Solar PV Renewable Energy Sustainability: Economic Essential or Financial Folly

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Abstract

In a period of falling energy prices, many sceptics have cast doubts on the sustainability of renewable energy (RE) projects. This paper will re-examine the difference between economic cost/viability (EIRR) and financial viability / bankability (FIRR) to place the subject matter of renewable energy feasibility and sustainability in its proper perspective. A review of the various components of economic costs for conventional fossil-fuel electricity is undertaken to assess the most suitable economic parameters. Current conventional financial analyses of projects do not consider the negative externalities of fossil-fuelled electrical energy generation. These negative externalities cause damage to the environment which directly contribute to (i) global warming/climate change (due to greenhouse gas emissions), (ii) human health problems (due to emissions, such as arsenic, mercury and other particulate matter) and (iii) other impacts to the environment (such as acid rain). The economic cost parameters of these negative externalities will be featured, and they will be used to highlight the substantial economic benefits of emission-free RE solar PV electricity which is the most popular RE type currently deployed in the Malaysian electricity grid. In this context, the Paper will analyze solar PV projects from both the financial and economic perspectives which will include the impact of these externalities on the levelised cost of electricity (LCOE). This short-term deficits in financial viability are compared in conjunction with the long-term benefits and suggest the need to consider policy mechanisms which deal with this viability profile. This could form a bridge between policy maker's intent that decisions are economically based and funder's requirements that are principally governed by financial viability / bankability.

1 Introduction

Thermal Power Generation and Carbon Emission

Thermal Power generation is the backbone of electricity supply in Malaysia as it generates approximately 340,200 GWh to deliver final electrical energy consumption of 116,353 GWh. Major contributors include Coal Fired Power Plants which constitute 164,316.6 GWh (48.3%) and Natural Gas Power Plants which constitute

134,379 GWh (39.5%). The other components that make up the total figure are Hydro, Diesel, Oil and Renewable Energy which constitutes 25,174.8 GWh (7.4%), 9,185.4 GWh (2.7%), 6,464.8 GWh (1.9%) and 680.4 GWh (0.2%) respectively (*National Energy Balance 2012 Report)* [1]

This however comes at a large cost principally in terms of Carbon Dioxide emissions which is the most important agent in climate change. It has been accepted by most relevant scientific bodies that the emissions of anthropogenic greenhouse gases is slowly changing the climate and will continue to do so. Carbon dioxide in particular, is the primary greenhouse gas emitted by human activities and in June 2014, global concentration of carbon dioxide in the atmosphere was approximately at 400 parts per million.

In Malaysia, the increase in carbon dioxide emission levels emission levels may have been the catalyst of many environmental and health issues such as increases in drought and flooding, rising in sea levels, more frequent and extreme weather phenomena, greater spread of diseases and the increase in ocean acidification [2]. Malaysia has and will continue to face such issues if the situation of the increase in carbon dioxide emission levels is not adequately addressed. Thus, in order to maximize Malaysia's economic prospects, there must be a concerted effort towards quantitatively analyzing the benefit of employing technologies which reduce carbon dioxide emissions.

It is a weakness of the market that for Thermal Power Generation, negative externalities that are in the form of greenhouse gas emissions have no influence on policy. Externality, in economic terms is defined as the cost that is unintentionally incurred, such as medical bills or environmental cleanups. In an attempt to internalize these effects, we need to find out the external cost per tonne of carbon dioxide. The Effective Carbon Price can be viewed as the cost of reducing greenhouse gas emissions using a given policy [3]. Certain regional policies such as Renewable Portfolio Standards and energy efficiency measures can be set up to either limit emissions for specific groups or promote the use of certain technology over another. Here, the effective prices of carbon, (shaped by national economic interests) ranges from 6 USD/tonCO2 to 200 USD/tonCO2. Though, this is a less objective determinant of price, it is useful when comparing the extent other countries are going to reduce greenhouse gas emissions.

