Electricity from solar energy in Malaysia: Clean, renewable, and abundant energy source, so what’s the problem?

In 2010, Malaysia’s electricity generation totaled at 137,909 GWh. Malaysia, being near the equator, receives between 4,000 to 5,000 Wh per sq. m per day. This means, in one day, Malaysia receives enough energy from the Sun to generate 11 years worth of electricity. This is an incredible potential amount of energy into which Malaysia can tap.

Malaysia currently adopts a five-fuel mix (gas, coal, hydro, oil, and other sources) for electricity generation. From 2000 to 2010, electricity generation in Malaysia increased an average of 8% per year from 69,280 GWh in 2000 to 137,909 GWh in 2010. In this period, the contribution from gas for electricity generation declined from 77.0 to 55.9%, hydro from 10.0 to 5.6%, and oil from 4.2 to 0.2%. In contrast, the contribution from coal for electricity generation increased from 8.8 to 36.5% and other sources from 0.0 to 1.8%.

Under the 10th Malaysia Plan, the Malaysian government wants 5.5% of total electricity to come from renewable energy sources by 2015. However, the current contribution from renewable sources (such as biomass, biogas, wind, and solar) for electricity generation remains very low, of which solar energy only contributes a mere 0.007% of the total generated electricity in Peninsular Malaysia. The negligible contribution by solar energy is due to several reasons. One of them is the lack of awareness among Malaysians about the use of solar energy for electricity generation. However, the largest hurdles to solar energy adoption are
the high cost and low efficiency of solar panels or photovoltaic (PV) cells.

Solar irradiance generally declines from the north to the south of Malaysia, so that northern states such as Kedah, Penang, Kelantan, and Sabah receive the most amount of solar radiation, whereas southern states like Johor and Sarawak receive the least (Fig. 1). The mean daily sunshine hours in Malaysia ranges between 4 to 8 hours per day.

![Fig. 1. Average daily solar radiation (MJ per sq. m) across Malaysia (Mekhilefa et al., 2012)](image)

On average, Malaysia receives about 17 MJ per sq. m of solar radiation per day (Fig. 2 and 3). From 1989 to 2008, there is no trend that the average daily solar radiation would increase or decrease throughout this period, except for towns such as Kuala Terengganu and Senai where there is a weak linear trend showing a decline in solar radiation received by these two towns. Kota Kinabalu in Sabah also showed declining solar radiation from 1990 to 1999, after which solar radiation would increase and stabilize at around 20 MJ per sq. m per day.
In Malaysia, solar energy is used for two purposes: 1) solar thermal applications, and 2) **PV technologies**. Solar thermal applications are where heat from the solar energy is used for heating purposes, while PV technologies are for electricity generation.

Solar panels for either thermal or electricity purpose can be mounted on rooftops. Although the rooftops of house and buildings are said to be “dead space” because they are unused, not all rooftops are suitable to be mounted. It is estimated that only 2.5 million houses and 45,000 commercial buildings in Malaysia are suitable for solar panel mounting. This is because the design and orientation, as well as
the external environment, of the buildings would affect the harvest of solar energy.

PV cells are emerging as one of the attractive alternative to national utility grid power. PV systems was introduced in Malaysia in the 1980s, and from 1998 to 2002, six pilot grid-connected PV systems was setup at high monetary costs. Since then, PV systems have grown steadily so that in 2005, a total of on-grid 470 kW peak was established, with 3 MW peak as off-grid.

![Solar panels on a rooftop of a bungalow in Malaysia (photo from mbipv.net.my)](image)

To further encourage the adoption of solar energy, the Malaysian government introduced the MBIPV *(Malaysia Building Integrated Photovoltaic)* project in 2005. MBIPV was to design the integration of PV cells into buildings or structures; thus, saving costs because the PV systems would be fabricated within the structure of the building. MBIPV aimed to increase PV capacity in buildings by 3.3 times while reducing costs by 20% compared to the baseline. Currently, PV systems with a total of 213.61 kW peak have been installed over 18 locations in Malaysia via the MBIPV project. Moreover, through MBIPV, **SURIA 1000** was established, with the aim to install solar panels on 1,000 rooftops in Malaysia (to date, however, only about 100 households have PV systems in Malaysia).

