Strategic Master Plan for Establishing Sustainable Transport System and Mitigating Climate Change Impacts in Thailand

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Abstract: This study deriving data and information from a large study project "Study for the Development of Master Plan for Sustainable Transport System and Mitigation of Climate Change Impacts" aimed to present specific scenario of greenhouse gas emission of the transport sector and the possibility to mitigate it and control the impacts of climate change through a Strategic Master Plan designed with Avoid-Shift-Improve strategy intertwined with instruments specifically developed for developing sustainable transport system: infrastructure planning and trip management (P), incentive through policy and regulation (R), economic inducement (E), awareness of sustainable transport and environmental cost (I), and use of pollution reducing technologies (T) and implemented in short and long terms focusing on various instruments with different strength. This Strategic Master Plan is expected to induce the sustainable transport scenario as presented in table 1 and help to develop a sustainable transport system in Thailand.

Keywords: Sustainable development, Master plan, Greenhouse gas emission, Climate change, Thailand

1. INTRODUCTION

The 1987 report of the World Commission on Environment and Development defined "sustainable development" as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." This concept took into account of all sectors of human activity including the "sustainable transport". Thus, it implies that the movement of people and goods should occur in ways that are environmentally, socially and economically sustainable, or paraphrasing the above definition for sustainable transport it can be defined that sustainable transport is the ability to meet today's transport needs without compromising that the ability of future generations to meet their transport needs (Black 1996). Sustainable transport has been considered as a key challenge of the EU Sustainable Development Strategy and with the same meaning one of its objectives is set to ensure that the EU transport systems meet society's economic, social and environmental needs whilst minimizing their undesirable impacts on the economy, society and the environment.

In this regard, Organization for Economic Cooperation and Development (OECD) and the Economic and Social Commission for Asia and the Pacific (ESCAP) incorporate ten elements for sustainable transport system: (i) safe, economically viable and socially acceptable access to people, places, goods and services; (ii) upholding health and environmental quality; (iii) protecting ecosystems by avoiding exceeding critical loads and levels for ecosystem integrity; (iv) does not aggravate adverse global phenomena, such as climate change and stratospheric ozone depletion; (v) reducing poverty in all its dimensions, including the elements contained in the Millennium Declaration; (vi) increasing levels of transport services that are affordable, reliable, efficient and rapid; (vii) minimizing resource use to sustainable levels in terms of energy, land and materials use; (viii) limiting the public debt burden to sustainable levels (taking into account changes in public capital and operating expenditure); (ix) maximizing long-term economic growth that is geared to benefit all parts of the country, including the hinterlands and border regions; and (x) facilitating the smooth flow of goods and people across national borders, including for transit, thereby supporting regional economic integration and contributing to peace, stability and “good-neighbourly relations” among countries.

The World Bank (1996) while considering the concept of sustainability puts forward the tri-pillar concept and postulates that “*economic and financial sustainability* requires that resources be used efficiently and that assets be maintained properly. *Environmental and ecological sustainability* requires that the external accounts of transport be taken into account fully when public or private decisions are made that determine the future development. *Social sustainability* requires that the benefits of improved transport reach all sections of the community.”

While considering the sustainability in transport sector it has also been recognized that the “transport system is complex, and this complexity derives from the pluralism of its hardware (infrastructure and vehicles) and of the people and organizations involved. The complexity is multiplied by the existence and roles of different modes, regulatory and legislative bodies, service providers, builders, financing system, technology, land-use patterns, and, most importantly human behaviour.” (Richardson, 2005). By now a vast literature has been developed on sustainable transport and cover areas like passenger issues (DeCicco and Delucchi, 1997; the Transportation Research Board, 1993 and 1997; Richardson, 1999 and 2000; Elvik, 2009); issues of freight transport (Gordon, 1995; O’Rourke and Lawrence, 1995; Duleep, 1997; 1997; Scrase, 1998; Beuthe et al., 2002; Friedl and Steininger, 2002; Priemus, 2002; Luoma and sivak, 2012); general sustainability issues (Wittneben 2009; Neppesen, 2011; Nguyen and Coowanitwong, 2011; Zito and Salvo, 2011; Beria et al., 2012; Bhattacharya, 2012; Gori et al., 2012) and international sustainable transport issues (Black and Nijkamp, 2002; Wilhelm and Posch, 2003).

