Energy Use and Its Effects on the Environment

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Energy is an essential commodity for human existence and way of life. It plays a central role in society's economic growth and development. Population growth, increasing urbanisation and the upgrading of the standard of living of the general population will result in an ever-increasing scale of energy consumption. On the international scene, in the *New Policies Scenario*, global energy needs rise more slowly than in the past. However, it will still increase by 30% between today and 2040[1].

In Malaysia, the energy consumption growth is even higher than this global figure. Under the Business As Usual (BAU) scenario, by 2040 Malaysia's final energy demand is expected to rise by 63% (34 Mtoe) compared with the 2013 level, reaching just below 88 Mtoe. This reflects an average annual growth rate (AAGR) of 1.8%. This is almost double the Asia Pacific Economic Cooperation (APEC) countries average of 1%[2].

ENVIRONMENTAL EFFECTS

This paper does not deal with the environmental effects of nuclear fuel, as it is not used as such in this country.

Like all human activities, energy activities will have effects on the environment. Each stage of fuel extraction and consumption will have such effects. These various stages are:

1. Extraction
2. Refinement/processing
3. Transport/storage
4. Consumption/combustion
5. Disposal of waste products

Fuel Extraction: Coal mining is in the form of deep mining, open cast mining or, in the case of lignite, peat and even some coal extraction from relatively shallow deposits by strip mining or other open cast techniques. The main environmental issues at this stage are:

- Risks due to underground accidents including cave-ins, gas explosions and health hazards associated with dust and the release of radioactive gases such as radon.
- The surface effects caused by the large scale dumping of mine spoil or open cast activities. These include effects of land settlement, safety hazards, visual intrusion and the occupation of land and the local effects of smell, noise, vibration and dust.
- The acidification and pollution of local water.
- Disruption of aquifers, threatening nearby water wells.
- Water pollution, particularly siltation and acid drainage.
- Noise and road damage due to the transport of large quantities of spoil.
- Losses in land productivity from soil alteration (especially in prime agricultural areas).
- Loss of wildlife habitat.

Oil and natural gas are extracted mainly by offshore deep drilling and transported to the mainland refineries by undersea pipelines or bulk carriers. Leakage from pipelines and accidental spillage that cannot be localised are the main causes of environmental impacts.

Fuel Refining/Processing: After coal is removed from the ground, it is usually sent to a preparation plant near the mining site for cleaning and processing to remove rock, dirt, ash, sulphur and other unwanted materials.

Based on the technologies employed, the following environmental concerns will have to be addressed:

- Potential surface and groundwater pollution.
- Wastewater discharge.
- Emission of NO_x, SO_x, particulates, etc. leading to air pollution. This will be subsequently lead to greenhouse effects, acid rain and damage to plants.
- Occupational safety and health risks from accidents and toxic chemicals.
- Carcinogens in direct process, intermediates and fuel products.
- Possible localised odour problems.

Similarly, oil refining will involve the reduction of sulphur, benzene and lead content in the refined oil as compared with that in the crude oil. This will lead to air pollution, water pollution, deforestation and disruption in the eco system.

Fuel Transport/Storage: Fuel has to be transported from mines and processing plants to consumers and the environmental concerns from the transport and storage of fuels include:

- Risks of accidents and spillage with subsequent problems from air/water pollution.
- Noise and road damage from the transport of large quantities of fuel.
- Land use and disruption to the eco system.

Energy Use in Fuel Extraction, Processing, Transport and Storage: Apart from the earlier stated environmental concerns in the extraction, processing, transport and storage of fuels, it has to be accepted that energy is also needed for this, resulting in further environmental impacts. Figures for such energy consumption are difficult to obtain, due to the variations involved and the lack of studies on this.

For coal obtained from surface mining (often used when coal is less than 60m underground), the overall energy consumption per ton of material moved is estimated to be about 20,000 Btu/t. Even this figure, when compared with the USA Department of Environment (DOE) figures, reveals that it is about 3.85 times less than what the DOE had indicated[3].

For oil production in the 1920s, it took 1 barrel of oil to extract, process, refine, ship and deliver 100 barrels of oil. Now, conventional oil production worldwide pays off at about a 20-to-1 ratio. In Canada, where the oil comes from tar sands, it's closer to 5-to-1[4].

Fuel Combustion/Consumption: Table 2 shows the final end use by energy type in Malaysia. It can be seen that about 22% of this is in the form of electricity.

Table 2: Final Energy Use by Energy Type in Malaysia (2015)[5]

ENERGY TYPE	AMOUNT OF ENERGY (THOUSAND TONNES OIL EQUIVALENT)
Natural Gas	9,566
Petroleum	29,087
Coal and Coke	1,778
Electricity	11,375
TOTAL	**51,806**

Table 3 shows that about 89% of the energy used for electricity generation is from thermal power stations. It is thus pertinent to look into the environmental effects of fuel combustion/consumption in power plants.