One important progress towards reducing dependency on fossil fuels and mitigating climate change is the establishment of **Feed-in-tariff (FiT)** scheme in Malaysia last year. FiT encourages the adoption of renewable energy such as solar energy by households by enabling house owners to sell excess electricity generated from their homes to **TNB (Tenaga Nasional Berhad)**, for example. For
every 1 kWh, house owners could get between RM1.20 to 1.23. Moreover, homes with solar PV would obtain an additional 26 cents. It is thus possible for house owners to earn as much as RM700 per month if they could generate as much as 4kW peak of electricity from their homes.

Although Malaysia is the world’s fourth largest PV modules producer, solar technology is ironically not adopted widely here. One reason is the cost of installing PV systems in Malaysia is expensive, even though the cost is falling at a rate of more than 10% per year. In 2005, for instance, the cost of PV system per kW peak was RM31,410, falling to RM24,970 in 2007, and to RM20,439 in 2009. Today, the cost has reduced to about RM15,000 per kW peak – a rate still unaffordable or impractical to most Malaysians.

There are four kinds of PV solar panels available in Malaysia: mono-crystalline silicon (Mc-Si), poly-crystalline silicon (Pc-Si), copper-indium-diselenide (CIS), and thin film amorphous silicon (A-Si). A study by UKM showed that none of these solar panel types had more than 10% efficiency in converting solar energy into electricity. The module efficiency for Mc-Si, Pc-Si, CIS, and A-Si were measured at 6.9, 5.1, 4.0, and 2.2%, respectively. In addition, Mc-Si and Pc-Si performed best under clear skies, whereas CIS and A-Si did better under cloudy skies.

The low efficiency of PV panels sold in Malaysia is bad news because a great deal (more than 90%) of solar energy is unused for electricity generation. The implication is serious: a very large area of solar panels, costs notwithstanding, would be required for utilizing solar energy for electricity. How much land area? Let’s calculate.

1 MW of electrical generation is equivalent to:

\[1,000,000 \text{ W} \times 365 \text{ days} \times 24 \text{ hours} = 8.76 \text{ billion Wh}\]

As stated earlier, Malaysia receives 4,000 to 5,000 Wh per sq. m per day, taking 4,500 Wh per sq. m per day on average. In a year, this daily average is equivalent to:

\[4,500 \text{ Wh per sq. m} \times 365 \text{ days} = 1.642 \text{ million Wh per sq. m}\]

However, since the highest solar panel efficiency is nearly 7% (for Mc-Si), this means the total amount of solar radiation energy used for electricity generation is
only:

1.642 million Wh per sq. m x 0.07 = 114,975 Wh per sq. m

Thus, the total land area needed for solar panels is:

8.76 billion Wh / 114,975 Wh per sq. m = 76,190.48 sq. m

This means for every 1 MW of electricity required, about 76,000 sq. m of land area in Malaysia is required for harvesting solar energy. To meet even 1% of Malaysia’s electricity demand will require a land area of 12 square kilometers for PV panels and at a cost of about RM20 trillion!

Consequently, solar energy, as well as other renewable energy, cannot be a major contributor for electricity generation in Malaysia. This would be true until solar technologies become affordable enough and the technologies become much more efficient in electricity generation from solar energy. At the moment, solar energy, at best, could supplement Malaysia’s energy supply.

References

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Electricity demand, economic growth, and sustainable energy resources in Malaysia

In my previous blog entry, I wrote about the consequences of large dams, such as Malaysia’s Bakun Dam, on social and environment aspects. Essentially, I remarked that Bakun Dam, as a hydroelectric dam, is not a sustainable energy choice because it causes serious, long term, and irreversible destruction to many social and environmental aspects. Moreover, the expected lifespan of the gargantuan Bakun Dam could be shorten from 50 to 30 years if serious buildup of silt (sediments) occurs.
The Malaysian government’s perseverance with the construction of Bakun Dam contradicts the country’s Green Technology policy, launched in mid 2009, which seeks for more sustainable sources and technology development for energy.