2. STRATEGICAL ASSUMPTIONS FOR SUSTAINABLE TRANSPORT SYSTEM

At present, the state of sustainable transport is not encouraging. Considering ten critical elements of sustainable transport: (i) congestion; (ii) pollution; (iii) load on ecosystem; (iv) emissions; (v) poverty; (vi) transport inefficiency; (vii) energy and consumption; (viii) debt burden; (ix) participation; and (x) international transport and network, despite consciousness on the impacts of these elements on sustainability of transport system, there is either still growing tendency or difficult to maintain the status-quo ante on the negative consequences of these elements.

The United Nations ESCAP has compiled the various elements of sustainable transport system with a view to present the implications of a “dynamic-as-usual” scenario versus a sustainable transport scenario for the ESCAP region and presented in table 1 with a view to improve the state of transport sustainability in the Asian and Pacific region. The dynamic-as-usual scenario assumes that present trend continues in its own pace propelled by the underlying dynamism of the common unsustainable practices. To overcome the unsustainability an assumption is essential with general consensus of “sustainable transport scenario”, which ESCAP has prepared as presented in table 1 and this study has taken as the strategical assumptions for the sustainable transport system in general, which is basically applicable to the Thai context as well.

Table 1. Implications of a"dynamics-as-usual" scenario versus a sustainable transport scenario for the ESCAP region, for the period 2006-2030

Elements	Implications of "dynamics-as-usual" scenario	Sustainable transport scenario
1. Congestion	Congestion may worsen in urban areas and on major freight corridors in both the developed and developing countries.	Congestion levels are actively managed and mitigated through a combination of measures, including market instruments and encouraging modal shifts.
	There could be around 610,000 road fatalities in the region by 2020.	By 2030, the region's road fatality rate per motor vehicle is reduced to the current world average rate.
2. Pollution	Local air pollution will remain a major health concern in Asian urban clusters.	Local air pollution is reduced significantly in developing countries by 2015.
	Noise pollution will not decrease.	Noise pollution, particularly g busy roads, it corridors and airports, is decrease.
3. Load on ecosystem	Critical loads for certain ecosystems will be exceeded in the coming decades.	Exceeding critical loads is avoided in most parts of the region.
4. Emissions	Absolute amounts of nitrogen oxides (NO_x) emissions and carbon monoxide (CO) emissions from transport will remain roughly constant, or decrease slightly by 2030.	NO_x and CO emissions from transport are drastically reduced by 2010 to between one third and one half of current levels.
	Carbon dioxide (CO,) emissions from transport will continue to increase more rapidly than those of most other sectors.	The increase in CO, emissions from transport is decelerating, but its share in total CO_2 emissions continues to increase until 2030.
5. Poverty reduction	The contribution of transport to poverty reduction will primarily be limited to the "trickle-down" effect, with 40 per cent of all poor people living in urban areas by 2025.	By 2015, at least 66 per cent of all village in the ESCAP region are connected by all-weather roads and all village are connected by 2030.
6. Transport efficiency	Transport efficiency (especially ports and airports and their land linkages) and reliability will continue to increase and freight costs will continue to decline.	Better integration of transport modes, as well as improvements in "domestic logistics", lead to even higher efficiency and reliability.
	By 2030, the region's personal mobility levels will reach 270 motor vehicles per 1,000 persons, while railways both in urban and on intercity routes will lose ground in most countries of the ESCAP region.	By 2030, high mobility levels are reached, through not only vehicle ownership but also near-universal access to urban mass transit, new high-speed rail freight corridors and high-speed passenger railways.
7. Energy and consumption	Road construction alone will consume 3 million to 6 million hectares of land from 2005 to 2015.	Land consumption by roads is reduced to 2.5 million hectares or less from 2005 to 2015, owing to the reemergence of railways and other measures.
	Transport related energy use will remain almost entirely in gasoline and increase by another 400 million tons of oil equivalent per year in the region by 2020.	While transport-related energy use increases, the fuel mix changes towards a higher renewable content (e.g. biofuels, flex fuel).
	The use of virgin materials will continue to increase, despite higher recycling rates. Natural rubber prices will increase rapidly due to road freight.	Special efforts are made to increase recycling rates even further and to limit the need for additional amounts of natural rubber.
8. Debt burden	The public debt burden will increase substantially many developing countries over the next 30 years.	The public debt burden is limited through innovative ways of financing, including_ environmental co-financing and viability funding arrangements.