POWER GENERATION

Emissions from coal fired, oil fired and gas fired power stations depend on the composition of the fuels, particularly the sulphur content and also the combustion technology used. The emissions include carbon dioxide (CO_2), carbon monoxide (CO), sulphur oxides (SO_x) and oxides of nitrogen (NO_x). Apart from these, there may be small amounts of unburnt hydrocarbons and traces of heavy metals including mercury, arsenic and radioactive elements and isotopes such as uranium and thorium. Large quantities of warm water are also produced.

Table 3: Energy Used for Electricity Generation in Malaysia (2015)[5]

ENERGY SOURCE	PERCENTAGE
Hydro Stations	10.8
Thermal Stations	
Natural Gas	40.4
Petroleum	1.1
Coal and Coke	47.2
Renewables	0.5
TOTAL: 33,134 KTOE	

Figures exclude sources for self-generation

In Malaysia, the major fuel used for electricity generation is natural gas. It accounts for about 40% of the electricity generated in 2015[5]. Natural gas is a relatively clean fuel as for the same amount of energy produced, it emits about 40% less carbon dioxide than coal. In addition it emits almost no sulphur dioxide and little nitrogen oxide.

The environmental effects of emission from fossil fuelled power stations are complex. The main effects are increase in acid rain and global warming due to the greenhouse effect. They do not, however, contribute in a significant manner to the depletion of the ozone layer.

Hydro power generation also has environmental effects. This includes:

1. Fragmentation of river ecosystems – the dam acts as a barrier between upstream and downstream movement of river animals.
2. Reservoir sedimentation – resulting in diminished storage capacity.
3. Riverline and coastal erosion.
4. Greenhouse gas emissions – due to submerged biomass.
5. Effects on humans – diseases, resettlement.

Transport: From Table 4, it can be seen that the bulk (about 45%) of energy used is in the transport sector. Motor vehicle greenhouse gas emissions is the major environmental impact concern here and this is projected to grow as the result of vehicle miles travelled (VMT). With population growth and the growing ownership of vehicles, VMT is projected to rise sharply. Motor vehicle emissions include carbon dioxide, water vapour, methane, nitrogen oxides (NO_x), carbon monoxide and non-methane hydrocarbons (C_nH_m).

GREENHOUSE EFFECT

The burning of fossil fuels worldwide produces about 5,000 million tonnes of carbon, or about 18,000 million tonnes of carbon dioxide every year[6]. The atmospheric increase in carbon dioxide and the consequent climate changes are attributed to the burning of fossil fuels.

Table 4: Final Energy Use by Sectors in Malaysia (2015)[5]

SECTOR	AMOUNT OF ENERGY (THOUSAND TONNES OIL EQUIVALENT)
Industrial	13,989
Transport	23,435
Residential and Commercial	7,560
Non-Energy Use	5,928
Agricultural	895
TOTAL	**51,807**

The term "Greenhouse Effect" commonly refers to global warming due to man's activities such as by the burning of fossil fuels or the destruction of the rain forests.

Disposal of Waste Products: The disposal of solid wastes has long-term land use effects and in the possibility of toxic materials being leached from disposal sites. They are basically of two types:

- Ash wastes from coal plants.
- Elements removed from ash and coal, wastewater treatment sludges, other materials such as catalysts and partially combusted products.

The magnitude of the waste in terms of the land required for it is huge. Also some of these wastes can be hazardous.

Environmental Externalities: Electricity generation projects have external impacts on the community where they are situated. The emissions from the generation installations, for example, have an impact on the health and social life of the inhabitants in the immediate surroundings and in society as a whole.

Such external impacts include benefits or costs as a by-product of the generation activity that is borne by someone other than the parties involved in the generation activity. As such, the costs of external impacts do not enter in the market pricing calculations of the parties involved in the activity. However they have to be considered by public policy makers when considering different options for generation.

If such costs are considered, the least cost option may result in different projects being more favourable than what they would have been otherwise. For example, projects using renewable sources of energy may become more favourable than those using fossil fuels.

MITIGATION OF ENVIRONMENTAL EFFECTS OF ENERGY

Energy Efficiency Policies and Programmes in Malaysia

One of the ways to reduce the effects of energy use is to use it more efficiently. Various strategies developed to promote energy efficiency in the country include:

- Focusing on the major energy use sectors, i.e. the industrial and commercial sectors.
- Enforcement of Energy Efficiency Regulations.
- Encouraging local financial institutions to finance energy efficiency and renewable energy projects.
- Implementation of fiscal incentives.
- Implementation of demonstration projects.
- Establishment of integrated complexes and townships with the aim of them being energy efficient and having economies of scale.
- Implementation of demand side management.
- Development of related industries and services to encourage greater uptake of energy efficiency projects/equipment.
- Research and Development in the promotion of energy efficiency.
- Implementation of energy use benchmarking.
- Implementation of energy rating and labelling. At present there are requirements for energy efficiency rating and labelling for the following:
  - Refrigerators
  - Air Conditioners
  - Fans
  - Televisions
  - Motors
  - Lamps
  - Fluorescent Lamp Ballasts
  - Insulation Material
- Project on Capacity Building in the Energy Commission and Related Key Institutions on Energy Efficiency and Demand Side Management.
- Formulation of National Energy Efficiency Plans.
- The Malaysian Industrial Energy Efficiency Improvement Project (MIEEIP). Its programmes include:
  - Energy use benchmarking
  - Energy audits
  - Energy service companies (ESCOs) support
  - Energy rating
  - Energy efficiency promotion
  - Energy technology demonstration
  - Local manufacturing support
- High Efficiency Motor Promotion Programme.
- Efficient Refrigerators Promotion Programme.
- Efficient Lighting Promotion Programme.
- Newspaper/Other Mass Media Energy Efficiency Awareness Campaign.
- Energy Service Companies (ESCOs) Support Programme.
- Clean Development Mechanism.
- In terms of legislation, the Efficient Management of Electrical Energy Regulations 2008 was introduced and the Uniform Building By-

