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Study on Policies to Lower Oil Demand in the Transport Sector in the APEC Region

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Foreword

Under the Asia-Pacific Economic Cooperation's mission of promoting economic prosperity in sustainable ways, this research document proposes a policy framework for understanding the major factors involved in oil demand in the transport sector within the APEC region.

Oil accounted for the second largest share of primary energy demand in the APEC region in 2013 and will likely remain the top energy source in the long term. The majority of oil is used in the transport sector. Motorization, along with robust economic development, drives oil demand in the transport sector. This report presents a wide range of measures to control or reduce oil consumption in APEC member economies

This report is the work of the Asia Pacific Energy Research Centre. It is an independent study, and does not necessarily reflect the view of or policies of the APEC Energy Working Group or individual member economies. We hope that by leveraging APEC's economic and cooperative strengths, this research document will become a cornerstone for establishing information exchange and collaboration towards accelerating saving energy.

Takato OJIMI
President
Asia Pacific Energy Research Centre

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TABLE OF CONTENTS

Chapter 1 Oil Demand in Transport Sector in the APEC Region 1
Chapter 2 Policies to Lower Oil Demand in Transport Sector 7
2-1 Short-term Measures 7
2-1-1 Pricing and Taxation Measures 7
2-1-2 Mandatory Vehicle Use Control 10
2-1-3 Carpooling 13
2-1-4 Eco-driving 16
2-1-5 Rationing (Fuel Allocation) 19
2-1-6 Alternative Fuel (Biofuel) 20
2-2 Long-term Measures 22
2-2-1 Fuel Subsidy Reductions 22
2-2-2 Promotion of Public Transport Use 26
2-2-3 Research and Development 30
Chapter 3 Progress of Fuel Economy Standards and Clean Energy Vehicles in the APEC Region 32
3-1 Fuel Efficiency Improvement 32
3-1-1 Fuel Economy Standards 32
3-1-2 Labelling 39
3-1-3 Financial Incentives 42
3-2 Clean Energy Vehicles 43
3-3 Scenario Analysis 50
Chapter 4 Biofuel Use in Transport Sector 57
4-1 Overview of Biofuel Use 57
4-2 Biofuel Policy in the APEC Region 58
4-2-1 Australia 58
4-2-2 Canada 60
4-2-3 Chinese Taipei 62
4-2-4 Hong Kong, China 64
4-2-5 Indonesia 66
4-2-6 Japan 68
4-2-7 Korea 70
4-2-8 Malaysia 72
4-2-9 New Zealand 74
4-2-10 People's Republic of China 76
4-2-11 Peru 78
4-2-12 The Philippines 80

4-2-13 Thailand 82
4-2-14 United States 85
4-2-15 Viet Nam 88
4-3 Biofuel Projections (OECD-FAO Agricultural Outlook 2015) 90
4-4 Future Challenges 92
Chapter 5 Implications: Effectiveness and Challenges of Policies to Lower Oil Demand in Transport Sector 98

LIST OF FIGURES

Figure 1-1 Primary Energy Demand in APEC region (2000-2013) 2
Figure 1-2 Average Annual Growth Rate of Oil Demand between 2000 and 2013 2
Figure 1-3 Final Energy Demand of Oil by Sector (2000-2013) 3
Figure 1-4 Oil Demand by Sub-Sector in Transport Sector (2000-2013) 3
Figure 1-5 GDP per Capita and Vehicle Ownership (2013) 4
Figure 1-6 APEC's Net Oil Importer and its Dependence in 2013 5
Figure 2-1 Comparison of Fuel Price between Japan and the United States 8
Figure 2-2 Traffic Volume Compared to Vehicle and Car Population in Singapore.... 10
Figure 2-3 Total Numbers of Motor Vehicles in Beijing 13
Figure 2-4 Commuting by Automobile in the United States: 1960 - 2013.... 15
Figure 3-1 CAFE standards for LDVs.... 33
Figure 3-2 GHG Emission Standards in Canada 34
Figure 3-3 Top Runner Standards for Passenger Vehicles 35
Figure 3-4 Corporate Average Fuel Consumption in China 37
Figure 3-5 Suggested Passenger Car Fuel Economy in Chinese Taipei 39
Figure 3-6 Labelling: New Zealand and Korea.... 40
Figure 3-7 Labelling: United States and Chile.... 41
Figure 3-9 Cumulative Spending by Category (2008-2014).... 46
Figure 3-10 PHEV Battery Progress 46
Figure 3-11 Difference in Road Oil Demand between Current and Non-Policy Scenarios 52
Figure 3-12 Oil Demand Reduction in the "Current Policy" Scenario Compared to the "Non-Policy Scenario" 53
Figure 3-13 Oil Import Reduction in the "Current Policy" Scenario Relative to GDP .. 53
Figure 3-14 Oil Demand Reduction in the "Fuel Economy Improvement" Scenario Compared to the "Non-Policy Scenario" 54
Figure 3-15 Relative Oil Demand Reduction of the "Fuel Economy Improvement" Scenario and the "Alternative Vehicle" Scenario Compared to the "Non-Policy" Scenario.... 55
Figure 3-16 Incremental Growth of Clean Energy Vehicles in Stock in the "Alternative Vehicle" Scenario Compared to the "Non-Policy Scenario" 56
Figure 4-1 Biofuel Demand-Supply Balance in Australia.... 60
Figure 4-2 Biofuel Demand-Supply Balance in Canada 62
Figure 4-3 Biofuel Demand-Supply Balance in Chinese Taipei 63
Figure 4-4 Biofuel Demand-Supply Balance in Hong Kong, China 66
Figure 4-5 Biofuel Demand-Supply Balance in Indonesia.... 68

Figure 4-6 Biofuel Demand-Supply Balance in Japan 70
Figure 4-7 Biofuel Demand-Supply Balance in Korea 72
Figure 4-8 Biofuel Demand-Supply Balance in Malaysia 74
Figure 4-9 Biofuel Demand-Supply Balance in New Zealand 76
Figure 4-10 Biofuel Demand-Supply Balance in China 78
Figure 4-11 Biofuel Demand-Supply Balance in Peru 80
Figure 4-12 Biofuel Demand-Supply Balance in the Philippines.................................... 82
Figure 4-13 Biofuel Demand-Supply Balance in Thailand 84
Figure 4-14 Biofuel Demand-Supply Balance in the United States 88

LIST OF TABLES

Table 2-1 10 Recommendations for Eco-driving 18
Table 3-1 Fuel Consumption Limits for LDVs.. 36
Table 3-2 Fuel Consumption Limits for HDVs 37
Table 3-3 Fuel Economy Target in Korea.. 38
Table 3-4 Clean Energy Vehicle Policy 47
Table 3-5 Estimated Road Oil Demand in 2030 by Scenario... 51
Table 4-1 Canadian Provincial Blend Mandates 61
Table 4-2 EPA Proposed Renewable Fuel Volumes (million gallons) 86
Table 4-3 EISA vs EIA Targeted Total Renewable Fuels Volumes (million gallons)...... 87
Table 4-4 Bioethanol Outlook in the APEC Member Economies.................................... 91
Table 4-5 Biodiesel Outlook in the APEC Member Economies....................................... 92

Executive Summary

Oil accounted for the second largest share of primary energy demand in the APEC region in 2013 and will likely remain the top energy source in the long term. The majority of oil is used in the transport sector. Motorization, along with robust economic development, drives oil demand in the transport sector. While motorization is expected to increase in many APEC member economies, 16 economies are net oil importers. Ongoing motorization and increasing oil import dependency are the main factors that necessitate oil efficiency policies. It is also important to secure oil supply to mitigate against oil supply disruptions. Oil supply-side measures, e.g., oil stockpiling, are commonly used to enhance oil security. However, this report focuses on demand-side measures that intend to curb oil use.

This report presents a wide range of measures to control or reduce oil consumption in APEC member economies. These policies include pricing and taxation measures, mandatory vehicle use control, car-pooling, eco-driving, rationing (fuel allocation), alternative fuels (biofuel), fuel subsidy reductions, promotion of public transport use, and research and development.

The effectiveness of these policies can be determined based on the usefulness to cope with oil supply disruptions, ease of implementation, and cost of implementation. If oil supply disruptions occur, methods such as rationing (fuel allocation) and mandatory vehicle use control have high effectiveness. The public is more likely to support these measures but only if they are established on a temporary basis. Carpooling, eco-driving, and labelling have the highest ease of implementation because they are less likely to meet high public opposition and do not require substantial investments. Although pricing and taxation measures and fuel subsidy reductions are very effective at decreasing oil demand, it is difficult to implement due to high consumer resistance. Improving access to public transport is also very effective but expensive to implement.

Additional methods to lower oil-dependency include the development of alternative transport fuels such as biofuels, electricity, and hydrogen. Biofuels have already been introduced in many APEC economies but still face many challenges. Several research studies have raised concerns about the impacts of biofuels on food prices, security and greenhouse gas emissions.

The use of clean energy vehicles is still relatively low. A scenario analysis examined in this paper demonstrates that substantial oil demand reductions would result if

economies implement fuel economy standards and set specific national targets for the deployment of clean energy vehicles. While the share of clean energy vehicles in the transport sector is unlikely to increase significantly in the near future, fuel economy standards may be easier to implement and can play an important role in improving fuel efficiency. As a result, mandatory fuel economy standards are most likely to make a difference in transport oil demand in the future.

Chapter 1　Oil Demand in Transport Sector in the APEC Region

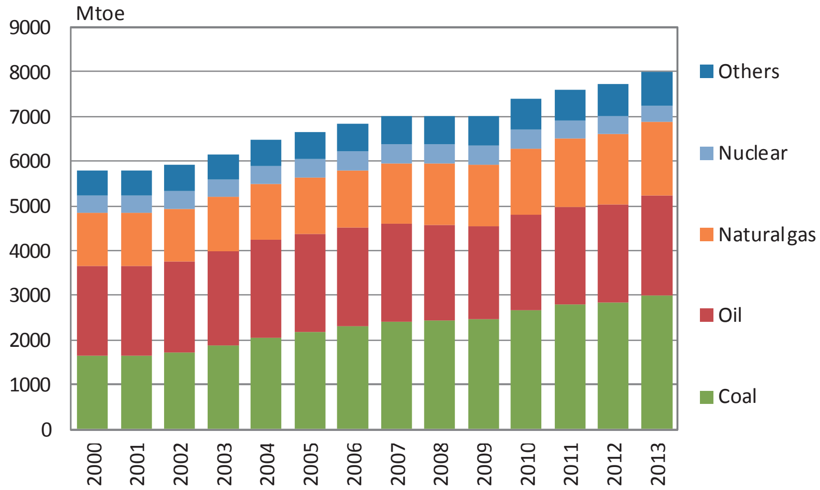
Securing oil supply is a critical issue for policymakers as oil plays an indispensable role in supporting economic activity. Oil stockpiling is regarded as an effective measure to secure oil supply. However, economies that have a well-developed oil stockpiling system are limited because the massive costs of infrastructure development and expenditures of operation and maintenance might hinder some economies from introducing or expanding the system. Oil-exporting economies may not find it necessary to urgently build one, either.

Oil security is not an issue that has to be dealt with only on the supply side. There are also many other ways to enhance oil security on the demand side. This report attempts to identify measures to curb oil demand as an alternative approach to improve oil security. The first chapter briefly describes the oil demand trend in the transport sector in the APEC region and clarifies how important measures to reduce oil demand are for the APEC member economies.

Oil accounted for the second largest share of primary energy demand in the APEC region, with coal being the largest, in 2013 (Figure 1-1). While oil's share in primary energy demand narrowed from 35% in 2000 to 28% in 2013 and was surpassed by coal in 2006, oil demand has moderately increased at an annual growth rate of 0.8% between 2000 and 2013.[1] There is a wide range of average annual growth rates of oil demand between 2000 and 2013 among the member economies as shown in Figure 1-2. Most economies demonstrate positive average annual growth rates whereas oil demand declined in some economies. Oil demand does not increase as much as expected in advanced economies such as the United States and Japan since population growth is relatively lower compared to the other developing economies and vehicle ownership has almost reached a saturation level. Substantial oil use reductions in power generation contributed to the negative growth of oil demand in other economies such as Singapore and the Philippines. In the case of Hong Kong, China, where oil demand recorded the highest negative growth rate of 6.1% during the period, coal has expanded its share in primary energy demand with an average growth rate of 6.0%.

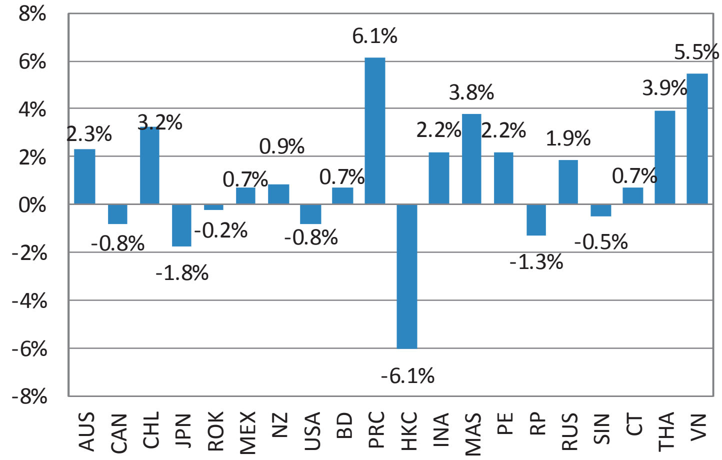
[1] International Energy Agency (IEA) (2015), *Energy Balances of OECD Countries 2015* and *Energy Balances of Non- OECD Countries 2015*. IEA's database does not include Papua New Guinea.

