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# The Potential Of Pvs In Developing Countries: Maintaining An Equitable Society In The Face Of Fossil Fuel Depletion

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## ABSTRACT

The availability of an adequate electrical supply to the whole population is essential for the wellbeing and equity of a society. However, for those countries that are largely dependent on fossil fuels for generating electricity, peak oil and gas threaten energy security and the ability to provide an uninterrupted supply of electricity on an equitable basis.

This paper will review future energy demand and supply in Malaysia and implications for its electricity supply. It will demonstrate that there is likely to be an energy deficit that could result in electricity rationing. Difficult decisions will need to be made about the priority of electricity supply that is likely to have a greater impact on the "bottom" layers of society.

The paper will also review the extent to which renewable energy, in particular photovoltaics, can contribute to the energy mix in Malaysia. It will be argued that a decentralised renewable energy supply system has the potential to maintain not only an equitable distribution of electricity but also potential earnings to low-income families.

In order to achieve this, technical and economic changes are required to make decentralised renewable energy systems a viable proposition. The importance of the introduction of 'smart meters' and a 'smart grid' as both a means of increasing energy efficiency and equitably distributing electricity will be addressed.

**Keywords:** energy security; low-income; photovoltaics; smart grid.

## INTRODUCTION

Malaysia's high dependence on fossil fuels to generate electricity makes it vulnerable to insecure future energy supplies and costs in view of peak oil, gas and coal. The timing of this problem may be accelerated due to the 'South China Sea conflict'. This emphasises the need for timely investment in renewable energy sources in order to mitigate problems associated with an inadequate fuel supply and consequent electricity rationing.

Lessons are being learnt from around the world of the devastation that an interrupted supply of electricity can cause in societies where a dependence upon a power supply has grown. A

loss of electricity results not just in discomfort but also a loss of food, security and communication with the greatest impact being on the 'bottom billions'.

Malaysia's electricity grid and subsidised cost of electricity have given access to an electrical power supply to all income groups. If this is to be maintained, then renewable energy sources need to become a larger proportion in the country's fuel mix. There is significant scope for electricity generated by photovoltaics (PVs) to contribute to the national energy mix provided an adequate area of arrays can be installed.

This provides an opportunity for low-income groups to benefit from a PV installation for their own energy security and to contribute to the national grid. However, PV installation costs are prohibitive for low-income groups and the current subsidies by tax rebates are of little benefit to these groups.

Smart metering and a smart grid offer a way of providing preferential feed-in tariffs to low income groups thereby contributing to an equitable supply of electricity.

## PLANNING FOR 'PEAK OIL'

Over the last 5 years several publications have appeared that have focussed on the impact that 'peak' fossil fuels will have on the economies and societies in various countries. These have come from a mixture of government, academic and business organisations and the message from these publications has had a similar pattern.

The Hirsch report [1] prepared for the US government, warned of economic decline and advised that contingency plans would need to be made at least 20 years before 'peak oil' in order to avoid a catastrophe and that early mitigation would be less expensive than late mitigation. They also advised that developing countries were likely to experience far worse problems that developed countries.

In the UK, an Industry taskforce was set up and produced reports [2] aimed at the UK government concerning peak oil and energy security. The message was similar to the Hirsch report and identified the issue of the country's growing dependence on electricity supplies and the need for investment in renewable energy sources in order to avoid supply interruptions.

In Malaysia, the publication 'Energy and Ecology: a view of Malaysia after 2020' [3] gave a similar view. Malaysia's economy has grown rapidly due to substantial gas and oil reserves and the traditional society has shifted away from a sustainable rural lifestyle to an urban one that has become dependent on uninterrupted and subsidised supplies of fuel and electricity. This has left Malaysia vulnerable to the impact of peak oil and gas.

The actual date of 'peak oil' has been the subject of much speculation. However, consensus appears to be that it will happen during this decade. Even the most conservative view of the International Energy Agency is that many countries have already reached peak oil and international oil production will reach a plateau by 2020 [4]. If this is the case, then according to the Hirsch report we should have started making contingency plans a decade ago.