The ‘social cost of carbon’ represents the monetary value of damage done by emitting an additional unit of carbon dioxide. Current policy costs of carbon dioxide should be used while a discount rate should be used to sufficiently factor for the time value of future cash flows. This ranges from 39 USD/tonCO2 to 137 USD/tonCO2. On the other hand, the Marginal Abatement Cost of Carbon is the cost of preventing one tonne of carbon dioxide from being in the atmosphere (Lucklow et al, [2]). The range can be quite drastic as it depends on the technology used to carry out the prevention.

Carbon Capture and Storage technology is a way to reduce carbon dioxide emissions from Thermal Power generation and it costs between 30 USD/tonCO2e to 80 USD/tonCO2e depending on the scenario. Thus, taking into account both Social Carbon Cost and Marginal Abatement Carbon Cost, a high value of 137 USD/tonCO2e and a low value of 30 USD/tonCO2e should be used in considering the externality of Greenhouse Gas emissions on different energy sources. However, in this study, we assume that Carbon Cost is at 30 USD/tonCO2 to take a conservative approach.

2 Peak Load Electricity Generation with Solar PV.

Based on the Energy Commission’s National Energy Balance 2012 report, the gross generation of electricity for Peninsular Malaysia is 117,797 GWh. Thus, the average daily gross generation is 322 GWh per day (for year 2012).

Based on Peninsular Malaysia’s daily load duration curve characteristics, the day-time peak load is mainly covered by the Open Cycle Gas Turbines and/or Peaking Hydro Plants.

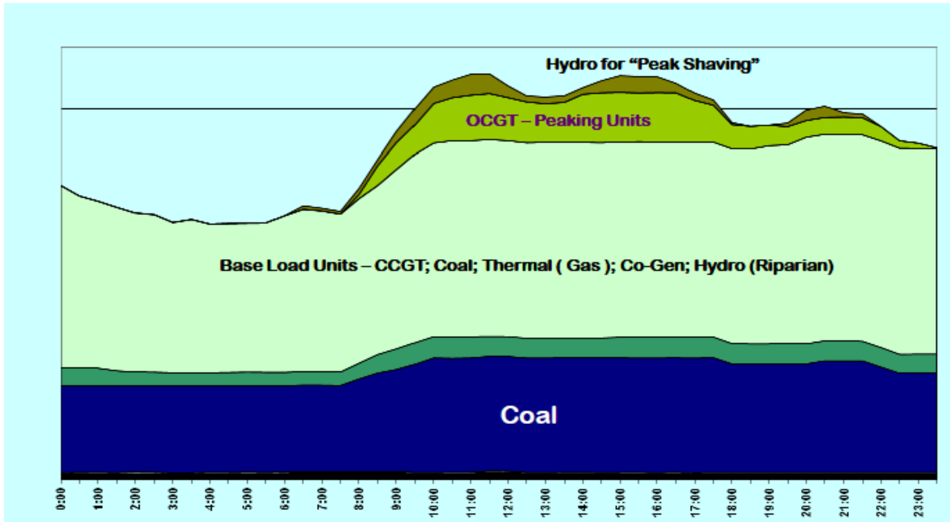

Figure 1: Energy Generation Dispatch by Fuel Type for Typical Daily Load Duration Curve Characteristic (Peninsular Malaysia)

This constitutes about 1% of the day-time peak load energy requirement, which is about 3GWh (3,000MWh). From established literature, carbon emissions from Gas-Fired Power Plants are 0.4 tonnes per MWh of generation. Thus daily carbon emission is about 1,200 tonnes from these Gas-Fired Peaking Power Plants.

On average, a 1MW Solar PV can generate about 3.3MWh of peak load electricity. Thus to displace 3,000 MWh of Gas-Fired Peaking electricity, we need to install 10X100 MW utility scale Solar PV Peaking Power Plants throughout the Peninsular Malaysia national power grid.

Daily carbon emission avoided is 1,200 tonnes. The social cost of carbon emission is 30 USD/tonCO_2e (high value). Thus, the daily carbon emission avoidance cost is USD $ 36,000 for peak load (day-time peak) electricity generation if Solar PV replaces gas-fired peaking electricity requirement.