Figure 1-1 Primary Energy Demand in APEC region (2000-2013)



Note: Others include hydro, geothermal, renewable energy, electricity, and heat.
Source: IEA (2015), *Energy Balance of OECD Countries 2015* and *Energy Balances of Non-OECD Countries 2015*

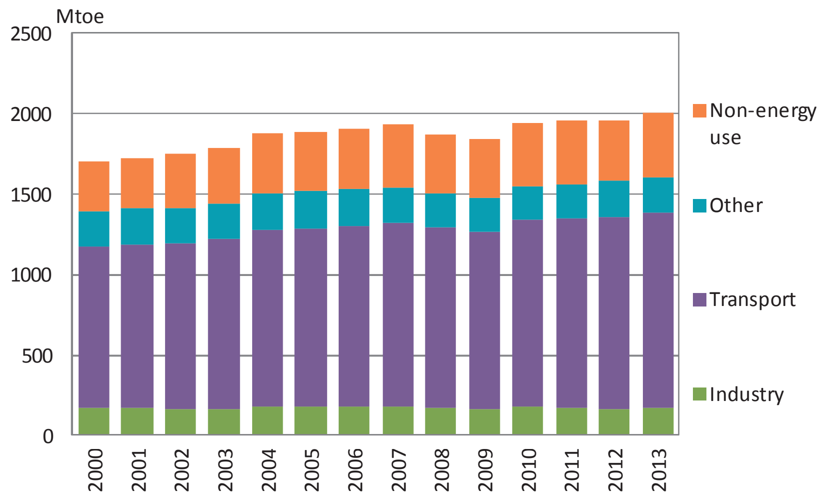
Figure 1-2 Average Annual Growth Rate of Oil Demand between 2000 and 2013



Source: IEA (2015), *Energy Balance of OECD Countries 2015* and *Energy Balances of Non-OECD Countries 2015*

In final energy demand, the majority of oil is used in the transport sector (Figure 1-3). Robust oil use in the non-energy sector is explained by increased feedstock for the petrochemical industry. On the contrary, oil demand in other sectors including the industry sector and the other sector has not grown as much as that of the transport sector. This is because fuel shifts from oil to other energy sources such as natural gas and electricity have been promoted for the purpose of reducing greenhouse gas emissions, and limiting exposure to oil price fluctuations and oil supply disruptions especially if the economies are dependent on oil imports.

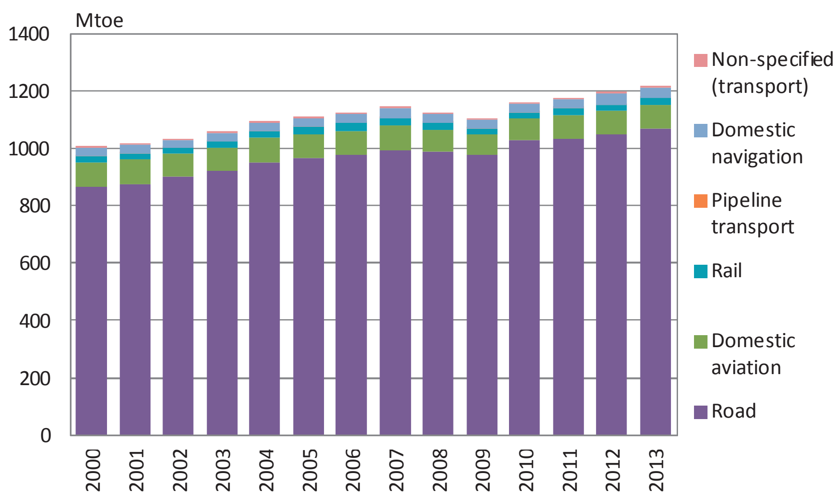
Figure 1-3 Final Energy Demand of Oil by Sector (2000-2013)



Note: The other sector includes residential, commercials/public services, agriculture/ forestry, fishing and non-specified (other).
Source: IEA (2015), *Energy Balance of OECD Countries 2015* and *Energy Balances of Non-OECD Countries 2015*

In looking at oil demand by sub-sector (Figure 1-4), road transport has remained as the largest sub-sector, explaining approximately 88% of oil demand in the transport sector in 2013. Motorization along with robust economic development has pushed oil demand upward.

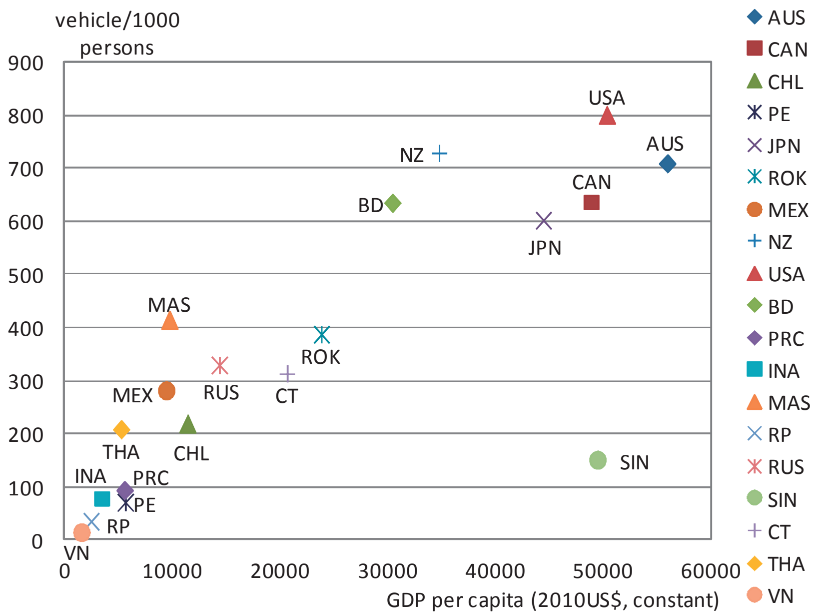
Figure 1-4 Oil Demand by Sub-Sector in Transport Sector (2000-2013)



Source: IEA (2015), *Energy Balance of OECD Countries 2015* and *Energy Balances of Non-OECD Countries 2015*

Figure 1-5 illustrates the relationship between GDP per capita and vehicle ownership, which are positively correlated. There is a tendency that the more income people earn, the more vehicles are purchased. Given the situations that many APEC economies have the potential of economic development, motorization is likely to continue in the future, probably at a faster speed for some economies. Singapore shows an exceptional case as the economy has successfully managed to control the number of vehicles largely due to its limited land, that is, limited room to further expand the road network. Singapore has coped with traffic jams through implementation of two effective policies: the Vehicle Quota System and Electric Road Pricing. Both policies are touched upon in the next chapter.

Figure 1-5 GDP per Capita and Vehicle Ownership (2013)



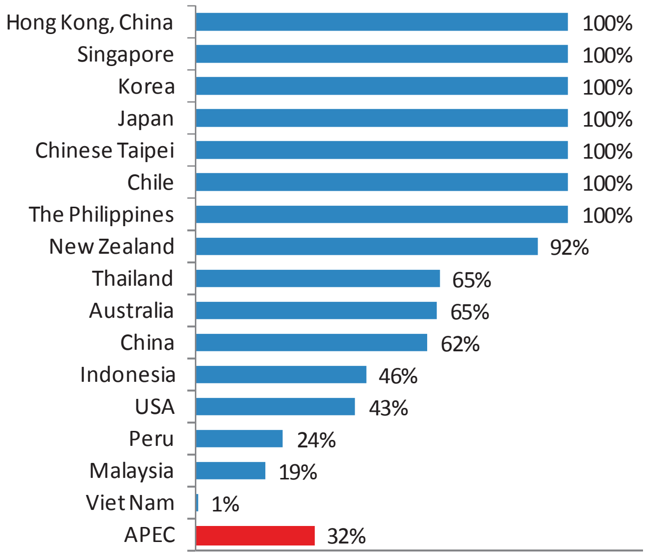
Source: The Energy Data and Modelling Center (EDMC), the Institute of Energy Economics, Japan

Oil is likely to remain the primary type of energy demanded in the long term in the APEC region. The Asia Pacific Energy Research Centre's (APERC) study shows that energy demand in the transport sector is projected to grow annually at 1.0% on average between 2013 and 2040.[2] Rising transport energy demand of the non-OECD APEC member economies will offset transport energy decreases in the United States and other parts of north-east Asia. Oil will be the leading fuel used in the transport sector, accounting for 85% of domestic transport demand in 2040.

[2] Asia Pacific Energy Research Centre (2016), *APEC Energy Demand and Supply Outlook 6th Edition*. APERC, Tokyo, pp. 36-38.

Nevertheless, the fact that the 16 APEC member economies are net oil importers is a concern (Figure 1-6). Many APEC member economies depend on oil imported from the Middle East to some extent where unstable situations have persisted. In addition to geopolitical risks, if natural disasters such as hurricanes that are hard to foresee hit the APEC region, the oil supply chain could be damaged. As such, regardless of its status of whether an economy has oil or not, it is important to prepare what to do in order to minimize damage, maintain economic development, and keep society stable even when such urgent situations occur. Policies to curb oil demand are considered to be a possible measure to enhance energy security.

Figure 1-6 APEC's Net Oil Importer and its Dependence in 2013



Source: IEA (2015), *Energy Balance of OECD Countries 2015* and *Energy Balances of Non-OECD Countries 2015*

The following chapters focus on energy use of road transport which includes passenger vehicles, heavy-duty vehicles, and motorcycles. Chapter 2 describes a wide range of policy measures that have already been applied in the APEC member economies in order to reduce oil demand in road transport. Chapter 3 reports the policy implementation and targets of fuel economy standards and progress of clean energy vehicles deployment for certain economies, followed by scenario analysis with reflection of fuel economy improvement and an expanding share of clean energy vehicles for all APEC member economies in the future. Chapter 4 addresses the biofuel policy and the current situations of biofuels demand and supply - both bioethanol and biodiesel - in the APEC member economies. In conclusion, some implications for effectiveness and challenges with regards to measures that attempt to reduce oil demand are drawn from the previous chapters.

Chapter 2 Policies to Lower Oil Demand in Transport Sector

There is a demand-side approach known as A-S-I which involves three strategies to improve energy efficiency in the road transport.[3] The A-S-I approach is a holistic framework to promote alternative mobility solutions and to develop sustainable transport systems. It consists of three pillars; Avoid/Reduce, Shift/Maintain, and Improve. The first pillar, Avoid/Reduce, means to avoid or reduce the need to travel through integrated land-use planning and transport demand management, and requires improvement of the transport "system efficiency." The second pillar, Shift/Maintain, is to shift or maintain a share of more environment-friendly modes, heightening "travel efficiency." The third pillar, Improve, aims to improve the energy efficiency of transport modes and vehicle technology as this "vehicle efficiency" is achieved through greater energy efficiency of individual vehicles as well as the optimization of transport infrastructure.

This chapter lists both short-term and long-term measures that are considered to work effectively to control or reduce oil demand in road transport. In accordance with the A-S-I approach, these measures described below are categorized as follows;

- Avoid/Reduce: pricing and taxation measures (2-1-1), mandatory vehicle use control (2-1-2), car-pooling (2-1-3), eco-driving (2-1-4), rationing (fuel allocation) (2-1-5), fuel subsidy reductions (2-2-1)
- Shift/Maintain: promotion of public transport use (2-2-2)
- Improve: alternative fuel (biofuel) (2-1-6), R&D (2-2-3)

Each measure is addressed in terms of policy overview, strength/advantage, weakness/disadvantage, and successful cases to refer to in the APEC member economies.

2-1 Short-term Measures

2-1-1 Pricing and Taxation Measures

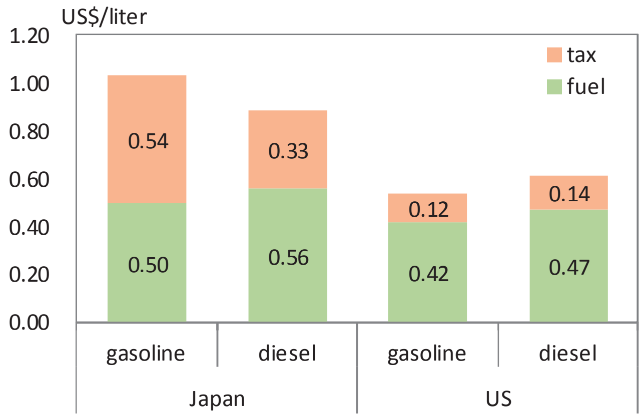
[3] GIZ(2012), *Urban Transport and Energy Efficiency – Module 5h Sustainable Transport: A Sourcebook for Policy-makers in Developing Cities*, GIZ, Bonn. Prepared for Federal Ministry for Economic Cooperation and Development, German. p.8.
GIZ (Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH) provides international cooperation services for sustainable development and is committed to this A-S-I approach as opposed to the traditionally supply-side oriented approach.

Policy overview

Pricing and taxation measures on road transport are expected to induce drivers to travel less by increasing the marginal cost of driving since consumers are sensitive to price signals and react to increased prices by reducing vehicle use or travel frequency. Another objective is to collect revenues that can be used for typical road maintenance and programs to protect the environment.

