Assessment of Air Pollution and GHG Mitigation Strategies in Malaysia using the GAINS Model

K Maragatham[1], P Rafaj[2]
[1] Malaysia Nuclear Agency, Kajang, Malaysia [2] International Institute for Applied Systems Analysis (IIASA)

[1]E-mail: maragatham@nuclearmalaysia.gov.my

Abstract

Planning for future energy development, taking into account the national obligations to mitigate climate change and air quality pressures is a major challenge faced by Malaysia. This research facilitates the impact assessment of simultaneous control of air pollution and GHG abatement through a set of emission scenarios while considering current and future Malaysian policies. The IIASA's GAINS (Greenhouse Gas-Air Pollution Interactions and Synergies) model is used for the estimation of emissions and costs, and the outputs of the MESSAGE and MAED energy models provide the underlying energy projections by 2050. Results show that current air-quality policies are efficient in keeping emissions growth at moderate rate, however, significant reduction potential exists if best available control technologies are introduced. This paper aims to discuss the energy outlook and impact of stringent air pollution policies in transportation sector in Malaysia.

Keywords: air pollutant, sulphur dioxide (SO_2), nitrogen oxides (NO_x), fine particulate matter (PM2.5)

1. Energy Status of Malaysia

In Peninsular Malaysia, domestic gas supply, including imports from Indonesia and the Joint Development Area with Thailand, is expected to decline at 12 per cent per year in the coming decade. The alternative is to import gas in the form of LNG, and LNG regasification terminal will be built to treat imported LNG. Efforts were taken to reduce the high dependence on gas into the generation mix by increasing the use of coal (The Report: Malaysia 2010).

The national oil reserves are depleting with remaining of 5.8 billion of crude oil in barrels by the end of 2010. Hence, Malaysia is expected to revert to being a net oil importer. Based on this current production level, the reserves are projected to last for 25 years. Therefore, oil is already decoupled from power generation sector (National Energy Balance, 2009).

Sarawak's hydroelectricity potential is virtually untapped with only 0.6 percent of the estimated 20GW of potential power capacity is currently developed. The plan to export power to Peninsular Malaysia from Sarawak through under-sea high-voltage direct-cable transmission does not appear to be economically viable at the current point in time (The Report: Malaysia 2010).

Malaysia has limited high quality indigenous coal deposits, with mostly sub-bituminous and lignite coal in Sarawak. Therefore, power generation sector solely depends on coal imported mainly from Indonesia, Australia and China. Malaysia imports about 90 percent of coal. However, escalating coal prices especially within the region and supply constraints with exporters unable to cope with demand are some of the major issues faced. Moreover, from the environmental perspective, any further increase in the utilisation of coal for power generation could have serious implications on the carbon intensity growth for Malaysia (National Energy Balance, 2009).

Table 1 summarizes the national commercial energy flow in 2010, showing the outlook of supply and energy demand in Malaysia as well as final energy use by six sectors: industrial, transportation, commercial, non-energy use, residential and agriculture.

Table 1: Outlook of supply and energy demand of six sectors

Fuel by Type	Production (ktoe)	Share of fuel consumption (%)					
		Industrial	Transportation	Commercial	Residential	Agriculture	Non-Energy
Coal	14777	14.1	-	-	-	-	-
Gas	31588	23.3	1.5	0.7	0.2	-	55.1
Oil	25023	21.6	98.4	29.0	26.8	0.03	44.9
Electricity	8993	30.9	0.1	70.2	73.0	0.57	-

2. Methodology

The study incorporates energy projections from MESSAGE (Model for Energy Supply System Alternatives and their General Environmental Impacts) and MAED (Model for Analysis of Energy Demand) into GAINS to explore emission scenarios for air pollutants in Malaysia in the period 2010-2050. The GAINS (Greenhouse gas – Air pollution Interactions and Synergies) model is a tool to identify emission control strategies that achieve given targets on air quality and greenhouse gas emissions at least costs. It quantifies the full DPSIR (demand pressure-state-impact-response) chain for the emissions of air pollutants and greenhouse gases. In particular, GAINS quantifies the DPSIR chain of air pollution from the driving forces (economic activities, energy combustion, agricultural production, etc.) to health and ecosystems effects.

This study takes into account energy issues and current policies in analysing projections for energy demand and supply in various sectors and explores the scope for managing future emissions of air pollutants on sulphur dioxide (SO_2), nitrogen oxides (NO_x) and fine particulate matter (PM2.5) emissions by fuel and sector in Malaysia using the GAINS (Greenhouse Gas - Air Pollution Interaction and

Synergies) from 2010 till 2050. Hence, this study focuses on assessment of air pollutant, nitrogen oxides (NO_x) resulting from transportation sector and impact of stringent air pollution policies in Malaysia.