Elements	Implications of “dynamics-as-usual” scenario	Sustainable transport scenario
9. Participation	Participation in international production networks will continue to be concentrated in maritime regions around major ports and a select group of countries.	All ESCAP member countries, including landlocked countries and hinterlands, participate to a varying extent in international production networks by 2030.
10. International transport and network	Overall overland cross-border transport flows will continue to increase slowly in Asia but, with few exceptions, will remain small compared with Europe or North America; cross-border facilitation issues, and especially transit issues, will continue to constrain traffic.	Infrastructure and cross-border transport facilitation are improved, so that by 2015 significant cross-border overland traffic (including for transit) emerges as a veritable alternative to maritime and air transport between neighbouring countries and certain long-distance routes, including the Euro-Asian land route.
	Whereas the integration or "melding" of physical transport and communication networks will continue as a business trend ("logistics"), Governments will continue to regulate them in isolation from each other. Melding with relevant non-physical networks will occur only in rare cases.	Public sector policies facilitate the integration or "melding" of physical and non-physical networks, including transport networks (e.g. road, rail, inland waterways and shipping), communication networks, and non-physical networks (e.g. freight forwarders, multimodal transport operators, banking, customs, health, security etc.).
	An increasingly complex "hub and spoke" system of international agreements on transport will emerge in the region. It will be difficult to manage. There will be concern that this system is too closed and inequitable, and that commitments under some of the agreements are incompatible.	A coherent system of agreements is developed that is equitable, open to accession any United Nations member, non-discriminatory and allows for a phased process for participation by ESCAP members, as they become ready for the various commitments.

Sources: United Nations ESCAP (2006).

3. OBJECTIVE AND METHODOLOGY

With the context of justification presented in Section 1, this paper has taken into considered the sustainable transport system in Thailand with special consideration of the mitigation of climate change, overviewed the state of emissions, and discussed strategies for mitigating the climate change impact in Thailand.

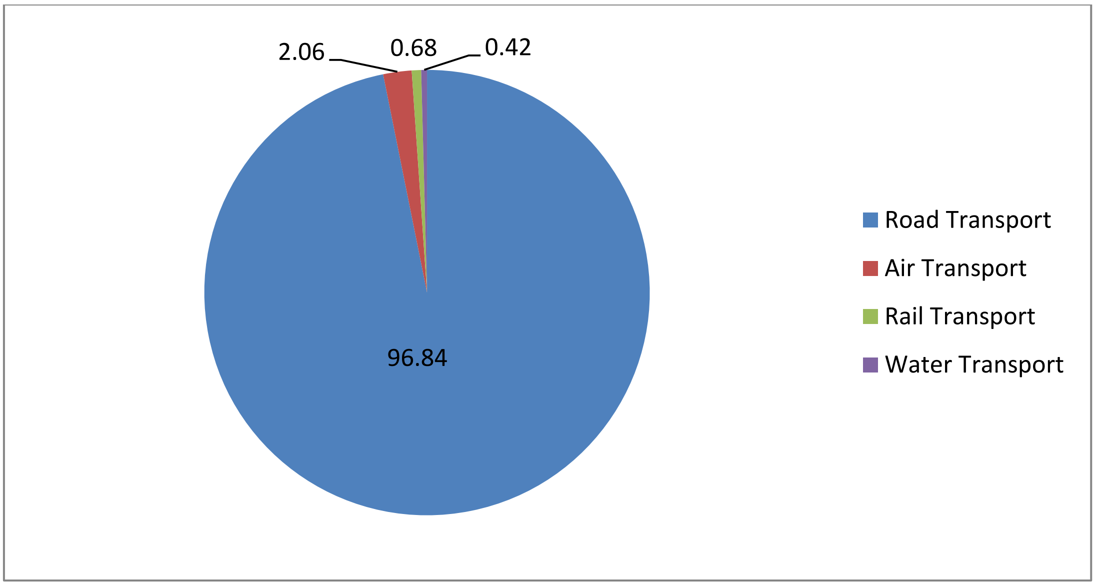
The basic data and information for this study is taken from the report “Study for Development of Master Plan for Sustainable Transport System and Mitigation Climate Change Impacts”.