## LESSONS FROM HISTORICAL RESPONSES TO PEAK OIL

The world has not experienced 'peak oil' before so we do not have any direct experience or models with which to predict the outcome or impacts that different countries are likely to face. With an imminent decline in natural resources, history has shown us that different countries with different political regimes respond in very different ways. Research at Oxford University [5] has identified various strategies that different countries have previously implemented when oil has been artificially 'peaked' due to an imposed rationing. The research proposes that there are three principal ways in which countries are likely to respond.

One strategy is typified by the action taken in North Korea. Starved of an oil supply by an international embargo, the country responded by keeping what little resources were left to the ruling elite while depriving the majority of the population. The result was a deeply divided society with a small minority experiencing extravagancies while the majority faced hardship and even starvation.

Another strategy is that taken by Japan in the 1940's. Again, starved of oil by US, the major oil producer at the time, it took military action to expand its empire towards its neighbouring countries, such as the Philippines and Malaysia, with known oil reserves.

Finally, another response is typified by Cuba. When Russia's interest in Cuba disappeared at the end of the cold war, it no longer received the oil it had grown to depend upon. This, coupled with an embargo by the US led to a country starved of oil. Cuba's struggle to survive is now well known [6] and has become an example of how communities can manage to break their addiction to oil and still maintain a good standard of living.

## IMPACT ON MALAYSIA

Every one of the above scenarios (a divided society, territorial claim for resources and cooperative strategies) will have an impact on Malaysia. The issue of how well resources such as food and fuel will be evenly distributed in a society with a high Gini Coefficient is a matter that will become acute when the impact of 'peak oil' reaches the country. Malaysia has one of the highest differences between the richest 10% and poorest 10% outside Latin American and sub-Saharan countries [7].

The expansion of countries, with inadequate reserves of fuels, moving towards areas of known oil and gas resources is of immediate and significant relevance to Malaysia. The conflict in the South China Sea [8] concerning China's claim to rights of these resources off the coast of Sabah and Sarawak is still to be resolved. A possible peaceful outcome to this may involve some form of cooperative extraction of oil and gas. If this were to be the case, then Malaysia's experience of 'peak oil and gas' could be brought forward by many years.

Lastly, the traditions within Malaysia for community involvement in overcoming problems of this scale offer an opportunity to manage the impact of peak oil provided the problems are recognised in advance and appropriate investment is put in place. The focus of this paper is to

identify those contingency plans that can benefit all communities and the investment required.

## LEARNING FROM COUNTRIES WITHOUT CONTINGENCY PLANS

As fossil fuels deplete, there will be a general trend towards electricity as the main supply of energy. For example, the car industry is now focussing on the production of electric cars to replace the internal combustion engine. Our dependence on an uninterrupted supply of electricity grows and, while supply matches demand, we take electricity for granted. Only when we are deprived of it do we realise the full extent of our dependence and the consequent social and economical catastrophes that occur when electricity supplies are interrupted for extended periods of time.

From around the world come an accumulation of examples of the likely problems that will occur within our societies and communities when we are deprived of electricity. The following examples illustrate a few issues including food deprivation, increased crime and loss of communication. With urbanisation we have become dependent on refrigeration to be able to keep food fresh while it is transported, processed, retailed and stored prior to consumption. When the lights go out, crime increases under the cover of darkness and without electricity our communication systems, including phones, internet and transport, fail.

In 2003, Italy suffered a huge blackout [9]. Planes were grounded; 110 trains were halted, some for over 12 hours, with 30,000 passengers; mobile phones stopped working; hundreds of elderly people were hospitalized after falling over in the dark; sales of coffee, food and ice creams worth 50 million Euros were lost; frozen food worth 70 million Euros was wasted in freezers; hospitals ran out of fuel for their emergency generators; water pumping systems stopped, causing supply problems; sewage plants stopped operating, causing effluent build-ups.