3. Transportation sector

Transportation sector is expanding with the completion of 196km electrified double track rail added in rail network by 2009. Electricity demand is expected to increase in future with completion of other electrified double track rail projects scheduled in Tenth Malaysia Plan (2011-2015). Furthermore, transportation sector reduces dependency on petroleum products by increasing use of biofuel and natural gas (NGV). National Bio fuel Policy (2005) introduced a biodiesel fuel blend (B5), 95% regular diesel with 5% palm oil biodiesel blended. By 2009, 5.49 billion litres of biofuel used in transportation sector and about 40955 vehicles are running on NGV.

Table 2: Energy Consumption and its share in 2010, 2030 and 2050

Fuel by Type	No of Vehicle (thousand of vehicle)			Share of fuel consumption (%)		
	2010	2030	2050	2010	2030	2050
Oil	8319.70	17353.3	22162.43	99.88	99.03	96.82
Natural Gas	27.30	543.18	1782.72	0.02	0.14	0.41
Electricity	8.13	459.85	1006.44	0.11	0.83	2.77
Total	8355.13	18356.33	24951.59	100.00	100.00	100.00

The country emphasized on preventive measures to mitigate and minimize pollution as well as addresses other adverse environmental impacts arising from development activities. In addition, steps were undertaken to identify and adopt actions to promote sustainable natural resource management practices in relation to land, water, forest, energy and marine resources (Ninth Malaysia Plan, 2006-2010).

In 1996, Department of Environment (DOE) has adopted the Air Pollutant Index (API), which closely follows the Pollutant Standard Index (PSI) system to monitor five air quality parameters namely, Carbon Monoxide (CO), Sulfur Dioxide (SO_2), Nitrogen Dioxide (NO_2), Ozone (O_3) and Suspended Particulate Matter below 10-micron diameter (PM_{10}). During Outlined Perspective Plan 3 (OPP3) period (2001-2010), the government has undertaken measures to address air pollutant issues caused by various sources by enhancing enforcement of emission controls for motor vehicles and instituting comprehensive traffic management systems (Compendium of Environment Statistics, 2011).

3. Scenarios

Two scenarios are developed:

3.1 Baseline Scenario

This scenario is driven by current policies and legislation, economy growth and efficiency of technologies, and not taking into account of climate policies. In transportation sector, European emission standards known as EURO standards are implemented (DELPHI, 2012/2013). These standards are obtained from legislations for vehicles in Department of Environment (DOE). In 2009, all oil companies in Malaysia are required to upgrade their fuel quality to comply with the EURO 2 standard for both diesel and petrol. This new standard means a reduction in the sulphur content from 3,000 parts per million (ppm) to 500 ppm for diesel, and from 1,500 ppm to 500 ppm for petrol. By 2014, both diesel and petrol fuels will be upgraded to EURO 3 standards. Table below shows summary of standards for exhaust emissions for new models of motor vehicles.

Table 3: Emission Standard of Pollutants for new models of motor vehicles on or after 1st January 2000

Emission Standards	2 or 3 wheel motor vehicle	petrol engine	diesel engine
EURO 1	2 stroke & 4 stroke	maximum weight not exceeding 3.5 tonnes	total mass less and exceeding 3.5 tonnes
EURO 2	-	total mass < 2.5 tonnes	-

Source: Environmental Quality Regulations, Department of Environment

Currently, emission standards are upgraded based on EURO 2 for diesel vehicles and EURO 3 for petrol vehicles as in Ninth Malaysia Plan. The baseline assumes full implementation of this legislation according to the foreseen schedule. The analysis considers that new vehicles have higher annual mileage than older vehicles, so that their share in total mileage will be even larger than their share in the vehicle stock. Figure 1 and Figure 2 present the estimated shares of different European exhaust emission standards in the total mileage of Malaysia fleet. Future control strategies are implemented with a gap of 10 years after the first introduction of EU legislation based on the previous implementation trend in the country.