4. SUSTAINABLE TRANSPORT SYSTEM AND STRATEGIES FOR MITIGATING CLIMATE CHANGE IMPACTS IN THAILAND

In 2007, a White Paper on Multi-Modal Transportation Systems for Thailand’s Sustainable Development was prepared by the Ministry of Transport under the administration of Prime Minister General Surayudh Chulanont. The primary objective of this white paper was to lay down a firm foundation for future development of Thailand’s multi-modal transportation systems within the principles of sustainable transport.

The adoption of the principles and practices of sustainable transport for Thailand, however, requires adjusting the practices to match the Thai context.

First let us discuss the present scenario of the sustainable transport with specific consideration to energy use and emissions. In view of the overall energy use within the various sectors in Thailand, energy use by transport sector compared to the industrial sector is similar, which are recorded at 35.4 per cent and 35.9 per cent, respectively, while the remaining sectors contribute a combined 28.7 per cent. Within the transport sector, road transport has the highest CO_2 emission, amounting to 97 per cent of the total transport emission. Realizing that Thailand has a very high energy use and CO_2 emission from the road transport mode, it is now imperative that the efficiency of the mode be upgraded as the top priority in order to reduce the emission of the greenhouse gases.



Source: National Greenhouse Gas Listing

Figure 1. Share of greenhouse gas released by different modes of transport in Thailand

With the above objective in mind, it is necessary to develop a Master Plan for Sustainable Transport System and Mitigation of Climate Change Impacts in order to provide clear direction for the development our transport system as well as to mitigate the effects of global warming. The Office of Traffic and Transport Policy and Planning (OTP) has thus recognized the need to commission a study to develop such Master Plan for an Environmentally Sustainable Transport System which is to serve as guidelines for the long-term development of Thailand transport infrastructure and to put the country on the path for future competition in a world increasingly regulated by considerations of environmental impacts and climate change.

4.1 Testing and Analysis of Vehicle Emissions

The task involved tests on a sample of 73 motorcars with gasoline engine; 19 light diesel vehicles, 1 heavy diesel vehicle and 16 motorcycles. The vehicle samples were tested in the Emission Laboratory of the Pollution Control Department at various operating speeds (not exceeding 74 kph) based on their fuel types (i.e. gasoline, diesel, LPG and NGV). The test rig speeds emulated the speeds typical of traffic conditions in Bangkok. Additional test data were obtained from the results of previous testing by other projects for some 208 vehicles. These are combined with the results obtained from the 109 vehicle samples in order to arrive at an Emission Factor (EF) for each vehicle type, which in turn.

Figure 2 illustrates the average CO_2 emission rate at speeds of 30 kph and 60 kph for motorcycles, gasoline vehicles, light-duty diesel vehicles and heavy-duty diesel vehicles.

