Wind cannot be Directed but Sails can be Adjusted for Malaysian Renewable Energy Progress

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Abstract. Wind energy has been the promising energy technology since 1980s in terms of percentage of yearly growth of installed capacity. However the progress of wind energy has not been evenly distributed around the world. Particularly, in South East Asian countries like Malaysia and Singapore, though the Governments are keen on promoting wind energy technology, it is not well practiced due to the low wind speeds. Owing to the recent advancements in wind turbine designs, even Malaysia is well suited for wind energy by proper choice of wind turbines. As evidence, this paper presents successful wind turbines with simulated study outcomes to encourage wind power developments in Malaysia.

1. Introduction
Wind energy is used extensively to generate electricity in various part of the world. In fact, using wind as an energy source, it has a positive impact on the environment and on the cost of electricity [1]. This source is cheap and inexhaustible energy. Depending on availability, wind as a source of energy is one of the cleanest and reliable source of energy. As reported in Global wind statistics 2012, the energy generated using wind was about 282,586 MW [2]. The contribution of each region of the world is indicated in Fig. 1. Europe, Asia and North America accounted the large portion of wind power capacity. Even though Asia and the pacific region contributed high percentage of wind power, the large portion of the wind power capacity was being contributed by China and India which are 77% and 19% respectively. These results show that the usage of wind as an energy source in other Asian countries is very limited. One of the reasons of limited usage of wind as an energy source is the wind speed [3]. The average annual wind speed should be at least 4.0 to 4.5 m/s in order to run the wind turbine effectively. However, some of the Asia countries like Malaysia and Singapore have very low wind speed which is not adequate to generate power effectively. The annual wind speed Malaysia is less than 3m/s at 10 m height from ground level [4] which is too low. Thus, the Malaysia’s ability of generating power from wind is insignificant. In this paper, Malaysia wind energy opportunity has been discussed in detail and possible recommendations on suitable technologies and associated cost related to the technologies will be drawn.

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2. Malaysian energy scenario

2.1. Country Profile

Malaysia, a Southeast Asian nation, has two distinctive land extents; the western area contains the Peninsular Malaysia and the eastern part includes the states of Sarawak and Sabah, which shares the island of Borneo with Indonesia and Brunei [5]. It is situated in the equatorial zone in between $3^\circ 10'$ in the North of latitude and $101^\circ 42'$ in the East of longitude. Malaysia has a land extent of 329,847 km$^2$ and a population of 30,142,072 in July 2014 [6]. Malaysia’s economy strengthened to a sturdy growth of 6.2 per cent, while on a quarter-on-quarter seasonally adjusted, the economy continued a positive momentum by registering 0.8 per cent. In the first quarter of 2014, the GDP in current terms amounted to RM 256.9 billion and the GNI stood at RM 250.5 billion [7].

2.2. Malaysia’s Energy Sector

Energy has contributed suggestively towards the rapid growth of the Malaysian economy. As Malaysia headways towards flattering an urbanized nation, energy consumption congruently increases. While meeting the increasing energy demand, strenuous efforts needed to be undertaken to guarantee grander security and sustainability of energy supply. The primary functional components of the energy sector are portrayed in Fig. 2. To facilitate the energy security and sustainability, the National Energy Policy by the Ministry of Energy, Green Technology and Water plays an important role as a guide to the development of the energy sector in the future. The objectives of the National Energy Policy are energy supply, energy utilization and environmental conservation as highlighted in Fig. 3 [8].
2.3. Supply and Demand

Energy has been commonly acknowledged as one of the most important inputs for economic growth and human development. There is a resilient two-way relationship between economic development and energy consumption. On one hand, growth of an economy, with its global attractiveness, hinges on the obtainability of economic and environmental friendly energy sources, and on the other hand, the level of economic development has been observed to be contingent on the energy demand [9]. Malaysia is well-endowed with both exhaustible and renewable energy resources. Malaysia’s primary energy sources comprise natural gas, coal, oil, biomass even though renewable energy sources such as solar, wind, geothermal, tidal and hydro are currently being exploited. According to Malaysia Economic Planning Unit (EPU) [10, 11], there is an estimated reserves of 5954 billion barrels of crude oil and condensates, 92.122 trillion standard cubic feet of natural gas and 1938.40 million tonnes of coal and coke. As per Economic Planning Unit, Green Technology and Water, Energy Commission, Tenaga Nasional Berhad, Sabah Electricity Sdn Bhd & Sarawak Energy Berhad [12], the primary commercial energy final demand in 2013 was found to be: Petroleum products - 1,063.3 Peta Joules (53.9%), Natural gas - 84.3 Peta Joules (19.5%) and Coal & Coke - 82.8 Peta Joules. Further, it is estimated that Petroleum products will grow at 3.02% p.a., Natural gas will grow at 3.48% p.a. and Coal and coke will grow at 6.04% p.a. As far as electricity is concerned, the installed capacity as of 2013 was found to be around 26400 MW and the peak demand of 19589 MW with a reserve margin of 33%. The reserve margin has been reduced by 17.88% compared to 2012 [13, 14]. Coal has become the largest fuel input in the power sector with a share of 53.9% per cent, followed by natural gas at 39.3 per cent, hydro at 6.6 per cent and oil at 7.5 per cent.