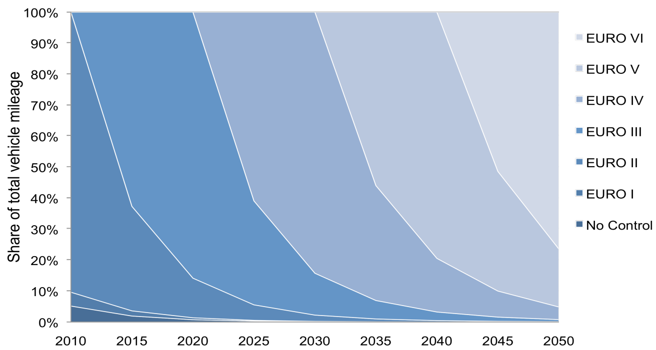

Figure 1: Penetration of EURO-standards for passenger cars

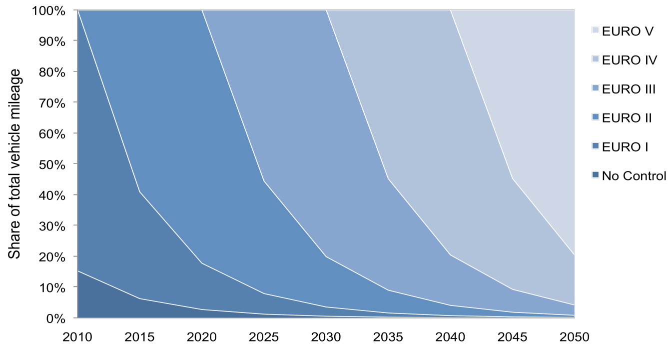

Figure 2: Penetration of EURO-standards for heavy duty cars

3.2 MFR (maximum feasible reduction) Scenario

This hypothetical scenario explores the scope for emission reductions from application of the most effective emission control technologies that are currently on the market for all relevant sources. These technologies are implemented starting as of 2030 in order to estimate the potential for maximum feasible emission reductions between 2030 - 2050. This set of technology options is deployed from existing 'best available technologies' for pollution control in the European Union. The implementation of the MFR control strategy for Malaysia is based on a report analysing future air pollutant emissions in Europe (TSAP IIASA, 2012)

4. Results

4.1 Baseline Scenario

NO_x is mainly emitted from transportation sector but the trend gradually changes in future as a consequence of staged introduction of more stringent emission controls on new vehicles. Introduction of higher EURO-standards reduces the NOx emissions in later years, although consumption of gasoline and diesel increases with growing vehicle fleet. Moreover, use of electricity and NGV for transportation sector is expected in near future, which also contributes to emission reduction. Since transportation and energy sectors are currently the major source of total emissions, the overall decline in NO_x emissions strongly depend on implementation of new control measures. Table 4 shows the gradual reduction in NO_x emissions from gasoline and diesel due implementation of new control measures and shift from oil consumption to gas in cars.

Table 4: NOx emissions by fuel for transportation sector

Fuel by Type	NOx emissions (kton)				
	2010	2020	2030	2040	2050
Gasoline	64.671	51.157	44.018	31.881	25.832
Diesel	253.448	266.141	266.905	214.08	172.476
Gas	0.023	0.055	0.164	0.207	0.278

Figure 3 shows an overall comparison of NO_x emissions from six sectors. NO_x emissions in transportation sector are gradually decreasing with implementation of control strategies over the study period.