In 2008, Zanzibar suffered a blackout that lasted 2 weeks [10]. Frozen food was wasted and small businesses suffered. Mobile phones were recharged at great expense by profiteers with generators and for many the power did not return as the electric cables were stolen for scrap metal during the blackouts [11]. Small communities were turned against each other due to hunger, crime and a lack of communication caused by a dependence on electricity for which there were no contingency plans.

In 2009, Brazil suffered the most extensive blackout yet experienced [12] in the world. Cities experienced the usual problems of transport coming to a standstill and communications breakdowns. Businesses lost money as the downtime of the credit card systems was exploited by purchasers with no intention of paying. However, the loss of street lighting resulted in a surge of crime from petty theft to drug cartel wars making full use of the dark. One of the first reactions to the blackout was an increase in policing on the streets.

In 2010, Pakistan suffered continuous blackouts, not because of a technical failure but because of a lack of energy policy resulting in electricity rationing. In June it was reported [13]:

> "Up to 12 hours of the day are routinely being endured without electricity across the country. Cities and villages take it in turns to have the lights turned out … to keep them on. Tolerating the current heat without power, without working fans, fridges, air conditioning (for those lucky enough to have afforded installation in the first place) and light, is not just a matter of inconvenience though: heatstroke, food poisoning and dehydration are killing in their hundreds while the death of livestock, paralysis of small and large business and the real threat to livelihoods and families is hurting further. The wealthy will switch on their generators to keep a running supply of power every time the electricity trips; the poor are simply left to swelter and suffer."

The above examples are just a few of the growing number of stories that illustrate not just the inconvenience of a lack of electricity but also the difficulties in maintaining basic standards of living and even the struggle for life itself.

## COULD MALAYSIA EVER FACE THESE PROBLEMS?

Malaysia's energy supply mix is heavily dependent on fossil fuels including imported coal. It is vulnerable to world market prices and will experience peak oil and gas in the next decade. While Malaysia has a significant potential contribution from renewable energy in its overall mix (approximately 20% by the year 2020), much of this is from biomass which is limited in the extent that it can be used for electricity production [3].

While there is some scope for additional hydro power, Malaysia is not well positioned to exploit wind power or geothermal energy. This lack of significant renewable energy for electricity supply leaves the country vulnerable to the probability of supply not being able to match demand in the coming decades. It is likely that a policy of electricity rationing will need to be implemented on a similar basis to that in India [14] and Nepal [15] at present.

Power cuts in India are due to a reduced supply of coal as the 'easy' coal has now been extracted. It is also due to a lack of rain which affects the small amount of hydro produced in the country. As a result electricity rationing is commonly up to 12 hours in rural areas and a 10% cut imposed on all government offices and 20% on cities. In Nepal, power cuts are typically 14 to 16 hours per day and are due largely to a lack of investment in power supplies because of the war.

If and when electricity rationing comes to Malaysia, political decisions will need to be made on which areas of the country, cities or villages will be rationed and for how long. The problem is that while blackouts save energy, they cost money. The examples above illustrate the cost that can accrue through loss of food supplies, crime, direct business losses and health related issues.

If electricity generated by renewable sources is to grow in Malaysia, the investment should not be based solely on the cost of the installations but also on the economic and social costs incurred due to blackouts when supply by fossil fuel based generators is inadequate.

## THE SCOPE FOR ELECTRICITY GENERATED BY RENEWABLE RESOURCES IN MALAYSIA.

Since wind power has a relatively small potential in Malaysia due to low average wind speeds and geothermal even less potential, generating electricity by photovoltaics is an obvious choice. This has been attempted before in different ways: the Suria 1000 programme, BIPV programme and remote off-grid installations such as Pulau Sibu.