3 <u>Success of Solar and Other Renewable Energies (RE) In Malaysia</u>

Sustainable Energy Development Authority Malaysia (SEDA) introduced the Feed In Tariff (FiT) programme in Malaysia under the Renewable Energy Act 2011. It was a move towards achieving energy autonomy and mitigating climate change for the country. The major role of SEDA is to administer and manage implementation of the FiT mechanism which is mandated under the Renewable Energy Act.

Since 2001, Malaysia has made efforts towards RE development where the principle adopted was using market forces to deliver the intended outcome towards electricity generation. This policy envisions enhancing the utilisation of indigenous renewable energy (RE) resources to contribute towards national electricity supply security and sustainable socioeconomic development.

The source of funding for the FiT programme is obtained by way of Polluter Pay Concept whereby an additional surcharge has been imposed on electricity bills. The rate has increased from 1.0% December 2011 to 1.6% in January 2014. This only amounts to approximately 1.0% of the total electrical generation cost as per the pie chart shown below.

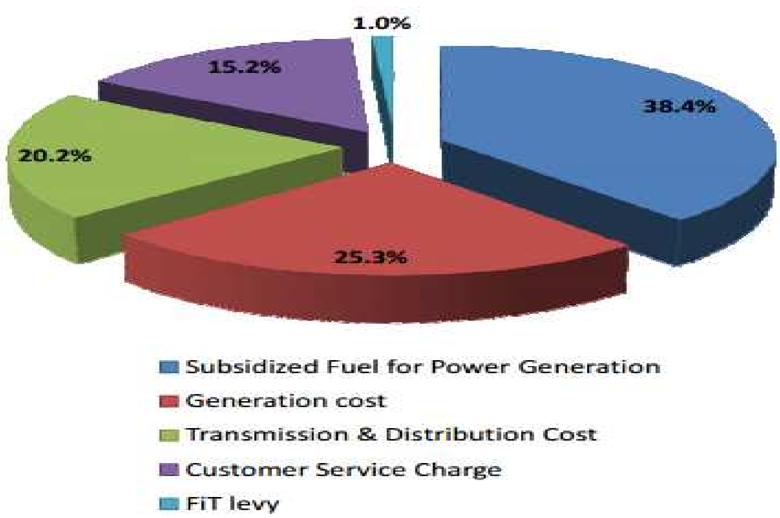

Figure 2: Total Electrical Generation Cost (source: SEDA Malaysia)

FiT is a simple mechanism as it gives Renewable Energy (RE) producers a secured revenue stream by putting legal obligations on utility companies to buy electricity from these independent RE producers. Both parties would be part of a Renewable Energy Power Purchase Agreement (REPPA) over a guaranteed period, making the installation of RE systems worthwhile and attractive investments for the producer.

According to SEDA, most countries which adopt the FiT as the mechanism to develop the RE Industry gradually move on to other methods once the critical mass is achieved and the technologies become common place. The FiT is normally used to kick start the RE Industry. It's no different in Malaysia. New FiTs for solar PV are planned to be phased out by 2017. In conjunction, we have to take note that SEDA has planned alternative approaches to replace FiT, subject to Government approval (K.S. Koh et al[4])

Net Metering, or Net Energy Metering (NEM), is basically the installation of PV systems for self-consumption by a consumer, where any units exported to the Grid during low load periods are subtracted or netted off from the consumer's monthly bill. NEM is planned to be launched in 2015, and gradually ramped up once the FiT is discontinued. With increasing electricity tariffs due to the gradual removal of fuel subsidies, NEM will become an attractive option for consumers with heavy consumption. (K.S. Koh et al[4])