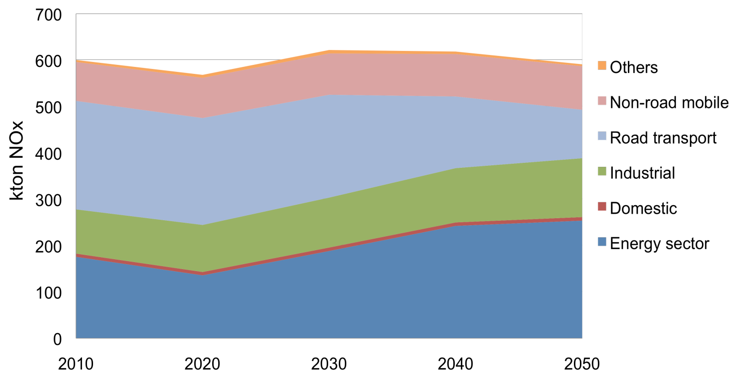

Figure 3: NOx emissions by SNAP sector

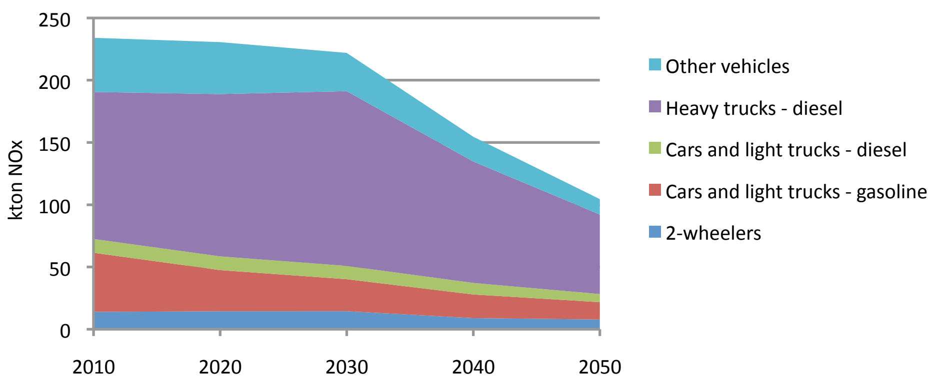

Figure 4: NOx emissions by vehicle type

Figure 4 shows the types of vehicle with NO_x emissions levels. Heavy vehicles contribute higher emissions compared to light vehicles due to penetration of EURO-standards for heavy and light vehicle as shown in Figure 1 and 2.

4.2 MFR scenarios

Comparison between Baseline and MFR scenarios is provided in this section. This section also analyses the impact of stringent air pollution policies. This hypothetical MFR scenario explores the ultimate scope for emission reduction that could be achieved through application of the best available air pollution control technologies starting in 2030.

Overall, NO_x emissions are expected to decline by 80% in 2050 compared to 2010 level for MFR scenario. With the implementation of the highest EURO standards in MFR scenario, NO_x emissions for transportation sector declined approximately by 80% for both road and off-road categories as in Figure 5 and 6.

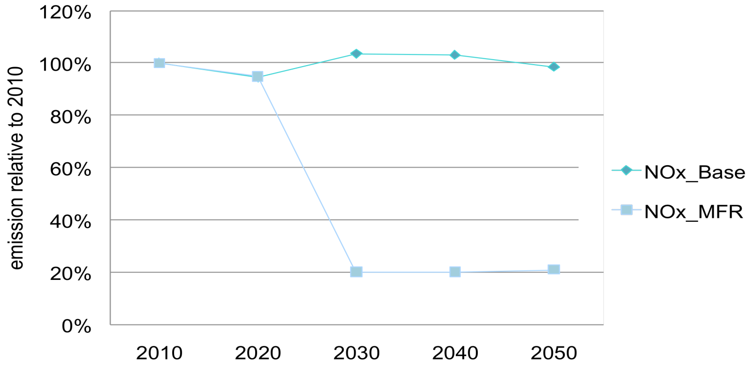

Figure 5: Scenario trends of NO_x emissions

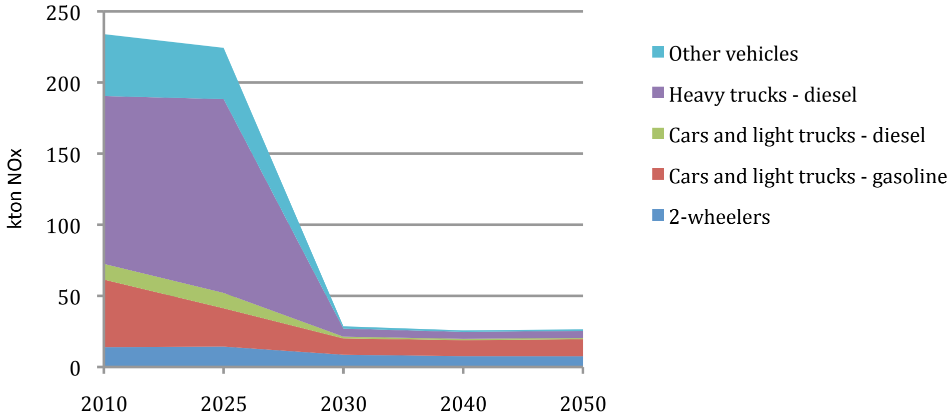

Figure 6: NOx emissions by vehicle type

5. Conclusion

This study presents an outlook of air pollutant emission projections for Malaysia through base case and MFR scenarios taking into account recent policies on transportation and climate change. Results show that current air quality policies - if enforced at the national level – might be efficient in keeping emissions growth at moderate rate, however, significant reduction potential exists if best available control technologies are introduced. However, implementation of such technologies needs high investments and commitment from the local decision makers.

In transportation sector, impact of standards for exhaust emissions (i.e. EURO-standards) is substantial in controlling NOx emissions, although the timing and effectiveness of implementing the control technologies for various vehicle categories by 2050 is uncertain. It is expected that the overall air pollution reduction in transportation sector can be tackled with the introduction of B5 biodiesel mandate whereby diesel fuel for land and sea transportation will be a blend of 5% processed palm oil and 95% petroleum diesel. Furthermore, hybrid electric vehicles also have potentials of reducing air pollutants. In future, hydrogen production using nuclear energy could reduce dependence on oil for fueling motor vehicles, which can contribute towards tackling emission reduction.

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