It has been estimated [3] that PVs mounted on roofs of houses in Malaysia could generate about 25% of current electricity demand. However, this will reduce proportionately as electricity consumption is increasing at a greater rate than roof area increases. By 2020, it is estimated that this will reduce to about 8%. The Malaysian Photovoltaic Industry Association (MPIA) has estimated [16] that PVs mounted on all building types could produce about 20% to the national energy mix by somewhere between the years 2030 to 2050. This is an ambitious target but could be feasible if other sources in the energy mix are assumed to deplete.

## OBSTACLES TO MARKET PENETRATION OF PVs IN MALAYSIA.

The PV industry has a fundamental problem with pricing of installations. The electricity generated by PVs may not be cost-effective before the cost of fossil fuels increases to a level where PV's can have grid parity. Subsidies and advantageous feed-in tariffs will help the PV market expand. But there will come a time when PVs have grid parity and subsidies will need to be removed. This has recently occurred in Spain [17] where the government has argued that the reduced cost of PV installations no longer justifies subsidies. Industry insiders are predicting that deep cuts could harm the development of Spain's booming solar industry.

A further obstacle is that of a reluctance of existing power suppliers to democratise the electricity grid system. Renewable energy that is 'fed in' to an existing grid from small suppliers (micro generation) has had considerable opposition from governments and national electricity suppliers [18]. There is a reluctance to allow individuals, millions in the case of solar roofs, to be able to have some say in future decision making. There is a struggle to get feed-in tariffs that make a system economically viable and even limitations on installations on the extent of supply based on maximum demand of the user.

These obstacles are based on economic cost-effectiveness only and do not account for the social costs of an inadequate or interrupted supply of electricity or any concept of sharing access to the electricity grid.

## THE PROBLEM OF SHARING ELECTRICITY AND 'TAKE-BACK'

Subsidy systems for PV installations that include tax rebates exclude lower income groups from both the incentive and benefit of the technology and also its potential energy supply and savings. Furthermore, the groups that do benefit from it tend to be those with high electricity consuming devices such as air-conditioning, clothes dryers, dishwashers and, in due course, electric vehicles. The benefit of PVs to high energy users is primarily to reduce their own electricity costs and to have a degree of energy security in the event of a blackout. Sharing the electricity produced with the grid is likely to be minimal and the feed-in tariff used only in times of extreme electricity production when grid demand is relatively low.

PV installations distributed according to wealth, provide energy security to the wealthy. During those times that an uninterrupted grid electricity supply can be maintained, PVs for high electricity consumers have limited potential in displacing electricity supplied by fossil fuels. This is due to a phenomenon of 'take-back' that is prevalent when energy efficient devices are installed.

For example, energy saving measures introduced in the UK over the last decades have done little to reduce energy consumption [19]. Rather than take the energy savings, people tend to take the additional comfort by extending the area and duration over which the energy consuming system has influence. Similarly, in New Zealand, the rapid market penetration of the heat pump was expected to save energy. It has done the reverse as householders have used it to provide additional comfort at times that it would never have been used before. They have 'taken-back' the savings and put them into higher comfort standards [20].

'Take-back' from electricity supplied by PVs is inevitable as global trends in delivered energy shift towards electricity. PV supplied electricity to a householder can begin to justify the purchase of additional household entertainment systems, more extensive air-conditioning or even an electric car. The increased energy consumption from these devices is likely to outweigh energy savings to a national grid.

## TOWARDS A DEMOCRATIC GRID

The coverage of the electricity grid in Malaysia to almost all of the population has been a remarkable achievement in providing such things as economic enterprise, security, comfort, refrigeration and communication. Without it many groups would have been deprived of the substantial advances in economic growth and standards of living that Malaysia has experienced since it has been able to exploit its resources of fossil fuels in the last half of a century. However, when grid supplies fail, there is a high risk that it will be the lower income groups that suffer.

