CHAPTER 5

CONCLUSION
CHAPTER 5
CONCLUSION AND RECOMMENDATIONS

5.1 Foreword

Air pollution is expected to increase considerably in most countries of the Asia-Pacific region over the next three decades. In addition, acid deposition is becoming increasingly problematic. Under 'business-as-usual' conditions (i.e., if no specific control measures be introduced), regional emissions of SO$_x$ are expected to increase fourfold by 2030 over those of 1990 (Global Environment Outlook, GEO-2000).

According to the World Health Organisation (WHO), 6 of the 15 cities with the highest levels of SO$_x$ are in Asia. Among different environmental pollution problems, air pollution is reported to cause the greatest damage to health and loss of welfare from environmental causes in Asian countries.

Globally, environmental regulatory authorities are increasingly concerned with SO$_x$ emission and are liable to consider introducing stringent regulatory standards in the future. Alternative scenarios focus on clean technology, increasing energy efficiency and fuel switching.
5.2 Conclusion: Summary of Results and Findings

Population increase, rising standard of living and industrialisation are easily recognised factors which contribute to the increasing energy demand of a country. All these factors are present in the case of Malaysia, as presented in Chapter 4: Data Analysis and Discussion. There is a conscious desire to increase the population and there is also a planned programme of industrialisation, the so-called Vision 2020. Raising the standard of living has always been one of the stated objectives of the National Development Plans (Baharudin, 1997).

For a country which is developing into an industrialised one, the energy demand is expected to grow at high rates. The impact of developments in the energy sector on the environment is of concern to society. With an average annual growth rate of primary energy consumption ranging from 10 - 15 per cent as recorded for the past few centuries, Malaysia needs to put in place an effective and efficient plan to manage and assure future supply of energy as well as to their associated environmental impacts.

Diesel, fuel oil and natural gas were identified to be the prime supply of energy, amounting to approximately 70 - 80 per cent of total consumption in Malaysia. Among the economic sectors, both the industrial and power stations accounted for more than 60 per cent of total consumption. The transportation sector has also grown to significant share (about 25 per cent) in recent years.
It was estimated that Malaysia emitted approximately 240 - 390 thousand tonnes of SO$_x$ annually in the past twenty years, with fuel oil being the dominant cause (60 - 80 per cent) of the country's total SO$_x$ emissions. Similar to the situation in other countries within the Asia-Pacific region, industry and power stations contributed the largest share (more than 80 per cent) in Malaysia too.

An interesting feature noted was the replacement of the power stations by the industry sector as the dominant contributor of SO$_x$ in the recent years in Malaysia. Further analysis revealed that the shift of fuel mixture of primary energy supply from fuel oil (87 per cent in 1980) to natural gas (66 per cent in 1995 with the share of fuel oil reduced to 21 per cent) was the cause of the reduction of SO$_x$ from the power sector.

As for the industry sector, diesel remained the primary energy supply in the past two centuries. Apart from the industry sector, transportation had also consumed significant share of the total supply of diesel in Malaysia.

In short, the analysis made in this study concluded that any concerted development and promotion of sustainable energy policy and strategies with regard to the curbing of SO$_x$ in Malaysia should focus on the consumption of fuel oil and diesel oil in the industry and power sectors.
Notwithstanding the significant contribution of SO\textsubscript{x} emissions by the two sectors, potential growth rate of the transportation sector should also be taken into consideration for long-term strategies. Emissions from vehicles, are also worrying because, as they occur at ground level, they tend to be less diluted by dispersion, so polluting the atmosphere immediately around us (Mackay et. al., 1995).

5.3 Recommendations

Environmental aspects of the energy sector have long been identified in Malaysia in the National Energy Policy established as early as 1979. It aims to achieve an efficient, secure and environmentally sustainable supply of energy in the future as well as to have an efficient and clean utilisation of energy.

The three primary objectives of the country’s energy policy are the supply, utilisation and environmental objectives, where the third objective targets to ensure that factors pertaining to environmental protection are not neglected in the pursuit of the supply and utilisation objectives. In achieving the objectives, other energy related policies, such as the National Depletion Policy (1980) and Four-Fuel Diversification Policy (1981), were formulated (Samsudin, 1999).

\footnote{See Appendix E for relevant up-to-date data abstracted from the National Energy Balance 2001}
Various reviews were made periodically to monitor the progress, with the latest, as reported in the Third Outline Perspective Plan (2001-2010) and Eighth Malaysia Plan (2001-2005) highlighted the following (Zamzam, 2002):

- Greater utilisation of natural gas in power and non-power sectors;
- The development of renewable energy as the fifth fuel, particularly in power generation;
- Efficient utilisation of energy through the introduction of new regulations and amendments to present laws;
- Adequacy of electricity generating capacity to ensure reliable, affordable and quality energy supply.