Pricing intends not only to curve oil consumption but also to deal with externalities such as greenhouse gas emissions and traffic congestion which are caused by vehicle uses. Road pricing is a strategy to apply a fee reflecting the cost of the road use and allocates road space to those who are willing to pay for it.[4] There are several forms of road pricing. A simple method is a direct fee based on vehicle-kilometers travelled.[5] Congestion pricing aims to alleviate congestion. A cordon approach charges vehicles entering or operating an area, usually a city center or central business district, as this mechanism has been utilized in Singapore and London. Lastly, parking pricing can also be effective since it adds another cost to driving.

Figure 2-1 Comparison of Fuel Price between Japan and the United States



Source: IEA(2016), *Oil Market Report*, January 19, 2016.

As for the taxation measures, fuel taxes or carbon taxes are charged based on fuel consumed or carbon emitted. Fuel taxes vary among the APEC member economies. In fact, fuel taxes make a difference in fuel costs that consumers have to pay as Figure 2-1 shows the difference of fuel prices between Japan and the United States. Although the price level of fuel itself is almost the same between the two economies, taxes levied on

[4] Transportation Research Board of the National Academies (2005). *International Perspectives on Road Pricing*, Conference Proceedings 34, Washington, D.C., p.1.
[5] IEA (2005), *Saving Oil in a Hurry*, OECD/ IEA, Paris, p.53.

the petroleum products are substantially different.

The rationale for a carbon tax is to cope with climate change. It intends to discourage activities emitting greenhouse gases. People would choose to drive less or shift to public transport, and use more efficient home appliances if they wanted to reduce this tax burden.

Strength/ Advantage

As long as people are elastic to changes in the cost of driving, these measures are considered effective in reducing vehicle use. Still caution is necessary, as the impacts may be influenced by availability of alternative travel modes. People tend to be inelastic to price changes if no other options are given.

Referring to the cases of Singapore and London, road pricing seems to work effectively in that the road congestion has been alleviated. In general, motorists who are privileged to avoid congestion could save fuel and time which can be valued highly for certain occasions.

Weakness/ Disadvantage

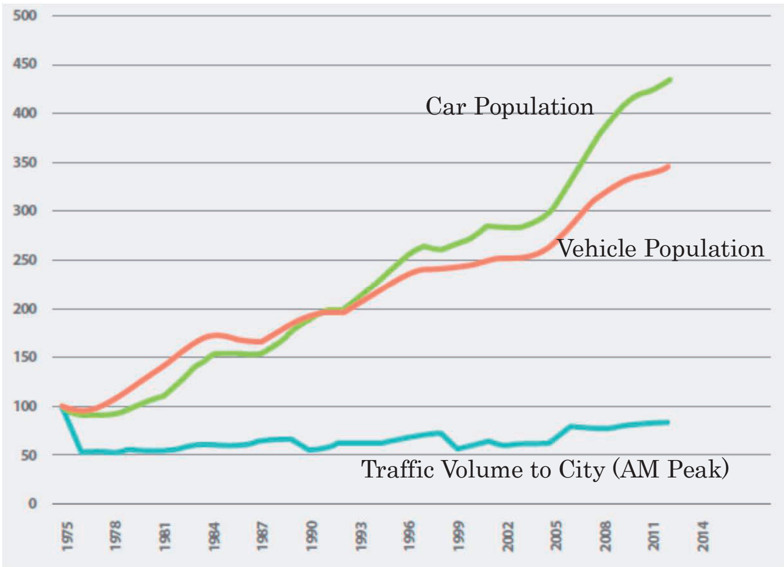
If these measures are not designed properly, unintended negative impacts may accompany them. Under cordon pricing, congestion or carbon emissions may worsen outside the priced area if drivers increase travelling around the area. Also, equity issues need to be considered. While higher-income drivers could benefit from the road pricing, those who cannot afford to cover extra costs may decrease mobility or opportunities to work or do business. Besides, since price increases usually face public opposition, how policymakers gain support and understanding from the public is a major hurdle to overcome for implementation of these measures.

In spite of revenues collected, some financial burden that the government has to shoulder may arise if a road pricing mechanism such as Singapore's fully automated system operating around the clock is implemented. Installation of both the hardware and software for road pricing systems is needed, along with the maintenance and monitoring of such systems. Administrative costs are probably not negligible, either.

Successful Case

Singapore's road pricing is a successful case that is known worldwide. In 1975, the Area Licensing Scheme was introduced in the Restricted Zone (RZ). To enter the RZ between 7:30 and 10:15 on weekdays and Saturdays, cars and taxis needed to buy and display an area license.[6] The current scheme called an Electronic Road Pricing System (ERP) has been in place since 1998 to manage road congestion and promote transit.[7] ERP rates vary based on the location, time periods, and vehicle classification depending on traffic conditions and are subject to a quarterly review of traffic speeds of priced roads and during the June and December school holidays. All vehicles registered in Singapore are required to have in-vehicle units installed into which CashCards are inserted. Each time a vehicle passes through an ERP gantry, ERP charges are deducted from the CashCard via short-range radio communication. Figure 2-2 illustrates that traffic volume into the city area grew at a much slower pace than the overall growth of car population.

Figure 2-2 Traffic Volume Compared to Vehicle and Car Population in Singapore



Source: Singapore Land Transport Authority (2013), *Land Transport Master Plan 2013*, p.45.

2-1-2 Mandatory Vehicle Use Control

Policy overview

A government could set regulations which control vehicle use and/or set quota of car ownership to reduce fuel consumption. This kind of top-down approach is implemented for the reasons of improving air quality as well as keeping the traffic flow as smooth as possible by reducing frequency and length of traffic jams. The vehicle use restriction

[6] GIZ (2012), *Urban Transport and Energy Efficiency*, GIZ, Bonn, p.13.
[7] Singapore Land Transport Authority HP.
https://www.lta.gov.sg/content/ltaweb/en/roads-and-motoring/managing-traffic-and-congestion/electronic-road-pricing-erp.html

intends to limit vehicles that are allowed to drive in certain areas or times of day whereas the vehicle quota system attempts to keep the number of cars owned under control.

A general case of vehicle use restriction is to forbid people from driving cars based on their license plate numbers. Those who have a license plate ending with a designated digit are not allowed to drive on a specific day. An odd/even day driving ban exemplifies this program as it has been implemented in some cities such as Beijing, Paris, and most recently, Delhi. It is regulated so that people are allowed to drive on alternating days for cars with odd and even numbered license plates. A one-day a week ban or weekend driving restrictions are also subjects discussed under this category.

Car ownership restriction is implemented in several ways. Vehicle quota is provided via mainly a bidding (auction) system as it has been in place in Singapore and Shanghai of China. A different system is to ration new license plates through a public-held lottery that Beijing, China, started in 2011. The auction is held at a regular interval, say, monthly, and people participate in the bidding through the internet or telephone and are allowed to revise the bidding price during the specified period of time. As a result, the right to purchase a vehicle will go to those who bid equal or higher than the price that is designated as appropriate in the bidding round. In the lottery system implemented in Beijing, companies and individuals go through separate processes to obtain car ownership that is non-transferable and effective for six months.[8]

Strength/ Advantage

Since these measures are mandatory, certain effectiveness is expected if the measure is designed clearly so that people do not get confused and the designated target is covered based on fair criteria. Alternative travel options such as public transport or car-pooling needs to be prepared to heighten the effectiveness.

Similar to the road pricing system, the government could secure revenues received from the auction. The fees collected from the auction are expected to be used for road maintenance and improvement or development of public transport.

Weakness/ Disadvantage

The vehicle use restrictions are likely to be effective only in the short-term. They

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[8] Feng and Li (2013), 'Car Ownership Control in Chinese Mega Cities: Shanghai, Beijing and Guangzhou,' *Journeys*, September 2013, pp.40-49.

would work well especially in emergency situations when people recognize the need to take joint actions and tend to accept inconveniences together. In the long-term, however, people may be encouraged to have two or more vehicles in the household to get around the ban. If the second (or third) car was less efficient in fuel use, demand for petroleum products would increase and air pollution would get worse.

Both vehicle use restriction and car ownership restriction via the auction system may lack social fairness. Wealthy people can afford to buy and maintain multiple vehicles and to purchase car ownership by winning the bidding process. In Singapore, under the Vehicle Quota System, it is getting expensive to obtain the Certificates of Entitlement (COE) which grants the right to own, register, and use a vehicle. For instance, the annual average quota premium of COE in 2014 was S$67,675 (US$51,219) for Category A (cars ≤ 1,600cc & Taxis) and S$73,282 (US$55,462) for Category B (cars > 1,600cc).[9] Additionally, other taxes and duties payable on new cars such as a registration fee, additional registration fee, and exercise duty further inflate the cost of owning a vehicle. Although these mandatory vehicle use or ownership restrictions appear to be effective to limit the growth rate of vehicles, a negative impression toward the auctioning in terms of fairness may grow among the public.

Successful Case

Beijing has put regulatory measures in place to manage to control vehicle use and to mitigate air pollution. Among the odd/even driving ban policies implemented in several cities, Beijing's case is considered effective. Beijing implemented odd/even driving bans during the 2008 Olympic Games and the 2014 APEC summit. During the Olympics, this driving restriction worked to reduce particulate matter concentrations by 20% with the help of rain and shutting down of the factories and industries.[10] A study conducted by Yang et at.(2014) found that the license plate lottery restrained increases in vehicles and new car registrations reduced by more than 75% between 2010 and 2011 (Figure 2-3).[11] The study concluded that, however, the lottery system did not reduce fuel use as much as expected.

Other attempts that Beijing has made to facilitate transport management worked

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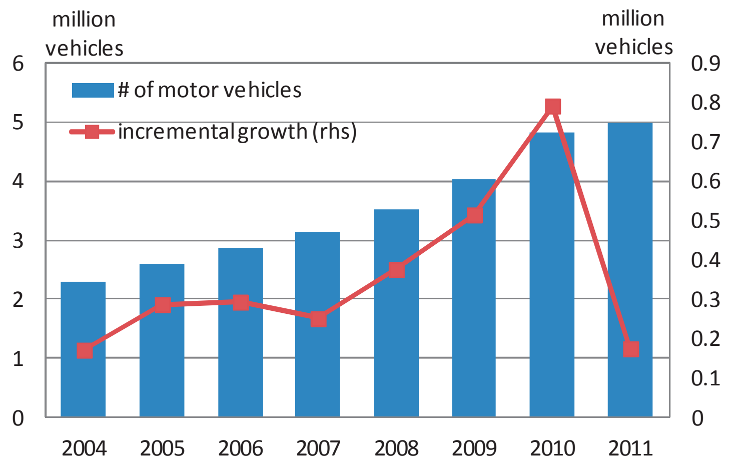
9 Singapore Land Transport Authority (2015), *Singapore Land Transport: Statistics In Brief 2015*, US value is calculated based on the exchange rate for 2014, US$1 = S$1.3213 (Source: Monetary Authority of Singapore)

10 The Guardian (2014), 'Why license plate bans don't cut smog,' 20 March, 2014.

11 Jun Yang, Ying Liu, Ping Qin, and Antung A. Liu (2014), 'A Review of Beijing's Vehicle Lottery: Short-Term Effects on Vehicle Growth, Congestion, and Fuel Consumption,' *Environment for Development,* Discussion Paper Series January 2014. p.30.

as a complement to the measures above and helped them to be more effective. In Beijing, non-local vehicles are not allowed to enter road networks within the 5th ring whereas subsidy to transit fares and development of the bus rapid transit encouraged people to shift from private vehicles to public transport.

Figure 2-3 Total Numbers of Motor Vehicles in Beijing



Source: Yang et al.(2014)

2-1-3 Carpooling

Policy overview

Carpooling is defined as two or more individuals with similar origins and destinations sharing a ride in a car. This measure aims to reduce vehicle kilometers travelled by increasing vehicle occupancies for work trips. Carpooling is different from carsharing or ridesharing in that it is more formalized and is often done on a regular basis.[12] Carsharing is to share a car with a group of people in turn and could take the form of car co-operatives and short-term rentals. Ride-sharing is rather an informal sharing of a ride and a driver takes advantage of using infrastructure for carpooling.

This policy option could become appealing with support of other measures. A prevalent approach in many cities in the United States is to build carpool-only lanes, so-called high-occupancy vehicle lanes, which allow carpoolers to use dedicated lanes so that they can avoid congestion. Park and ride facilities are also useful for carpoolers to meet one another near freeways or places adjacent to regional transit or rail services. These facilities would help carpooling to be arranged easily. Furthermore, carpooling

[12] IEA (2005), Op.cit., p.65.

could gain more support if priority parking is allowed for carpoolers. Especially when a parking lot is located in priced or restricted areas, people may choose carpooling if it provides convenient transfer compared to driving their own vehicle alone.

It is important to prepare a backup option for work travel in cases where carpooling riders need to leave early due to an emergency or stay late for work that needs to be finished urgently. Ensuring a "guaranteed ride home" program, employers or local governments guarantee a ride from work and reimburse the cost of a taxi or rental car. This kind of support would reduce participants' concerns about travel modes in the event of an emergency particularly in a place where other travel modes such as public transportation are limited.

In addition to the merits on the infrastructure side, financial incentives could encourage people to participate in this program. For instance, registered carpools could enjoy reduced public parking rates, discounted price for gasoline, and low-priced public transit services. These financial incentives are found to play significant roles in promoting carpooling.[13]

Strength/Advantage

According to the study conducted by IEA, carpooling is estimated to have the largest potential of saving oil among the measures compared if it is implemented successfully in all IEA member economies.[14] However, the success of this measure depends on the level of incentives aforementioned given to drivers.