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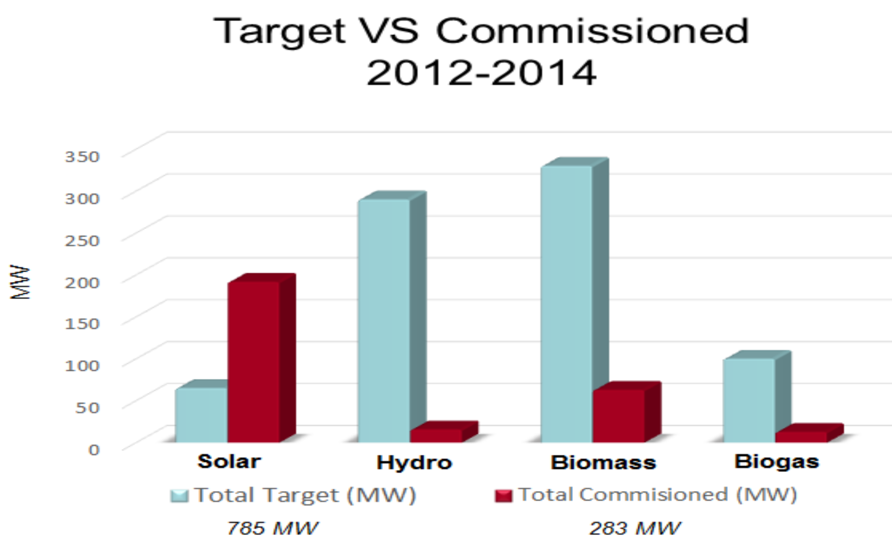

Figure 3: Target vs. Commissioned (source: SEDA Malaysia)

The Malaysian Government sets targets for various RE projects through the Malaysian Economic Plan (MEP) and National Energy Balance (NEB). SEDA then allocates quotas for the various RE producers to take up in order to meet these energy demands. Based on figure

3, total target from Year 2012 to 2014 stands at 785MW while total commissioned is merely at 283 MW, which translates to 36% of total target.

Solar, however, has surpassed its target due to high take up rates among Independent Renewable Energy Power Producers (IREPP). Among the commissioned RE projects, solar's portion is 63% and it is the most successful of all the RE projects in Malaysia. Furthermore, a large portion of commissioned hydro and biomass projects are a migration from the Small Renewable Energy Programme (SREP) programme into the FiT programme. If this is taken out, solar's contribution to newly commissioned projects will jump to 97%, this would make solar the star performer among REs.