In addition to the future strategies as identified by the Government of Malaysia in the overall energy plan for the country, specific recommendations for the curbing of SO$_x$ emissions in Malaysia are put forward in the following discussions.
5.3.1 Clean Technology - Fuel Processing and Desulphurisation

The first group of measures for reducing acid gas emissions considered here are those that either modify the way that fuel is burned, or "scrub" oxides of sulphur from the exhaust gas following the combustion processes.

As the sulphur oxides emitted during fuel combustion are derived from sulphur compounds present in the fuel, SO\textsubscript{x} emissions can be reduced by "cleaning" the fuel of sulphur before it is burned. Reducing the sulphur content of fuels is the most practical (sometimes the only) method of reducing sulphur emissions from area sources such as commercial/ institutional, transport, and domestic-sector use of coal and oil products.

Options for reducing the sulphur content of fuels include physical cleaning of coal, changes in oil refining, and changes in sources of raw and refined fuels.
- *Fuel Processing Technologies*

Burning heavy fuel in diesel engine is convenient mainly due to economics of residual fuel combustion for power generation. Diesel fuel is a fossil fuel which in most refineries is made from distillate fractions of crude oil. The combustion process inevitably leads to a number of pollutant emissions.

Diesel fuel normally contains relatively high levels of sulphur in this regard. It was reported that the contents could be as high as 1,000 ppm or much more in the developing countries.

For this reason, the U.S. Environmental Protection Agency (EPA), in its latest proposed regulations for diesel engine emissions and diesel fuel, has proposed that diesel fuel shall have no more than 15 ppm sulphur content. This regulation would take effect in 2006 (*Cannon, 2000*).
• **Burner Modification Technologies**

A number of different options are available or in the research and development phase for reducing SO$_x$ emissions by modifying the way that coal and other fuels are burned in utility and industrial boilers, furnaces, kilns, ovens, and combustion turbines. Among these are atmospheric fluidised-bed combustion (AFBC), pressurised fluidised-bed combustion (PFBC) and coal gasification technologies.

• **"End-of-Pipe" Technologies - Desulphurisation**

Three of the main technologies for controlling of SO$_x$ emissions from utility boilers, large industrial boilers, and large industrial furnaces and kilns all involve the injection of a sulphur-absorbing substance into the exhaust gases (flue gases) from the boiler. These technologies are most commonly used on boilers fired with coal, but could also, in some cases, be used on units fueled with high-sulphur residual oil. SO$_x$ removal technologies for devices smaller than utility or industrial scale are uncommon.
The three technologies are *duct injection*, *wet scrubber* or *flue gas desulphurisation* and *dry scrubber* or *spray dryers*. All three options are capable of a removal of 70 - 90 per cent of the SO₂ in flue gases (*Von Hippel, 1996*).

---

### 5.3.2 Fuel Switching to Cleaner Fuel Types - Renewable Energy

A class of options for reducing acid gas emissions that goes a step beyond using low-sulphur fuels is switching to fuels that contain little or no sulphur. This broad class of options includes using different fuels and technologies for electricity generation, in the industrial sector, commercial/institutional/domestic sectors, and in the transport sector.

Fuel switching measures include changing from processes fueled with fossil fuels to those fueled by renewable fuels, and changing from equipment fired with coal or oil to equipment fired with natural gas. In line with the objective of diversifying the sources of energy in Malaysia, renewable energy such as hydro, biomass, solar thermal power, geothermal, wind and municipal waste, has been identified as an alternative source of energy which could be promoted.
However, there are a number of challenges that inhibit the development of renewable energy in Malaysia. There is uncertainty in respect of the technological development to convert the renewable energy resources into usable forms where commercialisation of research findings has not been fully undertaken on a large scale.

The generation of renewable energy is also economically unattractive due to availability of cheaper alternative of energy. In this respect, the intended creation of a competitive electricity supply industry by year 2000 would also have implication on the role of renewable energy in the open electricity market in view of its relatively higher cost of energy generation compared to conventional energy.

In this regard, formulation of sustainable energy policy and strategies in addressing these challenges is indeed a pre-requisite for the concerted development and promotion of renewable energy.
5.3.3 Energy Efficiency and Energy Intensity

A final class of methods for reducing acid gas emissions are energy efficiency technologies and measures. This class covers a wide range of technologies spanning all of the sectors. Energy efficiency technologies reduce acid gas emissions by reducing the amount of fuel - coal, oil, gas, electricity, or biomass - needed to provide a specific energy service. When the amount of fuel required is reduced, emissions of SO$_x$ are reduced at least proportionately.

Though one would tend to think of desulphurisation in connection with the term "environmental preservation" in many cases, Goto et. al. (1993) reported that it will be very much effective to promote energy conservation through the improvement in the efficiency.