If an individual driver changed their travel behavior and joined the carpooling program, they would be able to save costs such as fuel and maintenance costs that they would have been forced to pay otherwise. It is also possible for the carpoolers to save travelling time by using high-occupancy vehicle lanes or preferential parking, which may result in relieving stress accompanied with commuting. At the community level, carpooling would help reduce traffic congestion and vehicle emissions since it consolidates more person-trips into fewer vehicles.

As a way to improve effectiveness, a database would be an important tool to connect potential drivers and riders who share travel to work but do not know each other yet.

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[13] The United States Department of Energy (2013), *Transportation Energy Futures Series: Effects of Travel Reduction and Efficient Driving on Transportation: Energy Use and Greenhouse Gas Emissions*, Prepared by Cambridge Systematics

[14] IEA (2005), Op.cit., pp.19-20.

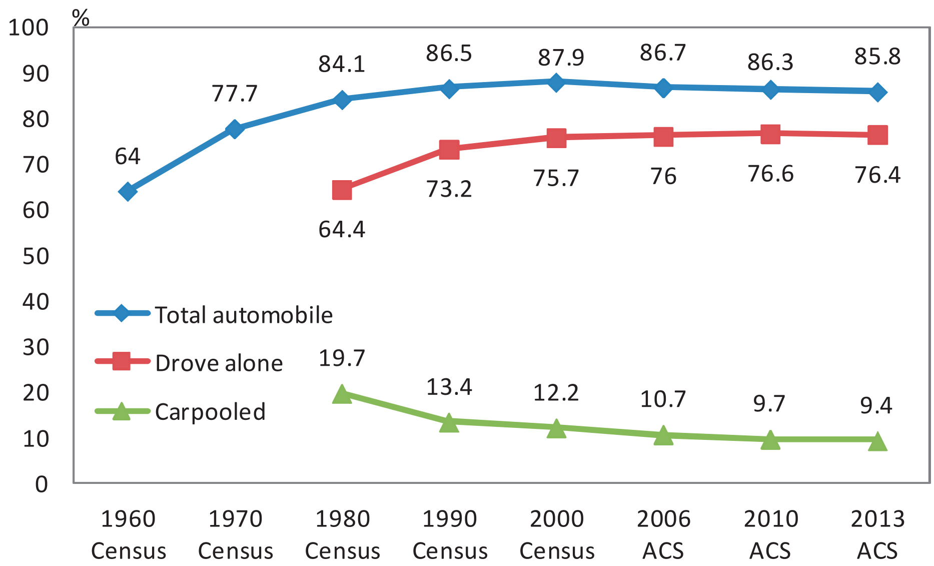
Recently, smartphone technology has made it possible for drivers and riders to coordinate carpooling without a pre-planned trip. For instance, smartphone apps such as 'Lyft' and 'Ride' are used to find appropriate carpooling services in the United States. In fact, carpooling services through smartphones apps have become popular not only in the United States but also in Singapore and Japan. This technology advancement makes carpooling more flexible and convenient.

Weakness/ Disadvantage

Carpooling could be costly when infrastructure development including high-occupancy vehicle lanes or park and ride facilities are involved. Administrative and marketing costs like maintaining a database that matches potential carpoolers may be a financial burden for some governments or employers which provide the service.

If this policy is implemented on a voluntary basis of private companies, cooperation of employers is necessary. Since this means increasing costs for employers or companies to some extent, there is uncertainty as to the level of cooperation and understanding there would be.

Figure 2-4 Commuting by Automobile in the United States: 1960 - 2013



Note: ACS = American Community Survey
Source: Brian McKenzie (2015), *Who Drives to Work? Commuting by Automobile in the United States: 2013*, United States Census Bureau, Department of Commerce, p.3.

Effectiveness of carpooling depends on how close the destinations of the driver and riders are located. Decentralization of work destinations would make the probability of neighbors sharing work destinations lower.[15]

Carpooling may face difficulty in maintaining usefulness as vehicle ownership increases. Carpooling is the second most common commuting mode in the United States. Yet, the percentage of commuters choosing to carpool has declined from 19.7% in 1980 to a mere 9.4% in 2013 although the national average of household car ownership has increased (Figure 2-4).

Successful Case

In the Greater Toronto and Hamilton Area of Canada, Metrolinx, an agency of the Government of Ontario, provides assistance for carpooling under the program called Smart Commute which aims to explore different commuting options such as transit, cycling, walking, telework and flexible workhours.[16] According to Metrolinx, a recent survey shows that 81% of carpoolers are satisfied with their commute. Carpooling users' high level of satisfaction is explained by the following incentives given.

- The Ministry of Transportation of Ontario provides free carpool parking lots near highway interchanges throughout Ontario so that carpoolers can meet before entering the highway system.
- Ontario also has high-occupancy vehicle lanes on highways that are allowed to be used if at least two people including the driver are in vehicles.
- Metrolinx is provided for free online so anyone can find a potential carpool partner.
- An employee of a participating Smart Commute workplace is eligible for Emergency Ride Home services. Up to $75 for emergency transportation costs can be reimbursed in case of an emergency.

2-1-4 Eco-driving

Policy overview

Eco-driving intends to improve vehicle fuel efficiency and reduce CO_2 emissions through driver behavior and vehicle maintenance. Public campaigns on eco-driving gives drivers useful information about energy efficient driving techniques. Training programs in eco-driving help individual drivers to understand how to reduce fuel use by

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[15] Texas A&M Transportation Institute HP, Mobility Investment Priorities – Carpooling, http://mobility.tamu.edu/mip/strategies-pdfs/travel-options/technical-summary/Carpooling-4-Pg.pdf
[16] Metrolinx HP, http://smartcommute.ca/

changing driving habits or styles. These techniques include performing proper gear shifts, maintaining a steady speed, accelerating or decelerating smoothly, avoiding unnecessary braking, switching off the engine at short stops, and reducing weight by removing unnecessary items from vehicles. Vehicle maintenance such as keeping tyres properly inflated and using low-rolling resistance replacement tyres is also supposed to make a difference in fuel use efficiency.

Strength/ Advantage

Substantial fuel savings could be expected if a comprehensive and proactive public campaign on the benefits of eco-driving was successful. The IEA's study reports that average fuel economy improvements of between 5% and 15% were recorded for vehicles soon after eco-driving training was provided.[17] Over the medium term, fuel savings of about 5% would be kept even if there was no further support after the initial training or around 10% if feedback was received.

Various technologies to facilitate eco-driving are available for vehicles to be equipped with. For instance, in-vehicle feedback instruments, cruise control systems adjusting speeds, and fuel economy indicators would help people to raise drivers' awareness and to drive in a way to save fuel.

Weakness/ Disadvantage

Effectiveness of this program depends substantially on individual driver's motivation and habit. A key to success of this policy in the long-term is to send a continuous message of eco-driving to drivers. It usually takes some time for a campaign of public information and education to be acknowledged widely and for the drivers to change driving behavior. For this reason, eco-driving would not be effective in short-term emergency situations if policies to promote eco-driving were not implemented yet at the time when oil supply disruptions happened.

Successful Case

In Japan, eco-driving has been in place since 2003 when "10 Recommendations for Eco-driving" was formulated in 2003. It was partially revised in 2006 and 2012 (Table 2-1) and "Eco-Driving Dissemination and Promotion Action Plan" was issued in 2006. The government of Japan designates every November as "Eco-Drive Promotion Month" to promote eco-driving through various symposiums and events because the month is

[17] IEA (2010), *Transport Energy Efficiency – Implementation of IEA Recommendations since 2009 and Next Steps*, OECD/IEA, Paris, p.37.

seen as a popular time for travel, therefore increasing the frequency that people drive cars.

Furthermore, Eco-Driving Management System (EMS) has been implemented since 2005. EMS is a comprehensive measure that promotes eco-driving systematically with the use of a digital tachograph which records data such as engine speed and vehicle speed while giving evaluation and guidance about driving behavior based on the recorded data. Under EMS, a workshop on eco-driving is provided to the drivers if necessary. As a result, fuel efficiency has improved by 26.3% on average among the participants after EMS was introduced.[18]

Table 2-1 10 Recommendations for Eco-driving

1. Press the accelerator gently when accelerating
2. Reduce acceleration and deceleration while keeping enough distance between cars
3. Release the accelerator earlier when decelerating
4. Use air conditioners appropriately
5. Avoid unnecessary idling
6. Avoid traffic jams; leave home with time to spare
7. Check the pressure of the tyres as the first step toward better maintenance
8. Take out unnecessary loads
9. Do not block traffic when parking
10. Be aware of your fuel consumption

Source: Ministry of Economy, Trade and Industry, Japan

In New Zealand, the Ministry of Transport and NZ Transport Agency started Safe and Fuel Efficient Driving New Zealand (SAFED NZ) jointly, in 2010.[19] Directed at mainly commercial fleet drivers, this program is a comprehensive one-day, off-the-job driver development course which teaches safe and fuel efficient driving techniques through a combination of theoretical and practical exercises. As of February 2016 when the SAFED NZ website was accessed, 5,068 drivers were trained with an average fuel saving of 6.46%, of which 2,911 were truck drivers saving 7.54% and 2,157 were bus drivers saving 4.99%.

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[18] Japan Ministry of Land, Infrastructure and Transport HP, http://www.mlit.go.jp/jidosha/sesaku/environment/shouenergy/ems/ems.pdf (*in Japanese*)
[19] Safe and Fuel Efficient Driving New Zealand HP, http://safednz.govt.nz/

2-1-5 Rationing (Fuel Allocation)

Policy overview

Rationing is a government policy that "consists of the planned and restrictive allocation of scarce resources and consumer goods, usually practiced during times of war, famine, or some other national emergency."[20] The objective of this measure is to discourage demand and conserve scarce resources. Under the rationing system, quantity provided can be controlled by limiting the hours or days when the commodity is available or assigning quotas. Rationing could function as a price control since prices of the scarce commodity are theoretically driven up due to excess demand.

Strength/ Advantage

Rationing seems to work if it is only a short-term measure and is required in emergency situations when oil supply disruptions are caused by a natural disaster or serious damage to oil production and transport facilities. Facing such an emergency situation, the public may perceive it as a signal that the government is responding and taking a swift action, which could thereby encourage them to follow the order in a cooperative way. Fuel allocation based on rationing is expected to result in alleviating panic or reducing long queues at gas stations.

Weakness/ Disadvantage

Whether or not rationing is effective to reduce fuel consumption has been argued because the restriction may not work in the long-term as initially expected. In general, it would not take much time for people to figure out how to avoid the constraint. With time, a black market may develop, which might seduce people to hoard fuel to sell it at a higher price than the market price.

If the government did not explain the rational to implement the measure with persuasive reasons, it might face strong opposition from the public. For instance, a riot was seen in Iran in 2007 when the government started a fuel rationing system all of sudden for the purpose of reducing oil imports. Since fuel is a necessity to daily life, it is critical for the government to introduce this measure in a way not to cause people to panic.

Successful Case

[20] Encyclopedia Britannica HP, http://global.britannica.com/topic/rationing

In October 2012, the rationing measure was taken in New Jersey and New York of the United States after Hurricane Sandy hit the east coast. Since the strong storm caused power outages which forced some gas stations to shut down and cut the supply chain to others, people lined up in long queues to fill up their tanks at gas stations due to the fear of being short of gasoline. New Jersey Governor Christie announced the odd/even rationing system which restricted gasoline sales to cars with even-numbered license plates on even days and odd-numbered on odd days. This rationing measure lasted about two weeks until power and fuel delivery were restored, which decreased queues.

2-1-6 Alternative Fuel (Biofuel)

Policy overview

With growing concerns over energy consumption and environmental preservation, many economies turned to using alternative fuel as a way to solve these problems while simultaneously reducing dependency on imported oil. Many economies have tried to build a biofuel industry by creating policies which offer two modes of support: quantity-based production targets and financial incentives. Several economies such as Canada, the Philippines and Peru all have minimum blend mandates in place for biofuels.

In general, biofuel prices cannot remain competitive without subsidies due to high infrastructure, research and development costs. Tariffs are also commonly used to protect domestic agriculture and biofuel industries. Agricultural and forestry policies have a strong influence on the biofuel industry, not only through subsidies and price support, but also through land acquisition policies. The majority of biofuel policies are made at federal levels, with some economies also implementing regional laws or bills.

For more information about regional biofuel policies in APEC economies, please refer to Chapter 4-1.

Strength/Advantage

There are three main driving forces behind government support for biofuel policies: energy security, climate change and support for domestic agricultural development. Fossil fuels are the dominant source of energy in society but these resources will be depleted sometime in the future. Energy security concerns are reflected in the massive price fluctuations and volatility of the global oil market. As such, many economies view biofuels as a way to reduce dependency on foreign energy sources.

Biofuels are very attractive because they are renewable resources that can also mitigate greenhouse gas emissions. Reducing greenhouse gas emissions is one of the primary reasons why governments began to implement biofuel policies. Feedstock crops can help offset emissions by directly removing carbon dioxide as they grow through photosynthesis. Biofuels may also produce less greenhouse gas emissions than fossil fuels when burned, although the exact amount varies depending on the type of feedstock.

Biofuel production also helps to increase demand in the agricultural market beyond traditional uses of food and feed. This helps to increase demand for feedstock crops for farmers and is seen as an excellent way to create more jobs, particularly in countries with a strong agricultural base. Improved infrastructure and increased investment, particularly in rural areas, are strong arguments for promoting biofuels.