2.4. Challenges and Solutions

Malaysia’s energy sector is fronting with momentous challenges that sternly restrict its sustainability.

- Dependence on fossil-fuels: Major portion of Malaysia's electricity generation capacity is natural gas-fired, though gas dearth and mounting electricity demand in recent years have stirred the use of other fuels such as coal, diesel, and hydroelectricity. However, it is reported that the oil reserve in Malaysia will be depleted by this decade and gas by 2048 [15].

- Need for energy imports: Despite government efforts to preserve declining energy reserves, Malaysia will become a net energy importer in the next 20 years [16]. Net import dependency will reach 32 per cent in 2030.

- Optimum Energy Mix Policy: To aim at sustainable energy management, it is imperative that energy supply remains as reliable and as inexpensive as possible. Hence the energy sector should go for a balanced, best value-for-money mix of renewables and fossil fuels from...
domestic and foreign sources. The reliance on a single fuel need to be avoided. Nuclear energy is also a necessary part of the mix.

- **Energy efficiency:** Improved energy efficiency/energy conservation is an additional task of energy sector around the world. The benefits are - reduced investments in energy infrastructure, lower fossil fuel dependency, increased competitiveness and improved consumer welfare. Enhanced efficiency and energy conservation also deliver environmental benefits by reducing greenhouse gas emissions and local air pollution. By improving energy efficiency and energy conservation, the final energy consumption in the industrial, commercial and residential sectors need to be brought down by 10% by 2030.

- **Environmental concern:** Total CO2 emissions from fuel combustion are projected to reach 264 million tonnes CO2 in 2035, which is 46% higher than in 2010 and 360% higher than in 1990. By 2035, the biggest source of CO2 emissions is the electricity generation sector (33%), followed by the domestic transport sector (24%) and the industry sector (21%) [17]. As national and global concern, the emission due to production and utilization of energy need to be reduced to the safer level considering the frequent hazes in the various parts of the country. Reducing the usage of fossil fuels could be a timely solution.

- **Rural and secluded area electrification:** A meagre portion of the rural population and secluded communities were not adequately electrified. The limiting factors are
  - High cost of electrification
  - Need far-reaching and complicated installation works
  - Geographical obstacles
  - Long distance from National Grid sources
  - No contribution towards renewable energy

A Solar/wind hybrid power system suitable for future grid integration is a feasible solution for providing electricity to such rural and secluded societies.

### 3. Renewable energy opportunities

Malaysia's potential for renewable energy generation is significant. According to government targets, renewable energy should contribute at least 6 per cent to the country's generation mix by 2015. The National Renewable Energy Policy and Action Plan aim to draw more of the nation's electricity supply (11 per cent by 2020) from renewable energy. The Ministry of Energy, Green Technology and Water's Green Technology Financing Scheme offers incentives worth of RM1.5 billion to green technologies. Any renewable energy plant (including biomass, biogas, municipal waste, solar, mini-hydropower and wind) may apply to sell energy to the grid on a "willing seller and willing buyer" basis [18].

The Sustainable Energy Development Authority of Malaysia (SEDA Malaysia) is a statutory body formed under the Sustainable Energy Development Authority Act 2011 [Act 726]. The key role of SEDA is to administer and manage the implementation of the feed-in tariff mechanism which is mandated under the Renewable Energy Act 2011 [Act 725] [19]. The Feed-in Tariff (FiT) is simply a guaranteed price established for anyone who wants to sell renewable electricity to the grid and acts as a guarantee that they will have access to the grid to do so. The tariff is set so that a modest profit is ensured and unleashes the collective capital resources of the entire province, state or country to be part of the transition to renewable energy [20]. With a gorgeous FiT rate and profuse natural resources with achievable national goals (Fig. 4), Malaysia is appropriate for foreign investment in renewable energy projects.
4. Promising wind energy

Several countries globally recognize that the present-day energy developments are not sustainable and that a better balance must be found between energy security, economic development and protection of the environment. Malaysia has many renewable energy sources such as solar, wind, biomass, hydro, geothermal and tidal wave. However, it is not yet widely developed. Table 1 depicts the installed capacities of the various renewables as of 2014 and the renewable energy on-going projects expected to be functional in 2016 [19].