That said, however, the construction of Bakun Dam is justified strictly from an economic point of view. Malaysia’s aspirations for higher economic growth to break Malaysia from the so-called “middle-income trap” and to become a developed nation mean much more energy is required.

Malaysia’s consumption of energy increases every year. In 2008, the total energy demand in Malaysia was 522,199 GWh, of which the industrial and transport sectors were the two largest users of energy, accounting more than three-fourths of this total demand. The residential and commercial sector was the third largest user (14%) of energy in Malaysia, and only 1% of the total energy was consumed by the agriculture sector.

The consumption of electricity in Malaysia rises rapidly every year, with an average of 2,533 GWh per year. The electricity consumption, for instance, in 1971 was 3,464 GWh and 94,278 GWh in 2008. By 2020, Malaysia’s electricity consumption is expected to increase by about 30% from its present value to 124,677 GWh.
Moreover, there is a strong relationship between Malaysia’s GDP (Gross Domestic Product) and Malaysia’s electricity consumption. To put it succinctly: high GDP = high economic growth = high production = high energy. For every 1 USD increase in GDP (at year 2000 rate), electricity consumption would increase by 13 Wh.

At full operation, Bakun Dam would most probably generate 10,512 GWh (50% of its potential capacity, the world average for hydroelectric dams), which means
that Bakun Dam could contribute nearly 8.5% of the expected electricity demand by 2020.

Thus, from these projections, Bakun Dam is needed to support Malaysia’s desire for high economic growth. But looking solely from an economic perspective is myopic because Bakun Dam, as stated earlier, is socially and environmentally destructive. But what are the sources of green energy in Malaysia?

Traditionally, Malaysia’s energy sources for electricity are based on a “four-fuel mix” strategy: gas, oil, hydro, and coal. From 1970 to 1980s, oil was relied heavily for electricity generation, but this over-reliance led to rapid depletion oil in Malaysia. But since the mid 1980s, gas and coal are increasingly being relied on for electricity generation. By 2010, for instance, it is estimated that gas and coal would contribute 92% of the sources for electricity generation. Hydro and oil would contribute the rest (7 and 1%, respectively).

Recently, the government has started to introduce a “five-fuel mix” strategy with renewable energy as the fifth source for electricity generation. The most promising potential for renewable energy in Malaysia is the biomass and biogas from the oil palm industry. This is not surprising considering that 15% of the total land area of Malaysia is covered by this single crop alone.
There are 417 palm oil mills in Malaysia, of which 246 are in Peninsular Malaysia and 117 in Sabah. These mills discard about 30 million tonnes of biomass, including empty fruit bunches (EFB) and other residues (shells and fibers), every year. Every tonne of EFB could potentially produce about 40 W of electricity, whereas every tonne of biomass residues (shells and fibers) an average of 148 W.

In addition to these oil palm biomass wastes, palm oil mills also produce about 43 million tonnes of palm oil mill effluent (POME) per year. These effluents, due to anaerobic (oxygen poor) conditions, emit greenhouse gases such as methane (65%) and carbon dioxide (35%). These biogases could be captured for electrical generation, rather than polluting the air and contributing to global warming. The biogases emitted from every tonne of POME could be captured to potentially generate 8 W of electricity.
At **Copenhagen Climate Change Conference 2009**, Malaysia pledged to reduce the country’s carbon emission by 40% by 2050. Part of this would be achieved by boosting renewables’ contribution to energy from the current 50 MW to 2,000 MW by 2020. This is certainly achievable considering that biomass and biogas from the palm oil mills could potentially contribute over 3,200 MW of electricity per year. This also means that, potentially, Malaysia’s oil palm could contribute about 28,000 GWh or meeting more than one-fifth of Malaysia’s electricity demand by 2020.