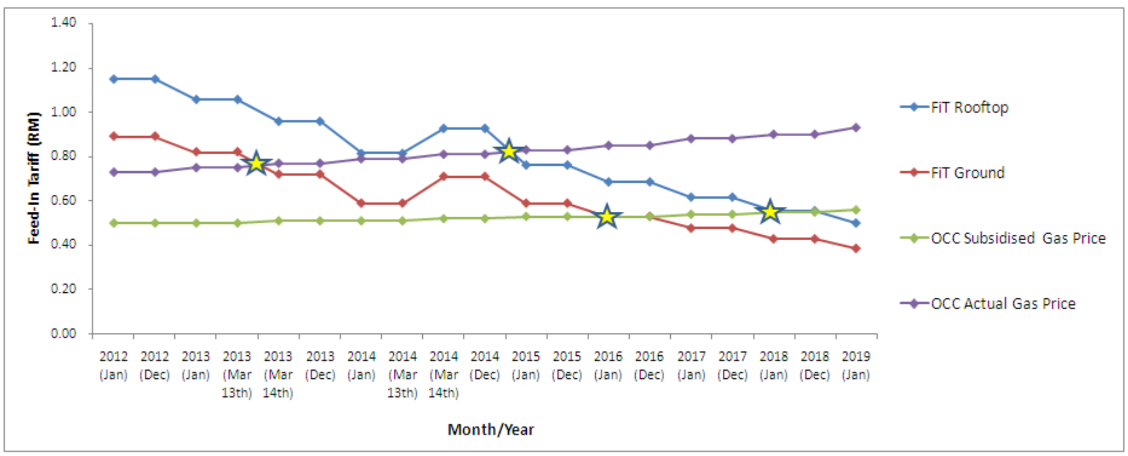

Figure 4: FiT Tariff vs. OCGT Gas Price

Figure 4 shows the FiT rates for both Ground Mounted and Rooftop solar installation and also the cost of Open Cycle Gas Turbine (OCGT) using Subsidised Gas Price and Actual Gas price from 2012 until 2019. We have assumed an increase of Gas prices of 5% p.a. As for Solar PV (30MW), FiT commenced in January 2012 at a rate of RM 1.15 per kWh for Rooftop and RM 0.85 per kWh for Ground Mounted. Based on the rates given, solar rooftop projects have an added advantage over ground mounted solar projects because of the an additional bonus awarded to it as it does not utilize land and therefore does not compete with agricultural. Over the last three years, SEDA has made a series of reduction in the rates resulting in a current pricing RM 0.76 per KwH for Rooftop and RM 0.58 per KwH for Ground Mounted, reflecting an overall reduction of approximately 35% over 3 years. FiT rates from 2016 until 2019 will be degressed at an 8% rate on an annual basis.

For an OCGT utilizing Subsidized Gas price it will reach Grid Parity in year 2016 for Ground Mounted and 2018 for Rooftop. OCGT utilizing Actual gas price, will reach Grid Parity in year 2013 for Ground Mounted and Rooftop in 2014. The subsidized gas price we used was RM 14.40/Mmbtu which is what the power utility pays Petronas the National Gas Supplier for the bulk of its needs. The Actual Gas price we used was RM 44.50/Mmbtu

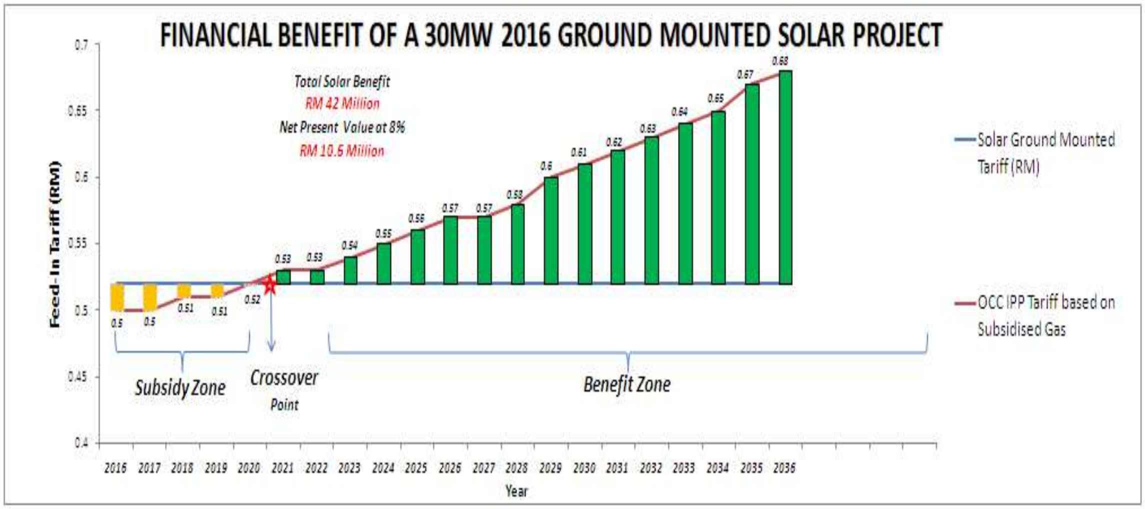

Figure 5: Financial Benefit of a 30 MW 2016 Ground Mounted Solar Project

Figure 5 shows the Financial Benefit to the Utility in Implementing a Solar Ground Mounted project for 2016 FiT rate prior to grid parity. The FiT rate for 2016 is at RM 0.52/kWh and will be constant for 21years (lifetime of a Solar Project) and for the OCGT Cost of Subsidised Gas price is assumed to increase at 5% p.a. From the figure, we can see that the Utility would see an overall greater benefit in using Solar Energy compared to an OCGT Power Plant. Although during the early years, there is a marginal subsidy to be covered but after the crossover point there is a solar benefit. Over the Total period of 21 years, it makes up the Total benefit is RM 42Million, which when Discounted at 8% of the Total Benefit to FiT Year 2016 it gives the Utility an Net Present Value of RM 10.6 Million.

Figure 6 shows the cost impact to the Utility. In the early years of FiT implementation, the utility absorbs a higher cost for RE. However, in the later years, it becomes beneficial to the Utility to switch to RE as opposed to OCGT due to increasing fuel price and lowering of the FiT rates.