Weakness/ Disadvantage

Implementing biofuels is difficult and expensive. Fuel distributors must invest in infrastructure; fuel producers have to increase production rates and the public must change their consumption habits. The willingness of investors to finance these infrastructure changes depends on the perceived willingness of consumers to adopt the new technology. Consumers may be hesitant due to complications regarding its compatibility with vehicles and the price competitiveness of biofuel compared to regular fuels.

Concerns over the distribution of limited resources between growing biofuel feedstock and food crops are another disadvantage of biofuel production. In order to meet blending mandates, feedstock crops often require large amounts of land which may limit land availability for food crops. Common feedstock crops such as corn, sugarcane and vegetable oil are also used as food and animal feed. Many economies, particularly developing economies, may not have viable substitutes for these crops. Prices could increase substantially, affecting food security for people around the world. Global hunger conflicts with the sustainable development principles of biofuels.

In theory, biofuels should be carbon neutral because they are derived from plants, but this may not the case. The greenhouse gas balance of feedstock production varies greatly depending on the method used to produce the feedstock and process the fuel. Today, most studies use life-cycle analysis to calculate greenhouse gas balances. Here, all emissions from raw material extraction, to the processing, distribution and consumption are combined to gain a better understanding of the environmental impacts of biofuels. Additional factors include the types of machinery, fertilizer and water irrigation methods. Sugarcane ethanol has the lowest carbon emissions, while corn ethanol is extremely energy-intensive and has a very poor greenhouse gas balance.

For more details about the challenges of biofuel implementation, please refer to Chapter 4-4.

Successful Case

The Thai government has been active in promoting biofuels and invests heavily into the industry. Successful implementation relies substantially on consumer demand and in response, price incentives are provided by the State Oil Fund. All E20 and E85 gasohol prices are subsidized to be 20%-40% cheaper than E10 Octane 95 gasoline. An excise tax rate for vehicles compatible with these blends is offered at 17%. Consumers can easily access E10 and E20 bioethanol from most fuel stations. On the supply side, investments into building more plants, increasing efficiency and distribution are continuously taking place.

Thailand has set ambitious targets and has implemented many policies to try and ensure that their long term biofuel targets can be obtained. Research on increasing yield, balancing palm oil supply and new feedstock technologies is a core part of the economy's biofuel policy. Pilot tests for higher blends have been continuously taking place while feedstock acreage and processing plant numbers have been steadily increasing. Altogether these policies have allowed the economy to not only be self-sufficient but also able to export to other Asian economies.

For more information about biofuel use and policies in Thailand, please refer to Chapter 4-2.

2-2 Long-term Measures

2-2-1 Fuel Subsidy Reductions

Policy overview

According to IEA's definition, energy subsidy is "any government action directed primarily at the energy sector that lowers the cost of energy production, raises the price received by energy producers or lowers the price paid by energy consumers."[21] Focusing on the oil demand side, this report pays attention to consumer subsidies which benefit consumers by keeping the prices lower than the market price. A principal reason behind the fuel subsidy for consumers is that it is a necessary measure to help reduce fuel costs for low-income households and for them to gain access to modern energy. Regardless of these social purposes, the fuel subsidy program seems to have brought various unintended results and negative impacts as follows.

First, the fuel subsidy program might benefit higher-income groups as opposed to the objective of assisting the poor, if the program was not designed appropriately to cover the targeted group and limit the high-income group's ability to purchase lower priced fuel. Second, the fiscal and trade deficits could grow because of the fuel subsidies. Since artificially low fuel prices tend to boost demand for fuel, the fuel subsidies that the government has to cover go up consequently. For oil importing economies, such growing fuel demand would lead to increases in oil imports as well. Third, excessive financial burden on the government may squeeze the available budget for other programs such as education and public health which could be more beneficial to the public otherwise. Fourth, if the fuel prices are kept low, the public may not be motivated to consume the fuel efficiently. Lack of incentives for efficient energy use could result in increasing greenhouse gas emissions, aggravating air pollution, and using up natural resources. Fifth, underpricing could be a disincentive for the producers to invest in production, infrastructure, or advanced technology due to the difficulty in recovering costs or earning profits. If the increase in investment or secure fuel supply was insufficient for a certain period of time, the imbalance of demand and supply of the fuel would be widened. Lastly, renewable energy could become less competitive in terms of costs against the subsidized fuel. This could be an obstacle to expand renewable energy use or advance technology in related areas while increasing dependence on subsidized fossil fuels.

In recognition of these negative effects, the policymakers seek to change the fuel subsidy mechanism to prevent market distortion which leads to misallocation of both natural and economic resources. The APEC member economies have been seeking to "rationalize and phase out inefficient fossil fuel subsidies" as was declared in Singapore in November 2009 and reaffirmed at the energy ministers' meeting in Cebu, the Philippines, in October 2015.[22] In fact, the APEC member economies have made

[21] IEA (2014), *World Energy Outlook 2014*, OECD/IEA, Paris, p. 315.
[22] APEC(2015), '2015 APEC Energy Ministerial Meeting' dated 13 October 2015.

significant progress in fuel subsidy reforms as some successful cases will be introduced later.

IMF points out the following six elements as the keys to increase the possibility of successful subsidy reform.[23]

i. a comprehensive reform plan
ii. a far-reaching communications strategy, aided by improvements in transparency
iii. appropriately phased energy price increases, which can be sequenced differently across energy products
iv. improving the efficiency of state-owned enterprises to reduce producer subsidies
v. targeted mitigating measures to protect the poor
vi. depoliticizing energy pricing to avoid the recurrence of subsidies

Strength/Advantage

Even with negative repercussions, eliminating or phasing out fuel subsidies is expected to bring in substantial benefits to the economy on the whole. Fundamentally, a removal of fuel subsidies would get the market working as it is supposed to. Without an under- or over-priced setting, the market price is theoretically decided by demand and supply and reflects the true economic costs. A transparent market pricing system facilitates investment that is necessary for economic development.

Eliminating fuel subsidies also reduces the financial burden on a government. It is important to redress the fiscal and trade balances for a sound economy. If energy subsidies were to be eliminated, positive changes in GDP are expected in some economies.[24]

Last but not least, fuel subsidy reductions certainly help to curb fuel consumption since the fuel prices are higher compared with the subsidized price. Another benefit is that fuel demand reductions help the oil importing economies reduce reliance on oil imports.

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[23] International Monetary Fund (2013), *Energy Subsidy Reform: Lessons and Implications*, IMF, Washington D.C., p.25.

[24] APEC (2012), *Reforming Fossil-Fuel Subsidies to Reduce Waste and Limit CO_2 Emissions while Protecting the Poor*, prepared by Global Subsidies Initiative of the International Institute for Sustainable Development, Singapore, pp. 30-32.

Weakness/ Disadvantage

Since fuel subsidy reform can be a drastic measure for the public, it is challenging for the government to plan and implement it. Success of fuel subsidy reform requires overcoming some barriers.[25] The foremost obstacle is public opposition. Whenever the government decides to remove or reduce certain benefits of a program, they encounter strong resistance from people that enjoy the benefits. In the past, public opposition was so violent that the fuel subsidy reform had to be cancelled in some economies. Hence, it is essential for a government to enhance public understanding of the need for reform and to gain their support before implementation. For that purpose, the government is required to explain to the public how the measure distorts the economy and constrains other social benefits. One of the most effective ways to overcome opposition is clearly explaining how the savings from the reform will be used for the public or what benefits the public will receive as a result of the phasing-out.

Also, there are concerns about the adverse impact on people in need. Additional burden of energy costs on the poor households could be mitigated if other social benefits, for instance, direct welfare payment to households and public services such as health and education are provided.

Whether or not the fuel subsidy reductions are accomplished could be influenced by the administrative capability of the government. The government needs to plan and design the subsidy reform that can be acceptable to the public. It is also important to implement it gradually so that people have enough time to prepare or adjust. The public may see the capability of the government at a time when unfavorable conditions are caused by increasing fuel prices. For instance, inflation is likely to go up even though it is a short-term. Energy-intensive industries may lose their competitiveness due to an upsurge in production costs. The government needs to prepare measures to handle these challenging situations.

Successful Case

The Philippines successfully phased out the fuel subsidies through legislation on deregulation of the oil industry and has maintained the liberalized market of fuel products for about two decades. In February 1998, the Downstream Oil Industry Deregulation Act of 1998 was enacted "to liberalize and deregulate the downstream oil industry in order to ensure a truly competitive market under a regime of fair prices,

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[25] International Monetary Fund (2013), *Energy Subsidy Reform: Lessons and Implications*, IMF, Washington D.C., pp. 23-25.

adequate and continuous supply of environmentally-clean and high-quality petroleum products."[26]

Even before that, then President Ramos built the foundation to remove the fuel subsidies soon after he took office in 1992. The government's strategies included some elements that contributed to the success of the reform as IMF suggests. The government launched a public campaign at an early stage to inform the public of the problems of the fuel subsidies and a coordination body between the executive branch and the congress was set up to facilitate a draft to deregulate the oil industry. In addition to the effective communication strategy and consensus building, the administration had a strong political will to pursue the reform continuously in spite of hardships. After the Supreme Court ruled the preceding bill passed in 1996 unconstitutional in 1997, the government introduced the revised bill again in 1998 amid a negative impact from the Asian crisis, domestic oil price increases due to exchange rate depreciation, and political pressure to reregulate the oil industry.[27] Furthermore, introducing the automatic pricing mechanism facilitated abolition of the Oil Price Stabilization Fund which was used to cover the difference between the regulated domestic prices and actual imported costs before 1996, and, therefore, was a financial burden for the government.

Taking advantage of the plunge in international oil prices since mid-2014, other Asian economies stepped into the policy arena that had been difficult to touch before. Indonesia struggled to reduce fuel subsidies for a long time. Soon after being inaugurated as President in October 2014, President Widodo took on fuel subsidy reform as one of his policy priorities to be dealt with urgently. Accordingly, Indonesia cut subsidies of gasoline (RON 88) and capped the diesel subsidy in January 2015. Similarly, Malaysia also abolished gasoline (RON 95) and diesel subsidies in December 2014.

Along with the oil industry reform, Mexico gradually increased the controlled prices of gasoline and diesel in 2014. The fuel prices have been adjusted to international oil prices and inflation since 2015. Mexico aims to achieve full price liberalization in 2018.

2-2-2 Promotion of Public Transport Use

Policy overview

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[26] Republic of the Philippines, Republic Act No. 8479, February 10, 1998.
[27] International Monetary Fund (2013), *Case Studies on Energy Subsidy Reform: Lessons and Implications*, IMF, Washington D.C., pp. 60-63.

Promoting a modal shift towards public transport is one of policies to reduce private car usage. There is a wide range of policies to encourage public transport use and this section highlights mainly three approaches which are regarded effective and have already been applied to many cities of the APEC member economies; mass transport system such as Light Rail Transit (LRT) and Bus Rapid Transit (BRT), improvement of quality in service provided by public transport, and fare reduction.[28]

The first possible option is to develop mass transport systems. Specifically, LRT and BRT. LRT is an advanced version of a tram that is friendly to people and the environment, and is expected to become a next generation transport system. Technology advancement has contributed to improvement of accessibility, comfort, and reliability. New technology such as low-floor vehicles and the onboard IC-card fare collection system has enhanced user-friendliness of the LRT system. As an alternative to rail systems, BRT has been introduced in many cities because it has advantages of lower investment cost, shorter construction period, and flexible implementation over rail systems.[29,30] The BRT system is characterized by bus corridors with designated lanes, high travel speeds and quick boarding systems.[31] Existing bus transport systems can be improved by setting separate bus lanes or creating dedicated lanes for bus service.

Integrating different public transport infrastructure, which are rail systems, subway and on-street buses, is crucial to enhance the utility of LRT and BRT. Well-designed integration of different services could make passengers' transfer easier and more convenient and could help save their travel time. A typical case is that feeder buses could help support operation of LRT and BRT, and bring more passengers from outside of the LRT and BRT network. "Park and ride" facilities could also help people to switch from private cars to public transport.

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[28] According to the study *Urban Transport Energy Use in the APEC Region – Benefits and Costs* conducted by APERC in 2008, LRT and BRT are defined as below.
LRT is "intra-city rail, typically with a smaller car weight, less passenger capacity, narrower rail gauge, shorter operating distance, and slower speeds than MRT systems" which are commonly known as heavy rail including metro or subway systems.
BRT refers to "a high-passenger-capacity road vehicle, with 2 or more axles, that is propelled by an on-board motor" and is "powered by on-board fuel or electricity and operates on exclusive busways or High Occupancy Vehicle lanes."

[29] Cervero (2013), 'Bus Rapid Transit (BRT): An Efficient and Competitive Mode of Public Transport,' Institute of Urban and Regional Development, Working Paper 2013-01.
Cervero notes that "more than 150 cities have implemented some form of BRT system worldwide" and LRT "can be more than four times as expensive." (p.3)

[30] Thaned Satiennam, Sittha Jaensirisak, Wichuda Satiennam, and Sumet Detdamrong (2015), 'Potential for Modal Shift by Passenger Car and Motorcycle Users toward Bus Rapid Transit (BRT) in an Asian Developing City,' *IATSS Research*

[31] GIZ (2012), Op.cit., p.27.