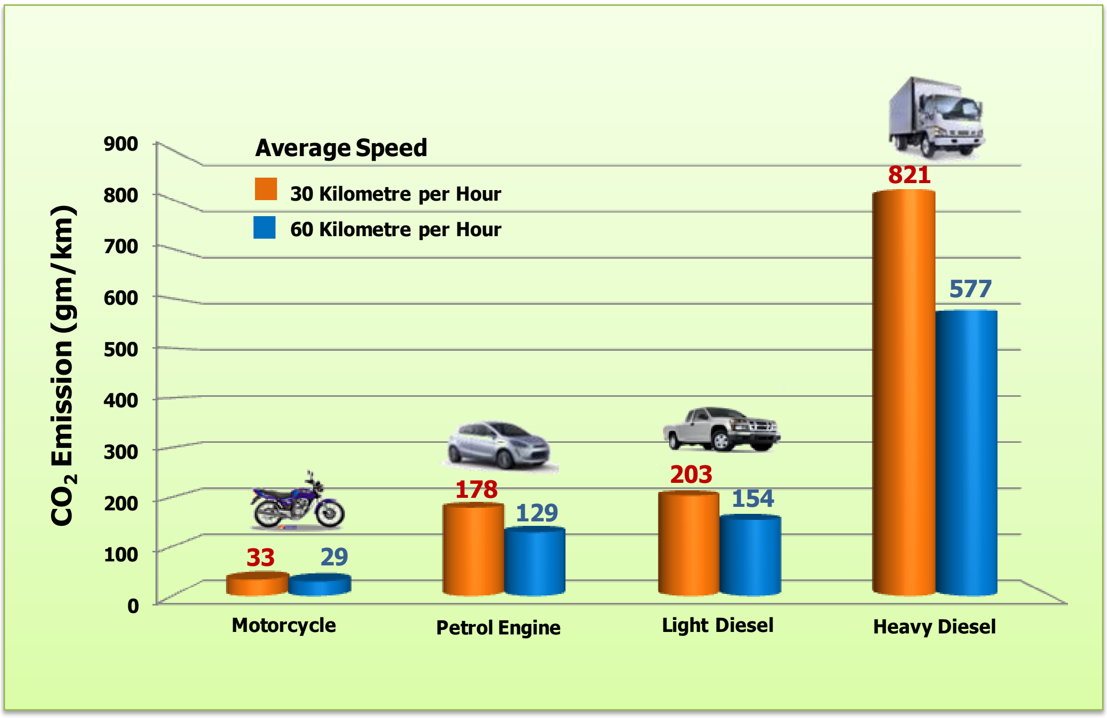


Figure 2. Average CO_2 emission at speeds of 30 and 60 kph by type of vehicles.

It can be seen that carbon dioxide emission rate tends to drop at higher road speeds. This trend was also noticed for other gaseous pollutants including hydrocarbon compounds (HC), carbon monoxide (CO) and oxides of nitrogen (NO_x).

To sum up, results of the pollutant emission tests were used to establish the EF factor, which was then employed in conjunction with the transport planning models to estimate the volume of pollutants and greenhouse gas emissions from the transport sector.

Emissions of pollutants released by the transport sector in 2011, based on outputs from the transport models, National Model (NAM) and Extended Bangkok Urban Model (eBUM), are shown below.

	NAM	eBUM	
• Hydrocarbon(HC)	**0.04**	**0.03**	M tonnes
• Carbon monoxide(CO)	**0.26**	**0.15**	M tonnes
• Nitrogen oxides(NO_x)	**0.24**	**0.11**	M tonnes
• Carbon dioxide(CO_2)	**39.21**	**18.21**	M tones

(Results shown are directly output from Transport Model. These figures have to be further calibrated against the Ministry of Energy's figures.)

4.2 Use of Transport Planning Models to Determine Pollution Attributable to the Transport Sector

This method involves calibration of transport planning models of the Office of Transport and Traffic Policy and Planning (OTP), i.e. the nation-wide model (NAM) and the BMR-level or eBUM model, and then integrates them with the model obtained from figure 2.

The two models developed by OTP are appropriate only for analyzing the pollutant reduction capabilities of work plans or projects involving large transport infrastructure, such as large-scale MRT construction, or intercity rail links. They cannot be used to evaluate the effectiveness of policy or measures for an environmentally sustainable transport system. Hence it is necessary to develop appropriate algorithms to help evaluate the efficacy of such projects in combating greenhouse gas emission. Reduction of greenhouse gas emission can be calculated by multiplying three parameters of road transport activities. These are: the number of trips generated; the average distance traveled; and the average rate of greenhouse gas emission among various vehicle types. The extent of pollution is given by the following equation:

Pollutant Volume = No. of trips made x Distance traveled x Emission Factor

In order to ensure reliable analyses of the likely pollutant reduction from a planned project, a number of assumptions must be made. These include the careful analysis of similar previous projects in other countries as well as the context of the current situation in Thailand in regard to existing transport infrastructure. The three main parameters for evaluating the effectiveness of a planned transport project are:

1) What is the reduction in the number of trips generated per day due to the project?
2) What is the reduction in vehicle-km per trip due to the project?
3) What is the reduction in greenhouse gas emission per kilometer traveled (gm/km) due to the project?

Multiplying together the three reduction ratios obtained above, and the result is the percentage of greenhouse gas reduction, or the effectiveness of the planned project in combating air pollution. Such evaluation will help to establish a target reduction of transport-generated pollution for a given future year.

It was found that the pollution volumes obtained from either of OTP's two models — NAM and eBUM —were on the low side when compared with the figures derived through the forecasts of the Ministry of Energy. Hence, values of released CO_2 obtained from the NAM and eBUM need to be adjusted to match those derived from the Ministry of Energy forecasts. The recalibrated values may then be used in further steps of analysis.