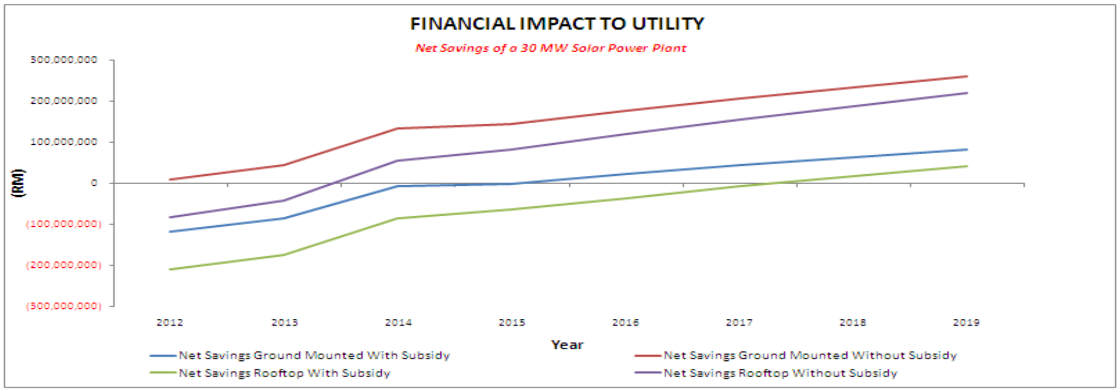

Figure 6: Financial Impact to Utility

4 Economic Study

Definition of Climate Change by Intergovernmental Panel of Climate Change (IPCC): A "change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer."

- It has been accepted by most relevant scientific bodies that the emissions of anthropogenic greenhouse gases is slowly changing the climate and will continue to do so.
- In particular, CO2 is the primary greenhouse gas emitted by human activities and in June 2014 was approximately at 400 parts per million.
- In order to maximise Malaysia's economic prospects, there must be a concerted effort towards quantitatively analyzing the benefit of employing technologies with reduced CO2 contributions.

Greenhouse gas emissions are an example of "externality" in economics (i.e. when a cost is unintentionally incurred). In order to internalize their effect, there is the need to find out the external cost per ton of CO2. There are ranging definitions, each with its own method of evaluation and set of variables to consider.

In determining a Carbon cost, we have used the Social Carbon Cost and Marginal Abatement Carbon Costs (MACC) for this paper (McKinsey [3]).

- MACC is the cost of preventing one ton of CO2 from being in the atmosphere. According to McKinsey report, Carbon Capture and Storage technologies give values of USD $30 – USD $80 per ton CO2e (depending on the scenario)

- Social cost of carbon is the collective cost of current and future damages related to climate change from the emission of one tonne of CO_2. The social cost of carbon is often used as part of the calculation of benefits of emission-reducing measures. This cost ranges from USD $39 – USD $137 per tonne.

Thus a high value of USD $137 per ton and a low of USD $30 per ton CO_2e should be used in considering the externality of Greenhouse Gas emission on different energy sources. As shown in Figure 3 and Figure 4 we have used the high value and low value by offsetting CO_2 emission through renewable electricity technology, and factored in the 'economic revenue' into the financial model of such power plant. We have used a typical 30MW Solar power project as a base.

Besides future costs from climate change "externality", fossil fuel electricity has also another economic externality which is associated with adverse human health impact due to air emission of particulate matter such as NOx, SOx, mercury and arsenic.

It has been shown in a US study [5], that the economic value of improved human health associated with avoiding emissions from fossil fuel electricity is USD$ 0.14 – USD$ 0.35/KwH. For coal-fired electricity, the associated economic value of health impact is USD$ 0.19 – USD$ 0.45/KwH and for gas-fired electricity is USD$ 0.01 – USD$0.02/KwH

In the same US study, the economic value of health impacts resulting from air emission is considered, the analysis suggests that on average, US consumers of electricity should be willing to pay USD$ 0.24 – USD$ 0.45/KwH for alternative such as energy efficiency investment or emission-free renewable energy resources, such as solar PV that avoid fossil fuel combustion.

