.1	29.7	°C
Mean	26.5	26.9	28.1	29.4	29.5	28.4	27.9	27.6	27.2	28.0	27.2	26.7	°C
Mean Min	23.0	23.5	24.5	25.7	26.3	25.5	25.4	25.2	24.7	25.2	24.3	23.7	°C

Table 1: Metro Manila climate and solar radiation data[10]

Household energy need

An average household in the Philippines uses 211 kWh of electricity per month, which costs them about 12% of their income.[11] Electricity is therefore a major expense for Filipino families. In comparison, a household of four persons living in Sweden consumes about 340 kWh in an apartment and 420 kWh in a house,[12] which corresponds to 1-2% of their disposable income.

Manila Electric Company (Meralco), supplier of about 55% of the consumed electricity in the country,[13] had a selling rate for residential customers at 11.13 PHP/kWh in March 2015.[14] Chart 2 shows that the electricity price in the Philippines has more than doubled during the last 15 years.

[10] Data from www.weather2travel.com, collected by E. Johanson
[11] Wooton, 2013
[12] Energirådgivaren, 2011
[13] Meralco, 2015
[14] Department of Energy, 2015

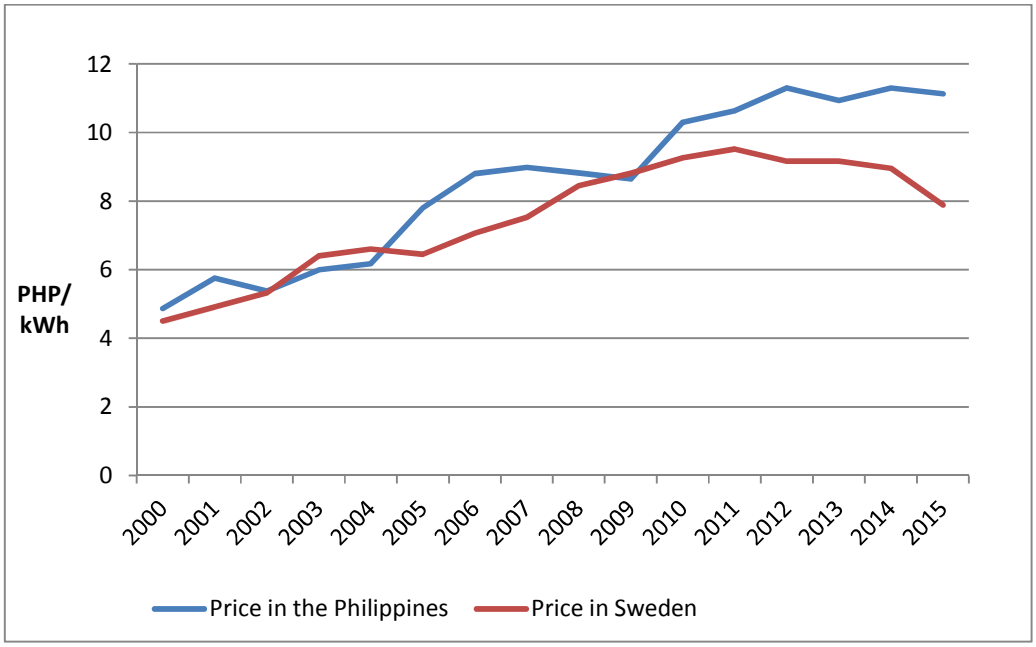


Chart 2: Average prices of electricity for residential customers in the Philippines and Sweden in 2000-2015[15]

4 Design for photovoltaic system

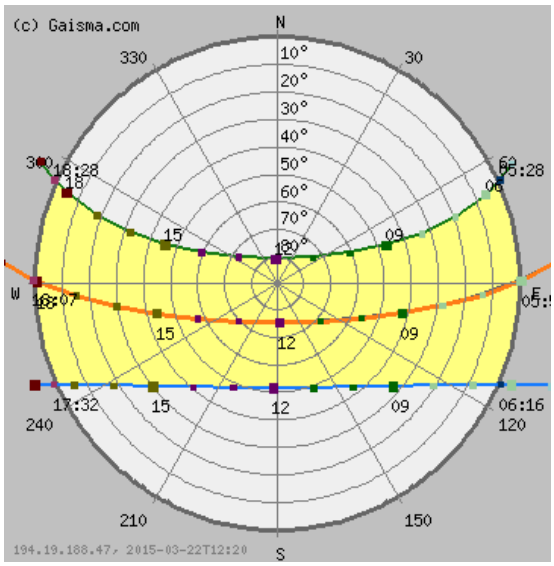
Case study building

To examine the feasibility of using solar energy, a case study of a typical modern low-income apartment building will be used as an example (see Figure 1). This is a building located in National Housing Authority (NHA) development in Barangay Holy Spirit, Quezon City, Metro Manila. The 5-storey building comprises 60 units of 24m^2 each and has pitched roof with an approximate area of 414 m^2.