Along with infrastructure development of public transport systems, improvement of quality in service provided is also important to facilitate a modal shift to public transport. Service quality improvements of public transport include increases in scheduled frequency, spatial coverage, comfort, reduced crowding and appropriate information provision.[32] For instance, increasing frequency of operations would reduce the users' waiting time, which is important for those who place a high value on time. The LRT and BRT systems are expected to provide a comfortable ride due to smooth operation and enhance reliability if they are operated on schedule. Also, the on-board IC-card fare collection system enables passengers to get on and off easier which is more convenient because they no longer are forced to go through a separate ticket gate.

Furthermore, a possible measure to encourage using public transport is to reduce or eliminate fares. In addition to facilitation of a modal shift, this measure may have other objectives, which are to increase mobility and equity especially for low-income households and socially vulnerable groups such as women and the elderly. With this purpose, the beneficiaries could be limited based on criteria such as income, age, or residency. The area's free or lower fares that are provided may also be restricted to certain areas or within some zones.

Strength/Advantage

While facilitating a modal shift from private vehicles to public transport is a potential way to reduce oil consumption of vehicle use, the prominent rationale is its effectiveness in reducing greenhouse gas emissions. More specifically, introducing the LRT and BRT systems will help fuel demand of the covered area decrease. LRT runs on electricity which presents a replacement of energy sources for the motor to cleaner energy. As for BRT, increases in bus fuel use compared to reductions in car fuel use are considered negligible because a lot of vehicles are removed from the road as every bus is added.[33] This environmental benefit is also achieved through reductions of traffic congestion which increased public transport use is expected to mitigate.

Weakness/Disadvantage

The major disadvantages of public transport are travel time, convenience, and reliability. Long travel time and inconvenience are caused by the limited geographical coverage of the rail or bus network if a station or bus stop is not located in a location in

[32] IEA (2005), Op.cit., p.55.
[33] Ibid. p.59.

the neighborhood. Frequency of operation is also related to the travel time and convenience. As waiting time is added, the travel time tends to get longer, which lowers convenience. Reliability of services could be problematic more for bus travel.

Cost is a challenging issue to overcome for the government which develops and runs the public transport system. Initially, the government has to arrange massive financial resources for a project developing or expanding rail network systems or bus rapid lanes. Also, public transport yields operating expenditure to continue and improve services as well as capital expenditure. However, public transportation fares, which are important revenue sources, need to be set at an affordable level especially in cases where social equity is pursued. This may require the government to subsidize the operation of public transport, which forces the government to go into debt.[34]

Nevertheless, there is uncertainty about the level of modal shift from private vehicles to public transport. A wide range of factors would influence an individual's decision of transportation; travel time, cost, age, gender, car ownership, household size, and income.[35] Particularly, effectiveness of the public transport system is not clear in the area where private vehicles dominate or motorcycles have been a major way to travel like in many Asian cities.

Successful Case

BRT in Guangzhou, China, demonstrates a successful integrated public transport system in which the BRT system is operated in connection with bike lanes, bike share and metro stations. The Guangzhou BRT opened in February 2010 and carries 850,000 daily passenger-trips which is the one of the only two BRT system to carry more than 25,000 passengers per hour in a single direction together with Bogota's TransMilenio, Columbia.[36] It has the highest BRT bus flows in the world, with one bus every 10 seconds into the city in the morning rush hour.[37]

The Guangzhou BRT has received attention as the first high capacity system to operate 'direct service' routes because most cities prefer 'direct service' over

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[34] There are successful cases of running the public transport system with high farebox recovery ration (the percentage of operational costs covered by fares) such as Hong Kong and Singapore.

[35] Abdullah Nurdden, Riza Atiq O.K. Rahmat, and Amiruddin Ismail(2007), 'Effect of Transportation Policies on Modal Shift from Private Car to Public Transport in Malaysia,' *Journal of Applied Sciences* 7(7): 1013-1018.

[36] Institute for Transportation & Development Policy HP, https://www.itdp.org/where-we-work/china/guangzhou/

[37] United Nations Framework Convention on Climate Change HP, Momentum for Change, http://unfccc.int/secretariat/momentum_for_change/items/7101.php

'trunk-feeder' BRT operations. The bike sharing system was critical to make the Guangzhou BRT operate 'direct service' routes. In June 2010, the bike sharing system was launched with 113 stations located along the BRT corridor with 5,000 bikes. Approximately 20,000 people utilize this system daily. Guangzhou also re-introduced bike lanes on major roadways, with dedicated lanes for bikes along the BRT corridor and opened 5,500 bike parking positions at BRT stations areas.[38]

There are other unique features in the Guangzhou BRT system, which also contributed to success. It is the first BRT system in China with more than one bus operator and with private sector operators. Along with a fully separated BRT corridor, a new greenway was created in September 2010, and high quality plazas and public spaces were installed.

2-2-3 Research and Development

Policy overview

Research and development (R&D) is an important measure to affect future demand for petroleum products in road transport. Conventional fuel consumption growth can be curbed if fuel efficiency is improved through vehicle technology development and/or if alternative fuel vehicles running on biofuels, electricity, or hydrogen become more marketable. What will help vehicle technologies to advance is R&D activities that pioneer new technology, pursue product development, upgrade existing products, improve productivity or operation process efficiency, and so on.

The government could assist R&D activities through funding, tax credits, deregulation, and collaboration among government, academia, and industry. In particular, funding is the major program in R&D because invention requires not only expensive equipment and long-term commitments but also it involves certain risks of feasibility which could be a concern for investors. Hence, funding programs may play a critical role until new technology for advanced and efficient vehicles is commercialized and scale of economy is achieved.

Strength/Advantage

The R&D program is expected to lead to a business opportunity. The program is often used to help nascent industry to develop and, if successful, the industry could

[38] United Nations Partnerships Engagement for the Sustainable Development Goals HP, https://sustainabledevelopment.un.org/partnership/?p=2250

grow to a leading business of an economy. Even an established industry could rely on R&D to strengthen its competitiveness and expand their new business field. Furthermore, there are positive ripple effects on the economy, one of which is that manufacturers create employment opportunities for the local community and induce their supply chains to the area. Another possible effect is the byproduct that technology developed for a specific purpose could be applied to a different product or industry as well.

Weakness/ Disadvantage

A challenging issue for the government is how long and how much budget can be spared for the R&D programs. It is uncertain whether the R&D would actually bear fruits as expected and when advanced technology would become commercially available. Given such uncertainty and risk of failure involved in the R&D programs, the government may face difficulty in receiving support from the public unless some progress is acknowledged. Also, the R&D program tends to be exposed to budget cuts especially when the economy is in recession.

Successful Case

The United States Department of Energy supports the development of advanced technology vehicles and associated components. The Advanced Technology Vehicles Manufacturing (ATVM) loan program has provided more than $8 billion to support the auto industry. It was reported that more than 4 million fuel-efficient vehicles were produced along with the creation of more than 35,000 jobs across eight states.[39] Furthermore, in January 2016, the Department of Energy announced more than $58 million of funding to advance fuel-efficient vehicle technologies and $55 million of funding will solicit projects across vehicle technologies such as energy storage, electric drive systems, materials, fuel and lubricants and advanced combustion.[40]

[39] Loan Program Office, the United States Department of Energy (January 2016), 'ATVM Loan Program: Driving Economic Growth'

[40] The United Stated Department of Energy(2016), 'Energy Department Announces $58 Million to Advance Fuel-Efficient Vehicle Technologies,' January 21, 2016

Chapter 3　Progress of Fuel Economy Standards and Clean Energy Vehicles in the APEC Region

3-1 Fuel Efficiency Improvement

To improve vehicle fuel efficiency, the policy package which consists of three pillars is considered useful: fuel economy standards, information measures such as labelling, and fiscal measures. First, the fuel economy standards of the APEC member economies are succinctly described. Then, the outline of labelling programs and fiscal measures of the APEC member economies follows.

3-1-1 Fuel Economy Standards

Fuel economy standards require manufacturers to improve the annual average fuel efficiency of new vehicles and to achieve the targeted level by the specific year. The objectives of implementing fuel economy standards are to curb fuel consumption, facilitate technological advancement and innovation, reduce CO_2 emission, and help individual expenditure for fuel to be saved. These standards are measured by either fuel reduction, CO_2 emission reduction, or greenhouse gas emission reductions and are indicated as levels for vehicle fuel consumption per kilometer (inversely, kilometers per liter or miles per gallon) of driving tested over a driving test cycle.

Both voluntary and mandatory measures have been widely introduced worldwide. However, a change from voluntary to regulatory measures has been observed due to limited effectiveness of the voluntary standards. In the APEC region, Canada, China, Japan, Korea and the United States have mandatory fuel economy standards while Australia has a voluntary target. Although these standards target mainly light-duty vehicles (LDVs), the APEC economies such as the United States, Japan, and China implemented the fuel economy standards for heavy-duty vehicles (HDVs) as well.[41]

(a) The United States

Corporate Average Fuel Economy (CAFE) Standards of the United States is probably the most recognized fuel economy standards. The CAFE standards require manufactures to comply with a weighted average fuel economy target based on miles

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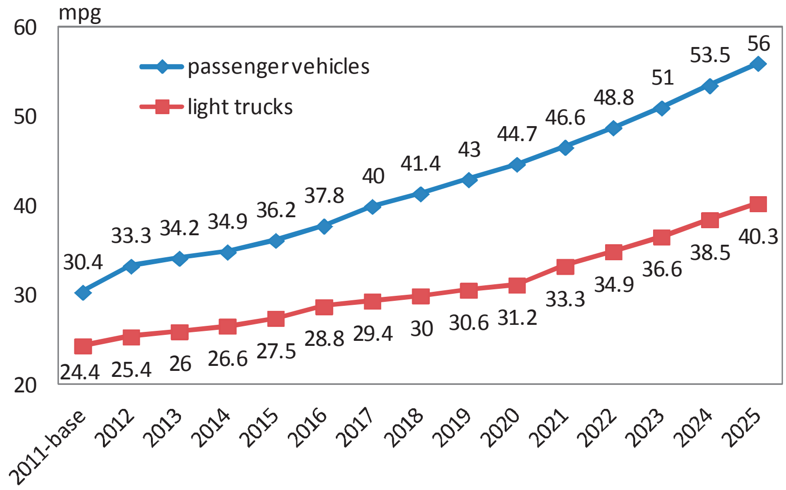
[41] IEA (2008), *Review of International Policies for Vehicle Fuel Efficiency*, OECD/IEA, Paris, p.29. Heavy-duty vehicles are excluded from fuel economy standards partly because owners of HDVs have traditionally been considered to be conscious of fuel use, thereby requiring no government intervention.

per gallon (mpg) for passenger vehicles and light trucks.[42] Fuel economy standards which apply to LDVs and trucks in model years 2012-2016 (phase 1) and 2017-2025 (phase 2) are set to improve as illustrated in Figure 3-1. Under the Heavy-Duty National Program announced in 2010, fuel economy standards for medium- and heavy-duty vehicles are also introduced for those of model years 2014-2018 (phase 1).[43] The United States use a footprint-based corporate average, which means that the fuel economy standards are based on the vehicle size since footprint is defined as the product of track width times wheelbase. For this reason, manufacturers may be encouraged to reduce vehicle weight rather than paying attention to fuel economy.

Figure 3-1 CAFE standards for LDVs



Source: United States Environmental Protection Agency

(b) Canada

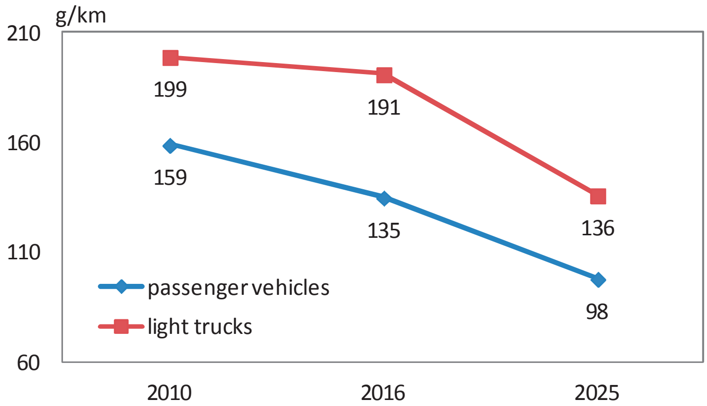
Canada's fuel economy standards are equivalent to the United States standards since the Canadian vehicle markets are highly linked with the United States markets. Similar to the United States, Canada's standards are a footprint-based corporate average. The long history of Canada's voluntary fuel efficiency targets ended when the

[42] A passenger vehicle is any automobile (other than an automobile capable of off-highway operation) manufactured primarily for use in the transportation of not more than 10 individuals (49 CFR 523.4). Light truck means a non-passenger automobile (49 CFR 523.2).

[43] Heavy-duty vehicles incorporate all on-road vehicles rated at a gross vehicle weight at or above 8,500 pounds.
In 2010, the U.S. Environmental Protection Agency (EPA) and the Department of Transportation's Highway Traffic Safety Administration (NHTSA) jointly announced the Heavy-Duty National Program to reduce greenhouse gas emissions and improve fuel efficiency of heavy-duty trucks and buses. Furthermore, in 2015, EPA and NHTSA proposed the phase 2 program covering medium- and heavy-duty trucks of model year 2018 and beyond.

fuel use of new light-duty passenger vehicles and light-duty trucks began to be regulated by Passenger Automobile and Light Truck Greenhouse Gas Emission Regulation Amended 2015 and On-Road Vehicle and Engine Emission Regulations Amended 2014, respectively.[44] These regulations aim to reduce greenhouse gas (GHG) emissions from passenger vehicles and light trucks by establishing emission standards and test procedures that are aligned with the federal requirements of the United States. Therefore, Canada reports fuel economy standards in GHG emission per mile (Figure 3-2).