The adjustment figures shown in table 2 and table 3 indicate greater add-up ratios for the NAM model relative to the eBUM. This was due to the fact that the eBUM accounted for a larger transport network by being based on busy metropolitan Bangkok, while the NAM model only covered transport activities on intercity routes, discounting those on smaller urban roads or intra-city trips. Table 2 and table 3 below show the values of greenhouse gas forecasts from the base year of 2005, derived from OTP's models, together with adjustment values to match the forecasts of the Ministry of Energy.

Table 2. Greenhouse gas emission predicted under NAM

Year B.E .(A.D.)	Energy use in transport (ktoe)	CO_2 gas released in "without project" scenario, or business as usual – BAU (M tones CO_2 equivalent)				
		From energy use	From model	%	Correction	%
2548(2005)	23,491	57.52	33.15	57.6	24.37	42.4
2560 (2017)	30,661	67.35	43.99	65.3	23.36	34.7
2563 (2020)	33,700	74.02	48.52	65.5	25.50	34.5
2573 (2030)	46,810	102.82	62.30	60.6	40.52	39.4

Source: *20-year energy conservation Plan 2011-2030 by Ministry of Energy*

Table 3. Greenhouse gas emission predicted under eBUM

Year B.E .(A.D.)	Energy use in transport (ktoe)	CO_2 gas released in "without project" scenario, or business as usual – BAU (M tones equivalentCO_2)				
		From energy use	From model	%	Correction	%
2548 (2005)	10,381	25.42	17.17	67.5	8.25	32.5
2560 (2017)	11,217	29.76	24.35	81.8	5.41	18.2
2563 (2020)	14,893	32.71	26.44	80.8	6.27	19.2
2573 (2030)	20,687	45.43	35.90	79.0	9.53	21.0

Source: *20-year energy conservation Plan 2011-2030 by Ministry of Energy*

4.3 Preparation of the Strategic Master Plan

The goals of an environmentally sustainable transport system are the development of action plans or measures to mitigate the emission of environmentally harmful substances, the establishment of guidelines for comprehensive and integrated planning and implementation of the measures necessary to achieve them, and the compilation of knowledge for training operators in the transport sector.

To this end, a new concept will be introduce that will aid in the promotion of an environmentally sustainable transport system through which the reduction in energy use and greenhouse gas emission is to be achieved. There are the aspects to the new concept: Avoid Shift and Improve. These are employed in determining guidelines for achieving our objectives. The guidelines involve a number of instruments and/or measures, as follows:

1. Planning Instruments (P);
2. Regulatory Instruments (R);
3. Economic Instruments (E);
4. Information Instruments (I); and
5. Technology Instruments (T).

Reviews and analyses of environmentally successful projects and measures employed in Thailand and other countries have been carried out in order to select suitable examples for this purpose. These examples were then investigated further using a method called Multi Criteria Analysis (MCA) which matches the examples with the situations prevailing in Thailand. Findings from such analysis were summarized together with their relative merits for transport sector greenhouse gas reduction. In addition, views and suggestions were gathered from involved agencies for use in carrying out a SWOT Analysis. The entire process called for joint efforts from all parties to formulate strategies deemed appropriate for the Master Plan. Outcomes of the SWOT analysis brought the following six strategies for the Master Plan.

Strategy 1: Upgrade capability of agencies and personnel for the development of an environmentally sustainable transport system.
Strategy 2: Establish appropriate plans and mechanisms for interfacing and monitoring of transport and traffic work plans/measures/projects; and to move them forward to implementation.
Strategy 3: Establish comprehensive and inter-connected transport infrastructure.
Strategy 4: Efficient transport management for sustainability and greenhouse gas reduction.
Strategy 5: Promote transport R&D and adoption of environment-friendly innovations and technologies.
Strategy 6: Promote public awareness of the environment.

The six strategies are tied in with the five key instruments for developing a sustainable transport model as presented in figure 3.