However, problems of irregular EFB supply and technology limitations currently hamper full exploitation of oil palm biomass for electrical generation.

Another major contender for renewable energy source is solar radiation. Being near the equator means Malaysia enjoys 12 hours of daylight per day all year round. On average, Malaysia receives 3 kWh per square meter per day from solar radiation.

The **Suria 1000 programme** is a government-initiated scheme to use photovoltaic solar cells to capture solar radiation for use in residential and commercial sectors. Photovoltaics, unfortunately, suffer from low solar-to-electricity efficiency. On average, photovoltaics have 10% efficiency.

This means photovoltaics would convert captured solar radiation into electricity at a rate of $3 \times 0.1 = 0.3$ kWh per square meter per day. As stated earlier, Malaysia’s demand in electricity by 2020 would reach 124,677 GWh. So, if we want solar power to contribute 10% of this expected electricity demand, the total land area needed for photovoltaics is: 

$$\frac{124,677 \times 1000 \times 1000 \times 0.1}{0.3 \text{ kWh per square meter x 365 days}} = 114 \text{ square kilometers}.$$ 

Malaysia’s total land area is nearly 330,000 square kilometers, so the fraction of land area needed for photovoltaics (114 square kilometers) is only 0.03%. We can further work out that to completely contribute to Malaysia’s electricity demand in 2020 by solar power (100% contribution), the total land area needed for photovoltaics is only 1,140 square kilometers or 0.3% of Malaysia’s total land area.

So, even though solar photovoltaics suffer from low conversion efficiency, the land area needed to capture solar radiation for electricity generation is no more than one-third of 1% of Malaysia’s land area. Moreover, solar photovoltaic cells
can be placed on roofs of houses and buildings, so these cells can occupy the same land area as houses and buildings (no additional land area required for photovoltaic cells if they are placed on roofs).

However, photovoltaics are prohibitively expensive at present. It costs about RM22.50 for every 1 kWh of electricity generated per year. This means for photovoltaics to contribute to even 10% of expected electricity demand by Malaysia in 2020, the total cost for photovoltaics would be over RM280 billion!

If Malaysia is willing to spend RM7 billion on Bakun Dam for electricity generation, the cost of photovoltaics must fall to about RM0.50 per 1 kWh of electricity. Possible? This is a fall in cost by a whooping 45 times than the present rate. Although the technology in solar power is progressing fast and cost falling, it is unlikely that solar power can be a major contributor to electricity generation in Malaysia in the short term.

Geothermal power is another source of renewable energy in Malaysia, but its source is currently untapped. This is unfortunate because Malaysia lies in a geothermal region. Countries like Indonesia and Philippines are already utilizing geothermal as a source of electricity, producing about 1,196 and 1,930 MW, respectively. Recently, a geothermal reservoir was found in Tawau, Sabah, which has the potential to provide up to 67 MW of electricity.
And there is of course nuclear energy. Although nuclear is a non-renewable energy, its use to meet Malaysia’s energy demand must be considered. Nuclear energy suffers from a poor reputation, but its safety record is improving. Countries that derive their electricity from nuclear energy such as France, South Korea, Germany, and Japan shows that nuclear energy is a practical and safe solution as well as having very low carbon emission. Nonetheless, building nuclear power stations are very costly (nearly RM10 billion a station) and require lengthy period before these stations could go on-line (about a 10-year preparation).

Other than finding sustainable sources of energy, the Malaysian government is planning to improve energy efficiency and to promote awareness among the public on the importance of energy conservation.

In conclusion, Malaysia faces big challenges ahead to meet the country’s growing demand for energy using sustainable practices. Malaysia can succeed provided there is a concerted effort for increasing the: 1) implementation and management of sustainable energy sources, 2) energy efficiency, and 3) awareness by the Malaysian public on energy issues and a change of lifestyle that has a lower carbon footprint.