Figure 3-2 GHG Emission Standards in Canada



Source: The International Council on Clean Transportation

(c) Japan

Fuel economy standards of both passenger vehicles and freight vehicles are regulated under the Top Runner Program.[45] These standards are set based on the values of the product with the highest fuel efficiency performance on the market at present while taking into consideration possible technological advancement in the future. Target values of fuel efficiency are regulated by each vehicle weight category and

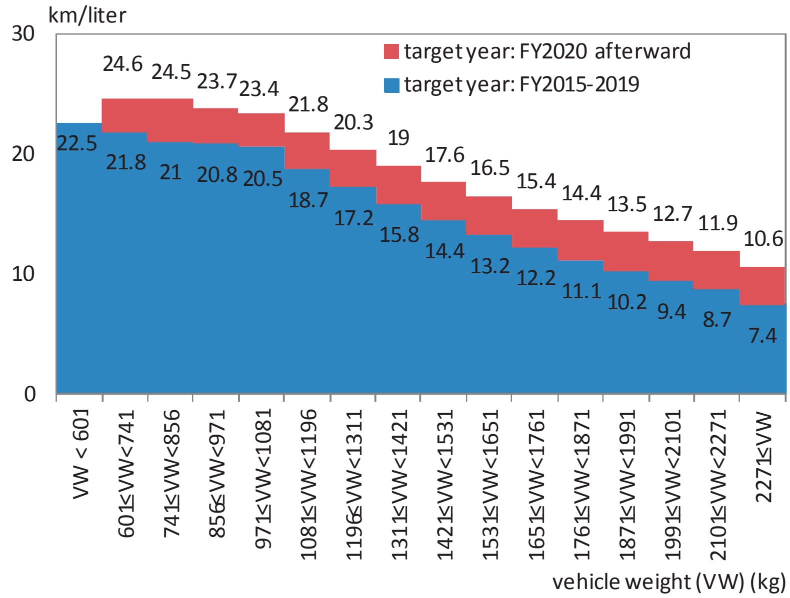
[44] A passenger vehicle refers to a vehicle with a maximum Gross Vehicle Weight Rating (GVWR) no more than 8,500 pounds and no more than 12 seats. A light truck refer to no-passenger automobile with maximum GVWR no more than 8,500 pounds and medium-duty SUVs and passenger vans with GVWR no more than 10,000 pounds.

[45] The Top Runner Program was introduced in 1998 to establish energy efficiency standards for machinery, equipment, and other items used in the residential and commercial sector and the transport sector. Starting with 11 product items to regulate, the program currently covers 31 items including vehicles.

Passenger vehicles refer to gasoline, diesel, and LPG passenger vehicles with less than 10 seats, gasoline and diesel passenger vehicles with more than 11 seats and gross vehicle weight of less than 3.5 tons, and diesel passenger vehicles with more than 11 seats and gross vehicle weight exceeding 3.5 tons with a device of preventing carbon monoxide emission. Freight vehicles refer to gasoline and diesel freight vehicles with a gross vehicle weight of less than 3.5 tons and diesel freight vehicles with gross vehicle weight exceeding 3.5 tons with a device of preventing carbon monoxide emission.

by target years (Figure 3-3). As for freight vehicles, such standards are set in more detailed categories which are separated by vehicle type, fuel, vehicle structure, transmission type, and vehicle weight. In setting the target years, appropriate lead time, usually three to ten years, is provided so that manufactures have time to invest in necessary equipment and develop technology to meet the target.

Figure 3-3 Top Runner Standards for Passenger Vehicles



Note: The blue line of 'target year: FY15-2019' covers passenger vehicles fueled with gasoline or diesel whereas the red line of 'target year: FY2020 onward' includes passenger vehicles and small buses with gasoline, diesel, or LPG.
Source: The Energy Conservation Center, Japan

This scheme is regarded fair for manufacturers because they have a level playing field if their vehicles are in the same category regardless of size. Given the similar conditions such as technology level and marginal compliance costs, they are required to improve fuel efficiency to reach the same standard. Meanwhile, this category-based standard could be ineffective in terms of cost in that manufacturers have to cope with the fuel efficiency standards of each category.

(d) China

China's fuel consumption standards for LDVs that are currently in Phase IV include both vehicle-maximum fuel consumption limits and corporate average fuel consumption (CAFC) standards for each manufacturer based on vehicle curb weight distribution.[46] A phase-in schedule of the standards has provided manufacturers with time and flexibility to accommodate new standards. What the first two phases of the standards (2004-2012) required was only vehicle-maximum fuel consumption limits in which each vehicle model complied with fuel consumption regulations. On the contrary to the case of Japan, these standards allow heavier vehicles to have worse fuel economy standards than lighter vehicles. Then the CAFC requirement was enacted under the Phase III (2012-2015) and a fleet average target of 5.0 liter/100km was expected to be achieved by 2020 under Phase IV. These standards are to regulate domestically manufactured and imported new passenger vehicles sold in China. Both vehicle-maximum fuel consumption limits and CAFC have become stricter to reduce fuel consumption gradually by phase (Table 3-1 and Figure 3-4).[47]

Table 3-1 Fuel Consumption Limits for LDVs

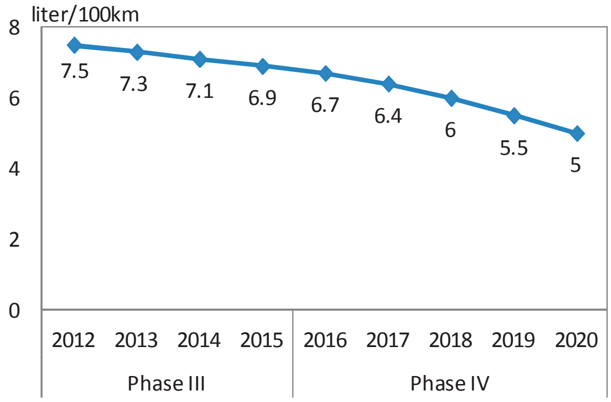
	Phase I Limits		**Phase II+III Limits**		**Phase III Targets**		**Phase IV Limits**		**Phase IV Targets**		
	As of July 2005 for new, July 2006 for all		As of July 2008 for new, July 2009 for all		*As of January 2012*		As of 2020				
Curb Mass (CM) (kg)	MT	AT and/or >= 3seat row	MT	AT and/or >= 3seat rows	MT	AT and/or >= 3seat row	MT	AT and/or >= 3seat row	>=2 seat rows	3 seat row and cw <= 1090kg	3 seat rows and cw> 1090kg or > 3 seat rows
CM≤750	7.2	7.6	6.2	6.6	5.2	5.6	5.2	5.6	3.9	4.1	4
750<CM≤865	7.2	7.6	6.5	6.9	5.5	5.9	5.5	5.9	4.1	4.3	4.2
865<CM≤980	7.7	8.2	7	7.4	5.8	6.2	5.8	6.2	4.3	4.5	4.4
980<CM≤1090	8.3	8.8	7.5	8	6.1	6.5	6.1	6.5	4.5	4.7	4.6
1090<CM≤1205	8.9	9.4	8.1	8.6	6.5	6.8	6.5	6.8	4.7	-	4.8
1205<CM≤1320	9.5	10.1	8.6	9.1	6.9	7.2	6.9	7.2	4.9	-	5
1320<CM≤1430	10.1	10.7	9.2	9.8	7.3	7.6	7.3	7.6	5.1	-	5.3
1430<CM≤1540	10.7	11.5	9.7	10.3	7.7	8	7.7	8	5.3	-	5.5
1540<CM≤1660	11.3	12	10.2	10.8	8.1	8.4	8.1	8.4	5.5	-	5.7
1660<CM≤1770	11.9	12.6	10.7	11.3	8.5	8.8	8.5	8.8	5.7	-	5.9
1770<CM≤1880	12.4	13.1	11.1	11.8	8.9	9.2	8.9	9.2	5.9	-	6.1
1880<CM≤2000	12.8	13.6	11.5	12.2	9.3	9.6	9.3	9.6	6.2	-	6.4
2000<CM≤2110	13.2	14	11.9	12.6	9.7	10.1	9.7	10.1	6.4	-	6.6
2110<CM≤2280	13.7	14.5	12.3	13	10.1	10.6	10.1	10.6	6.6	-	6.8
2280<CM≤2510	14.6	15.5	13.1	13.9	10.8	11.2	10.8	11.2	7	-	7.2
CM>2510	15.5	16.4	13.9	14.7	11.5	11.9	11.5	11.9	7.3	-	7.5

Note: MT: manual transmission. AT: automatic transmission. Phase IV includes hybrid cars.
Source: UNEP Transport – Global Fuel Economy Initiative

46 International Council on Clean Transportation (March 2014), 'China Phase 4 Passenger Car Fuel Consumption Standard Proposal.'
Light-duty passenger vehicles with weight less than 3,500kg are targeted.

47 United Nations Environment Programme (UNEP) Transport – Global Fuel Economy Initiative, 'The Chinese Automotive Fuel Economy Policy,' prepared by Innovation Center for Energy and Transportation

Figure 3-4 Corporate Average Fuel Consumption in China



Source: UNEP Transport – Global Fuel Economy Initiative

China also introduced maximum fuel consumption limits for HDVs such as tractors, trucks, and city buses and coaches (Table 3-2).[48] The Phase I standard was implemented for new vehicle type approvals on July 1, 2012 and Phase II took effect on July 1, 2014 for new type approvals and from July 1, 2015 for all new commercial HDVs manufactured in China.[49]

Table 3-2 Fuel Consumption Limits for HDVs

Trucks				Tractors			Buses/Coaches			
Maximum design weight (tons)	Phase I (l/100km)	Phase II (l/100km)	Phase II (dump trucks only)	Maximum design weight (tons)	Phase I (l/100km)	Phase II (l/100km)	Maximum design weight (tons)	Phase I (l/100km) (intercity buses)	Phase II (l/100km) (intercity buses)	Phase II (l/100km) (city buses only)
3.5-4.5	15.5	13	15	3.5-18	38	33	3.5-4.5	14	12.5	14
4.5-5.5	16.5	14	16	18-27	42	36	4.5-5.5	15.5	13.5	15.5
5.5-7	18.5	16	17.5	27-35	45	38	5.5-7	17	15	17.5
7-8.5	22	19	20.5	35-40	47	40	7-8.5	19	16.5	19.5
8.5-10.5	24	21.5	23	40-43	49	42	8.5-10.5	21	18.5	22.5
10.5-12.5	28	25	25.5	43-46	51.5	45	10.5-12.5	22.5	20	26
12.5-16	31	28	28	46-49	54	47	12.5-14.5	23.5	21.5	30.5
16-20	35	31.5	34	>49	56	48	14.5-16.5	25	22.5	34
20-25	41	37.5	43.5				16.5-18	26	24	37.5
25-31	47.5	43	47				18-22	27.5	25	41
>31	50	45.5	49				22-25	30	27.5	45.5
							>25	33	29.5	49

Source: TransportPolicy.net

(e) Mexico

48 HDVs fuelled with diesel or gasoline with gross vehicle weight less than 3.5 metric tons are covered.
49 TransportPolicy.net, 'China: Heavy-duty: Fuel Consumption.'

Mexico introduced fuel economy standards in 2013.[50] The standard is applied to new passenger vehicles – vehicles, pickup trucks, and SUVs - with gross vehicle weights up to 3,857kg for model years 2014 through 2016. The standard uses footprint and a single sales-weighted fleet average at 14.6km/liter over the period of 2014 to 2016. Since the average fuel economy was 13.1km/liter for new LDVs sold in 2011, the target to 14.6km/liter presents an improvement of 11%.

(f) Korea

Korea requires manufacturers to meet fuel economy in units of km/liter and CO_2 emissions in units of g/km.[51] Manufacturers have the choice of which regulations to comply with. With announcement of the Five-Year Plan for Green Growth in 2009, the government employed a GHG emission target as well as a fuel economy standard for passenger vehicles but did not include light trucks as a target to regulate. The new standards (2016-2020) will require manufacturers to meet a fuel economy target of 24.1 km/liter or GHG target of 97 g/km for passenger vehicles and a fuel economy target of 14.1 km/liter or GHG target of 166 g/km for light trucks (Table 3-3).[52]

Table 3-3 Fuel Economy Target in Korea

	2012-2015	2016-2020
Structure	Weight-based corporate average	Weight-based corporate average
Scope	Passenger car	Passenger car and light truck
Phase-In	100% by 2015	100% by 2020
Fuel Economy (GHG Emissions)	16.7 km/liter (140 gCO_2/km)	Passenger cars: 24.1 km/liter (97 gCO_2/km) Light trucks: 14.1 km/liter (166 gCO_2/km)

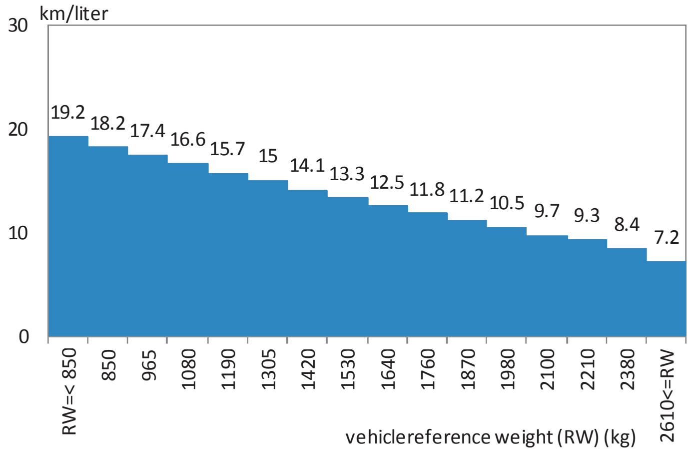
Note: Fuel economy value is converted to gasoline equivalent from g CO_2/km. GHG emissions include only CO_2 emissions.
Source: TransportPolicy.net

(g) Chinese Taipei

[50] International Council on Clean Transportation (July 2013), 'Mexico Light-Duty Vehicle CO_2 and Fuel Economy Standards.'
[51] Ministry of Trade, Industry and Energy regulates fuel economy standards and the Ministry of Environment sets GHG emission targets.
[52] LDVs include passenger cars, SUVs, minivans and light trucks with 15 seats or fewer with a gross vehicle weight less than 3,500kg.