Figure 1: NHA building in Metro Manila[16]

[15] Data from Meralco, 2015; Department of Energy, 2015; Statistiska Centralbyrån, 2015
[16] Photo: Author

Optimizing slope and orientation



As the Philippines is located in the equatorial zone, at noon the sun is close to the zenith most days of the year, and can be from both North and South directions. That suggests that the PVs would get most sun radiation when placed on the rooftops of buildings. PVs on the facades, on the other hand, would be shaded some parts of the day and are therefore not as effective.

Chart 3: Sun pattern in Manila[17]

Table 2 shows the estimated yearly production of 1 kWp PV system according to the slope and orientation of the PV cells. The results are generated by the Photovoltaic Geographical Information System. According to the data the most optimal solution would be placing the PVs horizontally. However, a horizontal roof is not practical considering the local climate with heavy rain falls; therefore a 15 degree slope is recommendable. While East-West orientated panels would produce slightly more energy than North-South orientated panels, the difference is so small that it can be disregarded. The calculated results are including combined system losses of 32%.

	Slope of PVs				
Orientation of PVs	1º	15º	30º	45º	90º
North	1250	1160	1010	810	270
South	1260	1290	1270	1190	604
North-South average	**1255**	**1225**	1140	1000	437
East	1250	1230	1170	1080	634
West	1250	1230	1170	1070	630
East-West average	**1250**	**1230**	1170	1075	632

Table 2: Total yearly production in kWh of installed 1 kWp PV system[18]

[17] Source: http://www.gaisma.com
[18] Data calculated using tool from http://re.jrc.ec.europa.eu/pvgis/apps4/pvest.php

System size and production capacity

A polycrystalline PV system of 1 kWp occupies an area of about 6.75 m^2. Thereby the example building's roof with an area of 414m^2 could accommodate 414/6.75=~ 60 kWp system. Such a system will produce 60 kWp*1230 kWh= 73,800 kWh of electricity annually. The annual energy consumption of the whole building is 60 units* 211 kWh/per month*12 months = 151,920 kWh. As a result, this 60 kWp PV system will provide roughly half of the energy needed for the households in the sample building on an annual basis.

Figure 2: Rooftop PV system[19]

Economic benefits for households

The investment cost for a PV system of 60 kWp is about 4,500,000 PHP including installation. [20] The yearly saving at current electricity price of 11.13 PHP/kWh is 821,000 PHP in total and 13,700 pesos per household. At the current installation cost and electricity price the investment will be paid back in 5.1 years. However, if the electricity prices keep rising, the period is likely to be even shorter.

Feed-in tariffs and net-metering

There has been a shift in recent years to promote the use of renewable energy in the Philippines. In 2012 the Energy Regulatory Commission fixed feed-in tariffs (FIT) for alternative energy producers. For solar energy the FIT is set to 9.68 PHP per kWh.[21] This opened up the possibility to sell the excess energy to the grid. However, since FIT is lower than the residential buying rate of 11.13 PHP per kWh, it is more beneficial to produce energy for own use rather than for sale.

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[19] Photo: from www.solar-philippines.com

[20] Estimated price, an average of two price quotes from a German (68,000 EUR) and a Filipino company (4,800,000 PHP)

[21] Renewable Energy Philippines, 2012

5 The Role of Architects

A PV system can quite easily be installed on almost any new or existing roof construction, but it can sometimes be challenging to do it in a functional and aesthetically pleasing way. This is especially relevant in a dense neighbourhood with different building heights, where there are windows overlooking other rooftops. The architect's role is to find the best solution for integrating the PVs in the building design. That should be done in a way that is both practical, ensuring that the PVs get maximum sun exposure, but also appear as a natural part of the building.

At the moment the most common solution is to mount the PVs on top of the roofing material. They key is to achieve an arrangement of the cells that creates a harmonious surface, taking into account skylights, ventilation openings, etc. An alternative solution is to use the PVs themselves as a roofing material. The PVs can be designed to resemble the looks of traditional roofing materials, such as tiles or shingles. This is still not common, because of some disadvantages; most importantly this system has lower production and is therefore less cost-effective than conventional PVs.[22] However, the PV technology is developing rapidly and it might become a viable solution in few years time, which might revolutionize the way buildings participate in the energy cycle, from consumers into producers.

Figure 3: A well-integrated solution, +energy house in Åkarp[23]

Figure 4: PVs as roofing material[24]

[22] Photovoltaic Solar Panels, 2014
[23] Photo: Author

Glossary

Brownout	Power outage
Household	People who live within the same physical structure and have common use of resources e.g. kitchen/sanitation, electricity, income, labour, equipment
Metro Manila	The National Capital Region of the Philippines. It consists of 16 cities and one municipality.

Acronyms and abbreviations

FIT	feed-in tariff, a buying rate offered to alternative energy producers
kWh	kilowatt hour, unit of energy
kWp	kilowatt peak, measure of the peak output of a PV system, the maximum possible output of a solar generator operating under standard conditions
MERALCO	Manila Electric Company
NHA	National Housing Authority, government-owned and -controlled corporation that is mandated to focus on socialized housing development in the Philippines
PV	photovoltaic, method of converting solar energy into direct current electricity using semiconducting materials
PHP	the Philippine peso, official currency of the Philippines, exchange rate 1 PHP=0.02 EUR as of 19.04.2015

[24] Source: www.ecofriend.com

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