Possibility of electricity from wind energy in Malaysia: Some rough calculations

Update (10 Apr. 2013): This article was used as a source of reference in the New Straits Times article "Getting wind of the situation" (pg. 7, Green Technology section, April 9, 2013) by Gregory Basil.

Is it possible to harness the wind energy on a large-scale basis to generate electricity in Malaysia? Malaysia's mean annual wind speed is low at no more than 2 m/s. Nonetheless, the wind does not blow uniformly throughout Malaysia; wind speed varies according to region and month.

What's the future for wind energy in Malaysia? (photo from pkukmweb.ukm.my/~jkas)

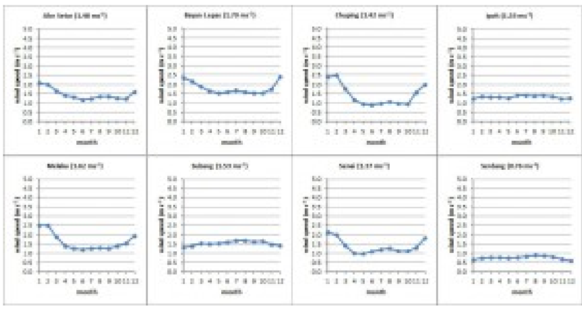
Malaysia experiences two main weather seasons: southwest monsoon (May/June to September) and northeast monsoon (November to March). Wind speeds during the southwest monsoon are often below 7 m/s, but during the northeast monsoon, wind speeds could reach up to 15 m/s particularly in the east coast of Peninsular

Malaysia. Moreover, during April to September, the effects from typhoons striking neighbouring countries (such as Philippines) may cause strong winds (even exceeding 10 m/s) to Sabah and Sarawak.

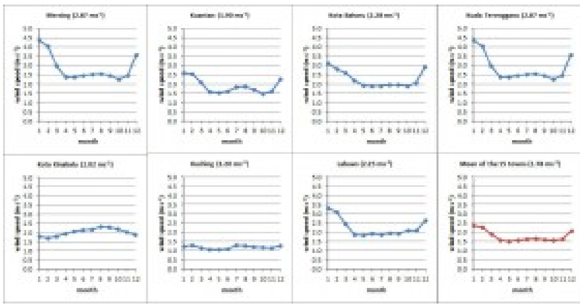
So although Malaysia, as a whole, experiences low wind speeds, some areas in this country see strong winds during certain periods of the year.

I requested the wind speed data for 14 towns from all over Malaysia from the [Malaysian Department of Meteorology](). These data were from 1989 to 2008 (20 years), and in addition to them, I included the wind speed for Serdang, the town where my [university main campus is located](). For Serdang, the wind speed data were from 1985 to 2007 (23 years). All wind speeds were typically measured 2 meters above the ground.

From my analyses, Malaysia experiences stronger winds in the early and late parts of the year. On the whole, Malaysia's mean annual wind speed is 1.8 m/s. However, towns in the east coast of Peninsular Malaysia such as Mersing, Kota Baharu, and Kuala Terengganu experience stronger winds. For these places, their mean monthly wind speed could exceed 3 m/s. East Malaysian towns, Kota Kinabalu and Labuan (with the exception of Kuching) also see stronger wind speeds than the national average.



Mean monthly wind speed for several towns in Malaysia, 1989-2008. Mean annual wind speed of a given town in brackets (1 of 2)



Mean monthly wind speed for several towns in Malaysia, 1989-2008. Mean annual wind speed of a given town in brackets (2 of 2)

Okay, let’s round up the mean wind speed of Malaysia to 2 m/s. This is the national average of wind speed at 2 m height above ground. Roughly, doubling the height increases wind speed by 10%. Since a typical wind turbine is 32 m above ground, this means the average wind speed at the height of 32 m above ground increases to nearly 3 m/s.

The energy per square meter area of a wind turbine is determined as:

0.5 x air density (kg per cubic meter) x wind speed x wind speed x wind speed

Note that wind speed (m/s) is cubed (multiplied by itself thrice). Using the aforementioned equation and taking air density as 1.3 kg per cubic meter and mean wind speed as 3 m/s give the energy per square meter area of a wind turbine as 17.55 W.

The diameter (d) of a typical wind turbine is 25 m, so the circular area of a wind turbine is:

3.142 x 0.25 x d x d = 491 square meter

Hence, the total power generated from a single windmill is:

17.55 W per square meter x 491 square meter = 8,617 W

However, the efficiency of windmills is not 100% but typically only about 50%. This means the actual total power generated from a single windmill (*i.e.*, after correcting for inefficiency) is half of 8,617 W or 4,309 W.