laws (UBBL) amended to require compliance with certain provisions of energy efficiency standards. More recently, the Electricity Regulations 2004 was amended to include provisions for Minimum Energy Performance Standards (MEPS).

- The introduction of suitable courses in institutions of higher learning on the use of renewable energy and the practice of energy efficiency will be continued.
- In terms of energy efficiency in buildings, the government has stated that it will lead by example by implementing energy efficiency measures in its buildings, with special emphasis being given to optimal lighting and air conditioning and the undertaking of energy audits to identify additional measures that can be implemented to improve efficiency of energy use.
- The government has stated its intention for the energy pricing structure to be reviewed to reflect market prices. In this respect, a review will be undertaken to gradually reduce subsidies on energy prices.
- At regional level, there are plans for an ASEAN Plan of Action for Energy Cooperation (APAEC) in Energy Efficiency and Conservation Programmes. This is important as the global and regional economies become more interconnected. It will include having common labelling, standards and testing facilities in order to achieve greater economies of scale. It will also assist in preventing cheaper and more energy inefficient products from being dumped into the country.
- Malaysia has also developed its own green building rating system known as the Green Building Index or GBI.
- To enable the country to develop energy efficiency strategies and programmes in a more coordinated and effective manner, the National Energy Efficiency Action Plan is being developed and is expected to be revealed soon.

CONCLUSION

In its World Energy Outlook, The International Energy Agency reports that the world is not on track to meet the target agreed by governments to limit the long-term rise in the average global temperature to 2 degrees Celsius (°C). Global greenhouse-gas emissions are increasing rapidly and, in May 2013, carbon-dioxide (CO_2) levels in the atmosphere exceeded 400 parts per million for the first time in several hundred millennia.

Malaysia is committed to reducing GHG emissions as part of its commitments towards the global climate change initiative. Ahead of the 21st Conference of Parties (COP) of the United Nations Framework Convention on Climate Change (UNFCCC) in Paris, Malaysia submitted its Intended Nationally Determined Contribution (INDC). According to this, the country intends to reduce GHG emissions intensity (per unit of GDP) by 45% by 2030, relative to the emissions intensity in 2005[7]. This reduction consists of 35% on an unconditional basis and a further 10% conditional upon receipt of climate finance, technology transfer and capacity building from developed countries.

Engineers have a great role to play in realising this commitment by the country. ■

REFERENCES

[1] International Energy Agency (14 November 2017), *World Energy Outlook 2017.*

[2] Asia Pacific Energy Research Centre (May 2016), *APEC Energy Demand and Supply Outlook, 6th Edition.*

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[4] Margolis J. (CDT Reporter), Mullins L. (Host), (November 2012), *The Energy Costs of Oil Production*, Public Radio International (PRI) The World November 02, 2012. 11:50 a.m.

[5] Energy Commission Malaysia (2017), *National Energy Balance*, 2015.

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[7] INDC Malaysia, 2015. *Intended Nationally Determined Contribution (INDC) of the Government of Malaysia*. Submitted to the United Nations Framework Convention on Climate Change in 2015. Available at https://goo.gl/Vh0caO.

Author's Biodata

Francis Xavier Jacob *a Registered Electrical Energy Manager and member of IEM, is involved in the design, monitoring and evaluation of energy efficiency and conservation projects and projects on electrical safety.*

IEM DIARY OF EVENTS

Title: Technical Visit to Proton Tanjung Malim

13 September 2018

Organised by: Mechanical Engineering Technical Division
Time : 9.00 a.m. - 1.00 p.m.
CPD/PDP : 3

Title: Talk on Stakeholder Management

13 September 2018

Organised by: Project Management Technical Division
Time : 5.30 p.m. - 7.30 p.m.
CPD/PDP : Applying

Title: Technical Visit to EWT Transformer Sdn. Bhd.

19 September 2018

Organised by: Mechanical Engineering Technical Division
Time : 9.00 a.m. - 1.00 p.m.
CPD/PDP : Applying

Title: Talk on Corrosion

22 September 2018

Organised by: Oil, Gas & Mining Engineering Technical Division
Time : 11.00 a.m. - 1.00 p.m.
CPD/PDP : Applying

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