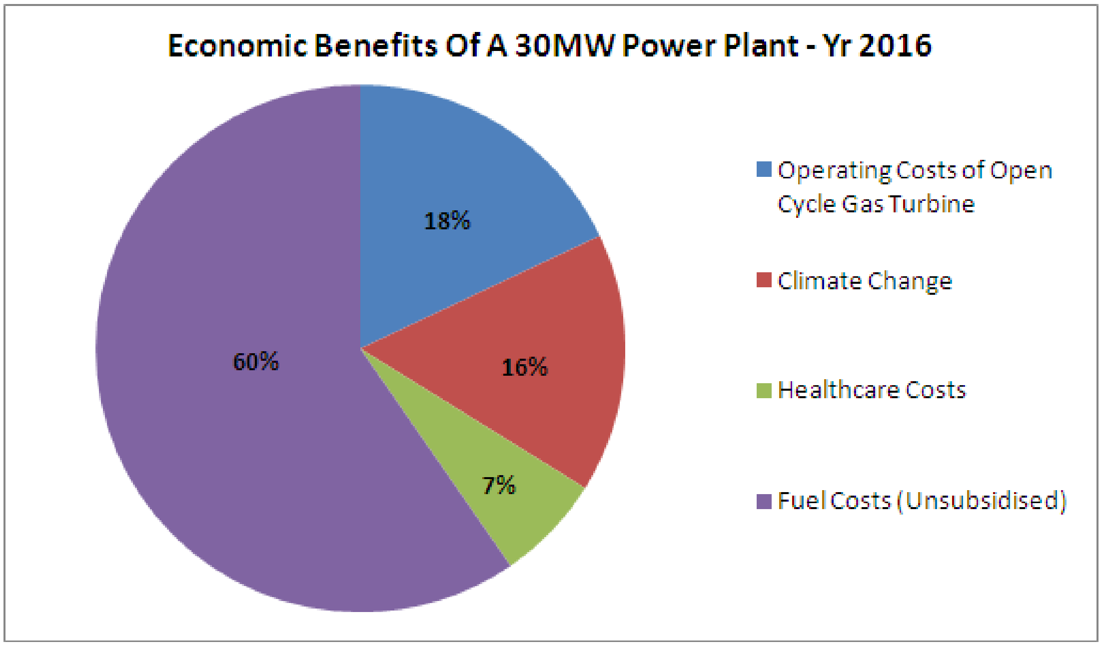

Figure 7: Economic Benefit of a 30 MW Solar Power Plant

Assuming a 30MW solar power plant in 2016, the financial benefit to the utility compared to on a OCGT utilizing subsidized gas is RM 20.6 Million. However, for an OCGT plant utilizing actual gas prices it is RM 175 Million. The Economic IRR (EIRR) of a solar power plant is 21%, giving an Economic Net Present Value (ENPV) of RM 297 Million.

The Economic Benefit of a 30MW Solar Power Plant for 2016 is shown in Figure 7. Based on the Pie Chart above, a significant portion of the Economic Benefit is the saving of the Actual Fuel Cost (60%) and the Operating Cost (18%) that has been borne by the Utility if an OCGT Power Plant is to be built. The other components of the Pie chart represents the Externalities such impact on Climate Change and Health care cost which takes up 16% and 7% respectively.

Conclusion

Early FIT rates were attractive to pull investors into this new field. These rates have reduced to reflect the increased competition and higher appetite for risk and lower hurdle rate for investment returns and also the lower capex costs with the reduced costs for panels amongst others. These rates will continue to drop with raising technology advancements and reducing costs of equipment but it is unlikely to be as drastic as in the early years.

Thus while solar projects appear to need a subsidy in the short run, in the long run they will subsidise the grid. More so if we take the economic benefits into account i.e: climate change, healthcare costs and the opportunity costs of a OCGT power plant, this will make the project economically essential and financially viable. Short terms costs are overweighed by long term benefits. For these benefits to materialize a robust policy framework should be developed and which is based on market forces.

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