Now let’s determine the power that could be generated from a square meter of land area occupied by windmills. Windmills cannot be placed too closely to each other. Doing so would cause one windmill to slow down the wind speed for another windmill. But placing windmills too far from each other wastes land area. Typically, windmills are placed no less than five times their turbine diameter without losing power. Hence, the power that could be generated by windmills per unit land area is

power per windmill (W) / land area per windmill (square meter)

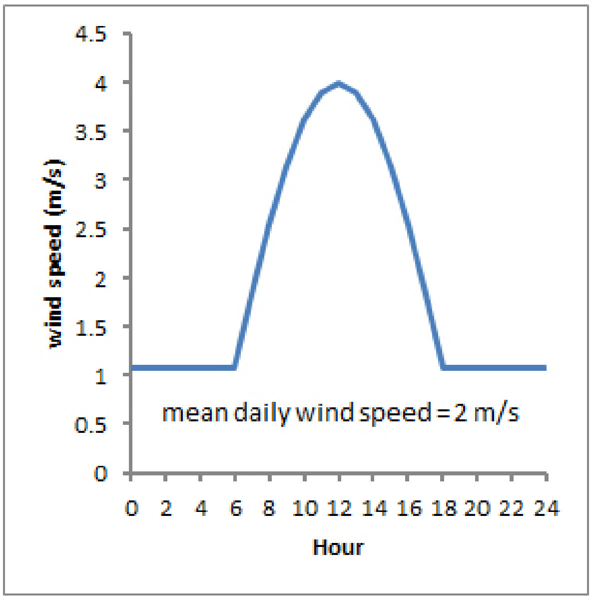
or

4,309 W / [(5 x 25 m) x (5 x 25 m)] = **0.28 W per square meter land area**

Recall that the diameter of a typical wind turbine is 25 m and two adjacent windmills are placed apart by five times their turbine diameter.

Windmills typically require a minimum wind speed of between 3 to 5 m/s to generate electricity. This means there would be periods of too low wind speeds for the windmills to generate electricity. Periods in a day with enough wind speed for the windmills to generate electricity is called "load factor" or "capacity factor". So, what is the load factor for windmills in Malaysia on the whole?

In calm weather, the typical wind speed distribution in a day can be depicted as below.



Idealized daily wind speed distribution in Malaysia

Wind speed is higher during the day (from sunrise to sunset) than that during periods before sunrise and after sunset. Wind speed follows a sine curve during the day, and it remains constant for periods before sunrise and after sunset. I am going to roughly estimate Malaysia's load factor by assuming that maximum wind speed is twice the daily average wind speed and that the average wind speed during the day is also twice that during early morning and night.

Consequently, the period when wind speed exceeds 3 m/s, which is required for windmills to generate electricity, is calculated to be from 8:45 to 17:15 hours. This is a duration of 6.5 hours or a load factor of 27% where windmills are able to harness the wind for electricity generation.

Thus, the power that could be generated by windmills per unit land area is 27% of 0.28W, which is **0.0756 W per square meter land area** or **1.8 Wh of electricity generated per square meter land area per day**.

Malaysia's demand in electricity by 2020 is expected to reach 124,677 GWh, so if wind power is to meet, say, 10% of this projected electricity use, the total land area of Malaysia needed for windmills is:

(124,677 x 1000 x 1000 x 1000 x 0.1) /(1.8 x 365) = 18,977 square kilometer

This area is equivalent to 6% of the total land area of Malaysia, or equivalent to over 1.2 million windmills to be set up.

Currently, it cost about RM1 for every 1 W of electricity generated from wind energy in Malaysia. Thus, to meet 10% of Malaysia's electricity demand in 2020 would cost approximately RM1.4 billion to setup the required number of windmills. These figures so far show it is plausible to harness the wind energy for electricity generation in Malaysia.

Although the minimum wind speed required for windmills is between 3 to 5 m/s, the minimum wind speed for commercial viability is instead 7 m/s. None of the 15 towns I analyzed had mean monthly wind speeds exceeding even 5 m/s.

According to Tenaga Nasional, in collaboration with Argentina's renewable energy firm, Industrias Metalurgicas Pescarmona S A (Impsa), 500 to 2000 MW worth of electricity could be generated from wind energy in Malaysia (meeting between 3.5 to 14% of the expected demand in electricity by 2020). They further reported there are areas such as the Malaysian-Thailand border which see wind speeds up to 15 m/s.

It is interesting to note that wind energy suffers contrasting problems with solar energy. Technology for solar energy is prohibitively expensive for large scale use in Malaysia. In contrast, harnessing wind energy is much cheaper than that for solar energy to set up in this country. Malaysia enjoys plenty of sunshine (as much as 3 kWh per square meter) all year round, but Malaysia sees only low wind speeds and sees high winds only at certain times of the year.

Windmills in Perhentian Island (photo from razmahwata.wordpress.com)

I believe there is certainly an avenue for using wind energy in Malaysia, but wind energy can only be used in limited areas and in certain periods only (*e.g.*, early and late in the year). Coastal areas, especially in east Peninsular Malaysia and East Malaysia, including small islands (such as Perhentian Island), could benefit from wind energy. But for the majority of Malaysia, the solution of large scale and uninterrupted renewable energies lies elsewhere.

References

1. "Sustainable Energy – Without the Hot Air" by David J.C. MacKay, UIT Cambridge Ltd., 2009.
2. "Harnessing the power of the wind" by Yvonne Chong, Malaysian Business, Oct. 16, 2009.