In particular to wind energy, only meager data is available with universities and research institutions. The Meteorological Department has been recorded the wind data at various stations particularly around airports at a height of approximately 10 meters. Some of the previous studies claim that wind power plant is feasible and offers a high potential based on theoretical simulations [12, 21, 22, 23]. Though not all areas in Malaysia are suitable for wind energy, the general assumption is that some locations have a good potential for wind power generation. However to know the realistic situation, a comprehensive wind map for Malaysia is being prepared to determine the potential for wind energy generation, which would be ready by 2015 [19].

Table 1: Renewable Energy Statistics [18]

| Status                      | Biogas (Landfill/Agri. Waste) | Biomass       | Biomass (Solid Waste) | Small Hydro | Solar PV | Total |
|-----------------------------|-------------------------------|---------------|-----------------------|-------------|---------|-------|
| Operational Plants (2014)   | 5.38 MW                       | 6.36 MW       | 43.40 MW              | 8.90 MW     | 11.70 MW| 118.28 MW|
| Plants in progress (functional in 2016) | 3.50 MW                     | 56.16 MW      | 114.75 MW             | 9.20 MW     | 215.59 MW| 500.33 MW|

Figure 4: - National Renewable Energy Goals
Table 2: Wind Turbine Performances at Low Wind Speed [26-28]

| Turbine           | Cut in wind speed (m/s) | Total investment (RM) | Net Income/Year (RM) | NPV (%) | (% Rate of Return (Year)) | Cost of generation (RM/kWh) | Capacity Factor (%) |
|-------------------|-------------------------|-----------------------|----------------------|---------|---------------------------|----------------------------|---------------------|
| Nordex N27/150    | 3                       | 433875                | 48534                | 5       | 9.30                      | 0.75                       | 4                   |
| Bonus 33.4/300    | 3                       | 867750                | 86495                | 5       | 7.71                      | 0.83                       | 4                   |
| NEG Micon 43/500  | 3                       | 1235000               | 133760               | 5       | 8.84                      | 0.77                       | 3                   |
| Nordex S70/1500   | 3                       | 5362500               | 389797               | 5       | 3.86                      | 1.09                       | 4                   |
| Nordex N29/250    | 4                       | 723125                | 52566                | 5       | 3.86                      | 1.09                       | 3                   |
| Vestas 44/600     | 4                       | 1482000               | 83832                | 5       | 1.21                      | 1.33                       | 2                   |
| NEG Micon 64/1500 | 4                       | 5362500               | 284102               | 5       | 0.56                      | 1.40                       | 3                   |

Table 3: Wind Turbine Economics

| Turbine           | Cut in wind speed (m/s) | Total investment (RM) | Net Income/Year (RM) | NPV (%) | (% Rate of Return (Year)) | Cost of generation (RM/kWh) |
|-------------------|-------------------------|-----------------------|----------------------|---------|---------------------------|----------------------------|
| Nordex N27/150    | 3                       | 433875                | 48534                | 5       | 9.30                      | 0.75                       |
| Bonus 33.4/300    | 3                       | 867750                | 86495                | 5       | 7.71                      | 0.83                       |
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| NEG Micon 64/1500 | 4                       | 5362500               | 284102               | 5       | 0.56                      | 1.40                       |
5. Conclusion

A simulation based study has been performed with several wind turbine manufactures at different cut in wind speeds. The wind turbine performances and the financial aspects are clearly depicted for reference. From the results, low cut in wind speed turbines such as 3 m/s yield a good rate of return at a minimum generation cost of 0.75 RM/kWh which returns a profit of 0.25 RM/kWh. Due to the advancements in wind turbine technology, lower cut in wind speed turbines (1 m/s, SheerWind Involex Technology) are entering into marketing, which in turn would result in potential benefits than the 3 m/s wind turbines. Since wind cannot be directed, our sails with suitable turbines can be adjusted to promote wind energy even in low wind profile regions.

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