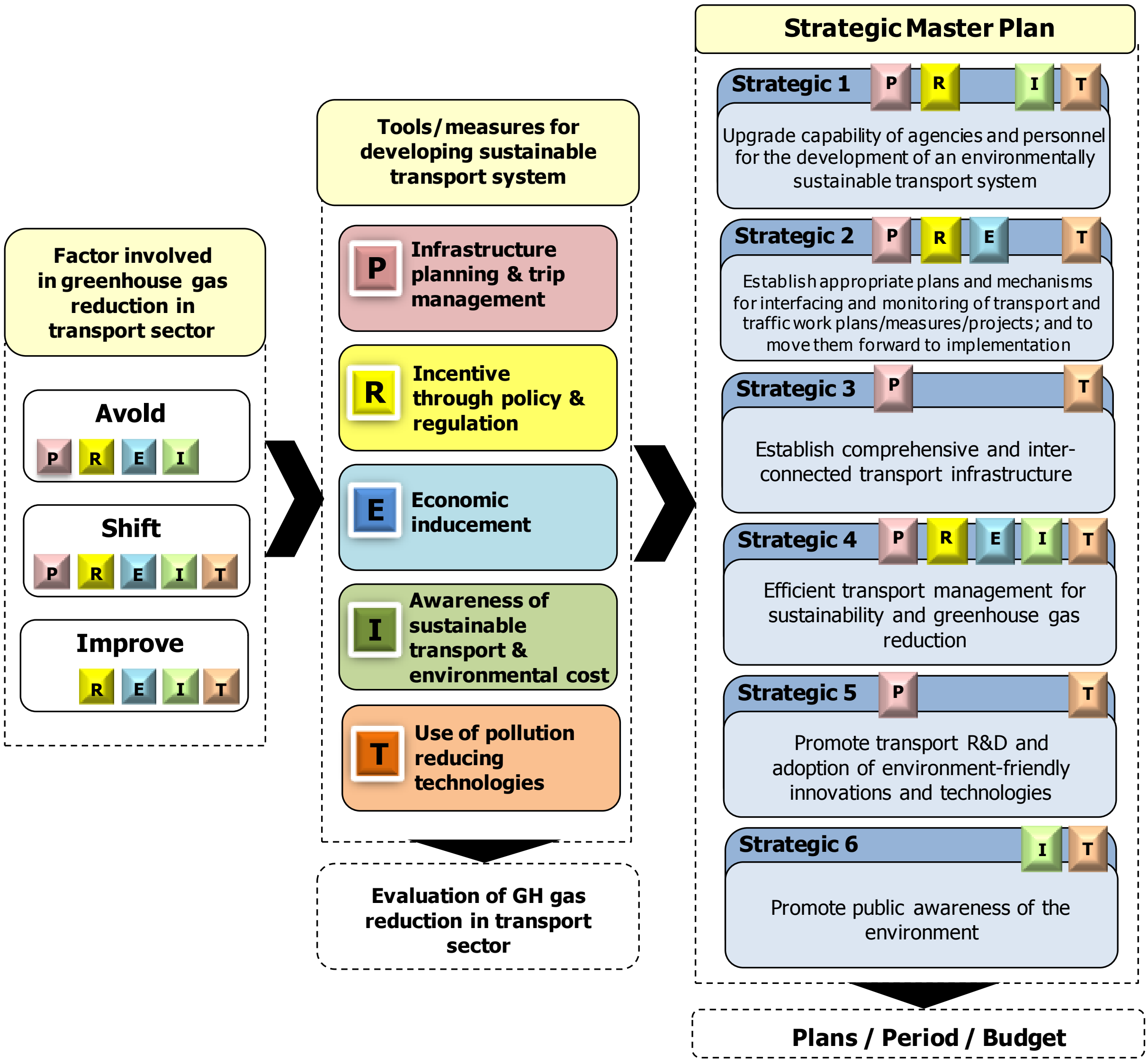


Figure3. Relationship between Shift–Avoid–Improve, 5 instruments and 6 strategies of the Master Plan

This strategic transport master plan can be divided into two key components, as follows:

i. Work plans/projects compiled from MOT plan for the next 3-5 years and those of related agencies; and

ii. Work plans/projects as per recommendations of related agencies, and

These work plans and projects are to be included in the short-term programme (2013-2017) and the long-term plan (2018-2030) where appropriate, incorporating details of their budgets, scheduled commencements and responsible executors.