Like the electricity grid, solar energy is also distributed relatively evenly amongst the population. It is a democratic from of energy requiring only some form of collection system, such as PVs, to be able to be converted into electricity. While the energy is free, the collection system is currently prohibitively expensive to many. Subsidising the cost of PV installations by preferential feed-in tariffs and tax incentives only benefits those who pay tax.

An alternative method of subsidy is through low-cost loans. This system has been used to great effect for many years in Bangladesh by the micro-credit loans of the Grameen Bank [21]. This model is most effective where there is no electrical grid supply and renewable energy serves to increase incomes by effectively extending the length of the day by the use of artificial light. However, PVs are now going 'beyond the light bulb' [22] are a widely used for agricultural and commercial activities.

The problem with subsidised prices for electricity supplied by grid systems, such as that in Malaysia, is that it makes the introduction of PVs uneconomic and micro-credit loans will have little appeal or purpose [23]. If PVs are to become widespread in the country, then the

benefit should go beyond that of the individual and the value of PVs priced so that it recognises the wider benefits and externalities.

## THE CONTRIBUTION OF PVs BEYOND THE INDIVIDUAL

PVs can reduce energy costs for individuals, potentially create an income and allow a degree of energy autonomy. However, they can go beyond this provided that they feed into the grid at times of greatest demand. Apart from contributing to a secure, clean and stable energy supply as an alternative to fossil fuel generation, they also have the advantage of creating a decentralised energy system that can contribute to load levelling.

This has value in particular during times when energy rationing may be required. Under these circumstances, subsidised electricity prices serve no purpose. The key to sharing electricity provided by PVs during times of energy rationing lies in technology that allows for feed-in supplies on a more equitable basis.

This has conventionally been achieved by ‘net-metering’ and is moving towards ‘smart-metering’ and ‘smart grids’. This technology allows for variable feed-in tariffs that can recognise the real-time price of electricity and can be adjusted to the income band of the PV owners. In this way, lower income groups can not only receive higher tariffs but also earn more depending on the need of the grid. The technology of smart metering and smart grids could help maintain an equitable distribution of electricity during periods of energy rationing.

## CONCLUSIONS

Malaysia’s high dependence on fossil fuels to generate electricity makes it vulnerable to insecure future energy supplies and costs in view of peak oil, gas and coal. The timing of this problem may be accelerated due to the ‘South China Sea conflict’. This emphasises the need for timely investment in renewable energy sources in order to mitigate problems associated with an inadequate fuel supply and consequent electricity rationing.

Lessons are being learnt from around the world of the devastation that an interrupted supply of electricity can cause in societies where a dependence upon a power supply has grown. A loss of electricity results not just in discomfort but also a loss of food, security and communication with the greatest impact being on the ‘bottom billions’.

Malaysia’s electricity grid and subsidised cost of electricity have given access to an electrical power supply to all income groups. If this is to be maintained, then renewable energy sources need to become a larger proportion in the country’s fuel mix. With low average wind speeds and inadequate geothermal energy, the country’s most effective renewable energy supplies are likely to be from biomass and solar PVs. If PVs are to make a significant contribution, there will need to be a significant surface area for collection.

Existing subsidies are aimed at groups that are economically advantaged. While electricity generated by PVs in this group may result in reduced electricity demand on the grid, higher income groups tend to have higher energy demands for such things as air-conditioning and

electric vehicles. PVs are therefore more likely to be used for personal supply rather than contributing through a 'feed-in' to the national electricity grid.

On the other hand, lower income groups with renewable energy supplies would have a greater economic advantage to share electricity through 'feed-in' to the grid. However, the cost of a PV installation is prohibitive to many in the lower income groups and subsidies involving tax rebates are of little benefit to low or non-taxpayers.

The micro-credit systems of subsidising PV costs for lower income groups works well where there is no existing grid connection but will have little appeal when grid electricity prices are subsidised. 'Smart metering' offers an alternative means of subsidising the costs of PVs for low-income groups by adjusting electricity tariffs according to income group as well as the electricity needs of the grid.

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