The report also holds a view that high efficiency desulphurisation facilities have high capital and operational costs which would be a heavy burden for developing countries to construct. On the contrary, the progress of energy conservation through the improvement in the efficiency of energy use will contribute not only to the reduction of the SO$_x$ emissions, but also to the reduction of fuel costs, and will stimulate the economic growth by the resultant capital investment, and accordingly it is important to proceed with this course of action.
Since the transport sector is likely to command much larger shares of the national energy budget in Malaysia as those developed countries, following the pattern of Japan, South Korea, and Chinese Taipei, detail outline of the various options available to improve the efficiency of energy use in the transportation sector is made here.

- *Energy Efficiency Options in the Transport Sector*

There are a number of possible options available to the transport sector for improving efficiency. They include replacing existing vehicles and technologies with efficient ones, “mode-shifting” or investing in public transport, mass transit efficiency improvements, and adopting strict emission standards for vehicles.

For personal passenger transport, a wide variety of engine and transmission modifications, modifications to reduce vehicle weight, and changes to reduce air and rolling friction have been proposed (*Gordon, 1991*). It was reported that these changes would have made it possible to reduce the energy intensity of automobiles by a factor of two or more compared to present conditions.
For mass transit of passengers, substantial efficiency improvements in bus engines and transmissions are possible. Traffic flow modifications, such as dedicated bus lane, are ways of increasing the efficiency of bus transit without changing equipment. Rail transport efficiencies can be increased by improving maintenance of trains and tracks, optimising train size and traffic flow (including computer control).

Finally, a highly effective option is to increase investment in public transport systems. Personal transport is highly energy intensive. Shifting transport modes from personal to public could save significant quantities of energy and reduce pollution level. This option includes policies that encourage the development of certain transport subsectors - such as urban and inter-city mass transit by train and bus - while discouraging other options such as low-occupancy use of passenger cars.
5.3.4 Regulatory and Monitoring Framework

As a fellow member of *Agenda 21* and the *Rio Declaration 1992*, Malaysia has put in place general policies in the supporting of energy efficiency and environmental sustainability. However, not all have been well-defined with quantitative set of standards in place to codify these general policies within the regulatory framework of Malaysia.

Where standard exist, they may not be stringent enough to satisfy regional needs for acid gas emission reduction. For instance, specific permissible standard for the emission of \( \text{SO}_x \) from various fuel burning equipment has not been defined in the Environmental Quality (Clean Air) Regulations 1978 until to date.

As such, the analysis here has taken a stand to assume that no particular desulphurisation or reduction of \( \text{SO}_x \) emissions have been put in place in the various contributing sectors in Malaysia. In other words, the equation adopted in Chapter 3 was calculated without omissions values of \( RS_i \) (removal of \( \text{SO}_x \) by desulphurisation equipment as defined by the reference source). This is also supported by Streets (1997), where it was reported that only Japan had any stack-gas control technology in place in 1990.
Japan's petroleum industry has been actively investing in desulphurisers and other facilities, and has worked for the reduction of environmental pollution. It was particularly noted that, for the future, quality regulations for environmental protection will continue to move to even greater strictness.

It is thus high time for the Malaysia's government to conduct more model comparisons and fundamental studies to better determine the most suitable parameters for use in modeling studies and support any estimates of the emissions of SO$_x$ or its resulting acid deposition.

Furthermore, despite the less significant of the problem of acid rain in Malaysia as compared to other countries in the Northeast Asia, Malaysia has, however, been identified as within those region where sulphur deposition exceeds the critical load, and thus those areas where ecosystems are predicted to be at risk (Carmichael et. al., 1996).

High ambient levels of SO$_x$ concentrations resulting from this scenario do not only imply serious risks to natural and agricultural ecosystems, but also impose a serious threat to human health. In this respect, Malaysia could adopt the WHO annual average guideline of 40 - 60 micrograms SO$_x$/m$^3$. 

88
In short, overall analysis of environmental laws will take us into two pronged environmental considerations: long term consideration on implementation of actual system emission limits; and short term aspects mainly centred around maintaining desired ambient air qualities.

On the other hand, since such air pollution resulted by $SO_x$ is not limited to the district of the source and has an influence on the neighbouring countries and should be regarded as an international problem, it is desirable to reinforce any forms of monitoring and research system within the region. Both research and policy forum will need to be further developed in Asia to address the challenges presented by these regional environmental problems.

One good example of such collaboration will be the Asia-Pacific Economic Cooperation (APEC) Energy Working Group (EWG). The EWG, initially called the Energy Project Group, was launched in 1990 to develop a programme for energy cooperation in the APEC area as sought by APEC Ministers meeting in Canberra in 1989.

Key outcomes of EWG included agreement by APEC Energy Ministers to 14 non-binding policy principles to guide their domestic deliberations in regard to energy policy and incorporating of good environmental practices into the development of power projects.
Several generic types of opportunities for regional collaboration to help address global environmental issues are listed as below:

- **Technology transfer**: provide information and general training to government officials, funding for demonstration projects;
- **Planning assistance for development**: urban planning, transport planning, energy planning, environmental restoration and conservation, pollution control, and industrial infrastructure;
- **Agreements on trade policies**