The models and algorithm for pollutant estimates as described in figure 3 will be employed to determine the pollution reduction or efficiencies of the various plans, measures or projects to be proposed in the master plan as well as to set the reduction targets for future years. Such targets will be based on the BAU scenario for 2005 (base year). The projected efficacy of the strategies for a given year can show the reduction of greenhouse emissions for that particular year and can be compared with the BAU scenario for the same year. And this will be achieved without any negative effect on Thailand’s socio-economic advancement (Greenhouse Gas Management Authority, 2010). It is to be noted that reduction targets will be set at 80 per cent of the actual capability of the transport sector (or 12 million tones CO_2 equivalent), which is consistent with the energy saving targets set for the next 20 years Office of Energy Policy and Planning (2011). The advantages of setting targets at only 80 per cent will aid in Thailand’s efforts in negotiating with the internationally supported NAMAs.

The preparation of Nationally Appropriate Mitigation Actions (NAMAs) in Greenhouse Gas reduction for the transport sector was carried out by reviewing the principles and background of NAMAs based on GHG reduction plans of the United Nations Framework Convention on Climate Change (UNFCCC). These are divided into 3 major categories depending on the scale and type of assistance received from overseas, namely:

- Domestically Supported NAMAs - are the projects that can be implemented domestically without having to receive external support.
- Internationally Supported NAMAs - are the projects that the government sets policies and implementation programs. But the capital and technology support from developed counties are necessary to ensure that the goals are achieved.
- Tradable NAMAs –are the projects that involve carbon credit from GHG emissions reduction and carbon trading using market mechanism similar to Clean Development Mechanism (CDM).

GHG emissions reduction schemes under NAMAs projects will be checked for transparency based on MRV framework —Measurable, Reportable and Verifiable. The MRV reflects different levels of intensity i.e. Domestically-supported NAMAs has the lowest intensity level while Tradable NAMAs has the highest intensity.

The attempts to decrease GHG emissions in individual countries over the years have not been very successful. Therefore, at the 17th Conference of the Parties (COP17) to the United Nations Framework Convention on Climate Change (UNFCCC) held in December 2011 in South Africa, a committee was set to work on legally binding practices to be imposed on every member country effective from year 2020, requesting each country to pledge on GHG emissions reduction by establishing NAMA as well as upgrading GHG inventory and reporting. Thailand is committed to implementing the same as other countries, under the Kingdom’s prevailing conditions and readiness in executing GHG emissions reduction.

The strategic master plan to develop sustainable transport system reflects the potential to reduce GHG emissions in the event that all the projects are fully supported by the government. But in practice, under the political, economic and technological conditions, 80 per cent achievability is difficult and support of international organizations is required under the internationally-supported NAMAs framework.

The strategic master plan to develop sustainable transport system and climate change mitigation under this study yields the potential to reduce GHG or CO_2 as assessed. But considering the circumstances and limitations on the national budget coupled with the necessity to obtain support/aid from overseas on technology and MRV mechanism and the impacts from global economic changes may cause the plan implementation to not achieve goals in the timeline as stated in the Master Plan. All the plan/ projects/ measures of the Master Plan are therefore proposed as internationally supported NAMAs projects.

5. CONCLUSION

Due to the country's current situation and budget limit as well as the necessity of support/aid from overseas in terms of technology and MRV mechanism and the impact of the changes in global economy, the Strategic Master Plan fall short to achieve the goals on schedule. Thus, it is suggested that all of the programs/projects/measures in the Master Plan will be categorized as internationally-supported NAMAs.

Based on the Strategic Master Plan, Thailand should be able to reduce Greenhouse Gas emissions by 15-16 million tons of CO_2e in 2020, or around 20-22 percent of the 2020 BAU. This potential should not be regarded as a hindrance to the country's economic and social development. Meanwhile, the goal to achieve the reduction in Greenhouse Gas emissions in the transport sector at 80% of the potential is a big challenge. At the same time, it would help Thailand to take a standing its negotiations with other countries in internationally-supported NAMAs and widen the opportunity for the country to gain support.

The Strategic Master Plan should feature more detailed study to ensure that the communication and transport sectors will have a comprehensive Master Plan in the future.

Further study should be carried out to furnish details to the Strategic Master Plan – for example – the mitigation of water and air pollution - in order to establish a more comprehensive plan for the transport sector in due course.

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