Chinese Taipei plans to implement new modified vehicle fuel economy regulations in 2017.[53] The government announced revised codes to regulate vehicle fuel economy as shown in Figure 3-5 and car retailers will be prohibited from selling vehicles whose fuel consumption exceeds the stipulated volume. New passenger vehicles sold in Chinese Taipei will be subjected to a test by the EU testing procedures from 2016.

Figure 3-5 Suggested Passenger Car Fuel Economy in Chinese Taipei



Source: China Economic News Service

(h) Other economies

As of 2015, some Southeast Asian economies are currently in the process of introducing fuel economy standards for LDVs.[54] Viet Nam is waiting for approval from the Ministry of Transport concerning fuel economy standards for LDVs and motorcycles. Thailand is considering developing fuel economy standards for automobiles. The Philippines and Indonesia have also started the necessary study to set appropriate fuel economy standards and cost-benefit analyses on fuel quality and fuel economy.

3-1-2 Labelling

Although fuel economy standards work in economies with vehicle manufacturing and large markets that have the potential to influence the type of vehicles developed and brought to market, they are not necessarily appropriate for some economies.[55] Labelling and fiscal measures seem to work better in economies where fuel economy standards are not applied but need to promote fuel-efficient vehicles.

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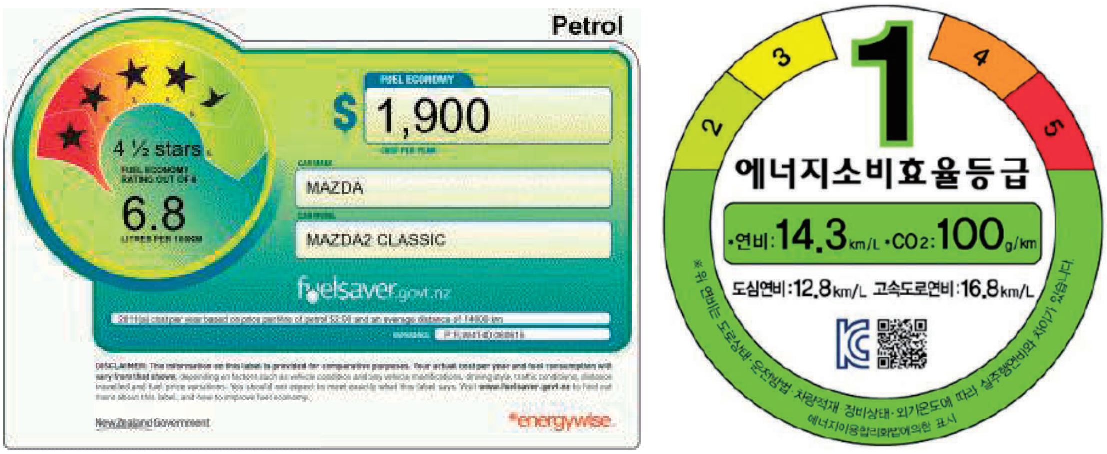
[53] China Economic News Service (2014), 'Taiwan to Promulgate New Vehicle Fuel-consumption,' October 20, 2014.
[54] IEA (2016), *Medium-Term Oil Market Report 2016*, OECD/IEA, Paris, p.31.
[55] IEA (2012), *Improving the Fuel Economy of Road Vehicles*, OECD/IEA, Paris, p.15

While labelling intends to raise the awareness of the public on fuel efficiency and CO_2 emissions, it facilitates technology advancement of manufacturers to meet the expected standard. The principal purpose of this measure is to provide consumers with information on vehicle fuel economy performance so that they can have a better understanding about the vehicle they purchase. Additionally, this measure works to pressure the manufactures. Since information on the labelling draws attention from consumers who refer it in decision-making, manufacturers are motivated to make efforts or investments to achieve higher fuel efficiency or to reduce CO_2 emissions in order to make their vehicles look superior to others.

There are mainly three kinds of vehicle labels, depending on the type of information provided and design; (i) graphical rating in relative or absolute terms, e.g. New Zealand, Korea, and Chinese Taipei (Figure 3-6), (ii) direct information disclosure with the value of the CO_2 emissions or fuel economy, e.g. the United States, Canada (voluntary), Chile, Australia, Hong Kong, China (voluntary), Singapore, Thailand, and Viet Nam (Figure 3-7), and (iii) relative vehicle performance compared to the fuel economy standard, e.g. Japan (Figure 3-8).[56]

Figure 3-6 Labelling: New Zealand and Korea

(i) New Zealand (ii) Korea



Source: New Zealand Energy Efficiency and Conservation Authority, Korea Energy Management Corporation

As Figure 3-6 shows, in New Zealand, fuel efficiency is rated out of 6: the more stars, the more efficient it is. The label also demonstrates fuel economy in liters per 100km,

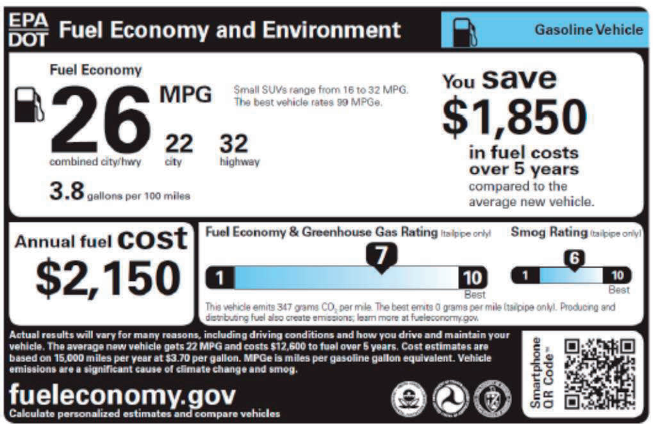
[56] Ibid. pp.16-21

estimated running costs per year, and average fuel price. Korea also takes the rating approach which grades from 1st to 5th in accordance with the energy efficiency. Not only a grade but also fuel efficiency in city mode and highway mode, combined fuel efficiency are shown in the label.

The second type of labelling seen in the United States illustrates fuel efficiency in city mode and highway mode, combined fuel efficiency, estimated annual fuel costs, and costs to be saved over 5 years. The label also rates the vehicle in terms of fuel economy, greenhouse gases and smog. As the first Latin American economy, Chile introduced mandatory labelling in February 2013. Every car in a show room must have a label in the wind shield showing the fuel economy in kilometers per liter tested in the New European Driving Cycle, CO_2 emissions, and local pollutant emission standards that the vehicle model meets.[57]

Figure 3-7 Labelling: United States and Chile

(i) United States



(ii) Chile

Source: United States Environmental Protection Agency, Agencia Chilena de Eficiencia Energética

The third example of labelling which is prevalent in Japan is the most simple as it shows only how much higher fuel efficiency a vehicle has achieved over the average regulated for the same class of similar vehicles (Figure 3-8). Since this label is awarded only to vehicles with better fuel efficiency than the regulated level, consumers can

[57] Global Fuel Economy Initiative HP, http://www.unep.org/transport/gfei/autotool/case_studies/samerica/chile/cs_sa_chile.asp

easily identify which vehicles are fuel-efficient or not. Without a specific figure of fuel economy performance, however, it is difficult to compare more details among vehicles with a label with the same achievement level.

Figure 3-8 Labelling: Japan

Source: Ministry of Land, Infrastructure, Transport and Tourism, Japan

As the latest policy development, two APEC member economies introduced fuel economy labelling in 2015.[58] In Thailand, all manufacturers and importers of LDVs are mandated to display the Eco Sticker from October 2015, which becomes a basis for revised excise tax rates from January 2016 on. The sticker informs consumers about fuel economy, CO_2 rating, and vehicle pollutant emissions. The taxation scheme favors passenger vehicles with low emissions. Another economy is Viet Nam where a mandatory fuel economy labelling program took effect in 2015 for locally assembled and imported vehicles with up to 7 seats. The car manufacturers and importers are obliged to publish fuel economy data.

3-1-3 Financial Incentives

Tax incentive programs are taken to encourage the use of environmentally friendly vehicles in many APEC economies. A vehicle tax system that is based on fuel economy and/or vehicle CO_2 emissions is effective to encourage the public to buy fuel-efficient vehicles. In Japan, the government gives tax reductions for green vehicles graded to fuel efficiency under the car acquisition tax system with six levels ranging from a 100% tax cut to none.[59] Chile introduced a carbon tax in January 2015 to promote vehicle fuel

[58] Global Fuel Economy Initiative (2015), *Fuel Economy State of the World 2016*, produced by FIA Foundation, p.23.
[59] Mainichi Japan (2015), 'Gov't agrees on new vehicle tax based on fuel efficiency,' December 9, 2015 A new vehicle acquisition tax system will be applied when Japan's sales tax rate is raised from 8% to 10% in April 2017. Vehicles that reach the latest standard for fiscal year 2020 will be taxed at 1% of the purchase amount; those whose performance tops the fiscal year 2015 standard by 10% or more will be taxed at 2%; and other vehicles will be taxed at 3%. The fuel efficiency standard will be reviewed every two years.

economy, which is applied to new car purchases based on both CO_2 and NOx emissions.[60] In July 2015, Singapore revised the Carbon Emissions-Based Vehicle Scheme, which was originally introduced in January 2013. Under this scheme, all new and imported used cars with low carbon emissions of less than or equal to 135g CO_2/km qualify for rebates of between S$5,000 (US$3,536) and S$30,000 (US$21,218) whereas cars with more than 186g CO_2/km incur surcharges between S$5,000 and S$30,000.[61]

On the other hand, there are tax measures to restrain the public from driving inefficient fuel vehicles and to encourage switching to efficient ones. In Canada, an excise tax called Green Levy could be a disincentive since taxes are to be increased for fuel-inefficient vehicles. Similarly, in the United States, the Gas Guzzler Tax imposed on new cars that do not meet required fuel economy levels aims to discourage production and purchase of fuel inefficient vehicles. Tax is paid on cars with fuel efficiency less than 22.5 mpg.[62]

3-2 Clean Energy Vehicles

Clean energy vehicles have received attention as effective means to reduce both CO_2 emissions and reliance on gasoline and diesel. Natural gas, biofuel, and electricity mainly represent automotive fuel for clean energy vehicles. Since biofuel is described in detail in the next chapter, this section focuses on natural gas and electricity.

Natural gas vehicles (NGVs) which run on compressed natural gas (CNG) have already been used to replace petroleum-fuelled vehicles widely since they are commercially viable, technically available, and environment-friendly. LNG vehicles are suitable for long distance travel but have not been commercialized yet in many economies.

There are advantages and disadvantages to driving NGVs. One of the merits of using natural gas is life cycle greenhouse gas emissions have benefits over conventional fuel.[63] CNGs reduce CO_2 emissions roughly 20% compared to gasoline-powered vehicles

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[60] Global Fuel Economy Initiative HP, http://www.globalfueleconomy.org/in-country/south-america-and-caribbean

[61] Singapore Land Transport Authority HP. US value is calculated based on the exchange rate for 2015, US$1 = S$1.4139 (Source: Monetary Authority of Singapore)

[62] US Environmental Protection Agency (EPA) HP. Gas Guzzler Tax provisions are included in the Energy Tax Act of 1978.

[63] Alternative Fuels Data Center, US Department of Energy HP, http://www.afdc.energy.gov/fuels/natural_gas.html

and emit little or no particulate matter. NGVs are also expected to enhance energy security on the grounds that oil importing economies could reduce oil import dependence, natural gas producers could utilize the domestic resource, and geopolitical risks related to natural gas are considered less than in the case of crude oil. CNG vehicles have been promoted with incentives given for some APEC member economies where natural gas is domestically produced such as Thailand and China.[64] Nevertheless, NGVs have disadvantages in limited driving range, not enough fuelling stations, and a limited number of models.

In the long-term, electric vehicles (EVs) are anticipated to have the potential to replace conventional fuel powered vehicles. Recent technology advancements have enabled EVs to make inroads into the vehicle market although its share is still very marginal. As of the end of 2014, total EVs stock reached 665,000 globally, which represents a mere 0.08% of all passenger vehicles.[65] EVs include battery electric vehicles (BEV), plug-in hybrid electric vehicles (PHEV), fuel cell electric vehicles (FCEV), and hybrid electric vehicles (HEV).[66]

EVs are considered to bring substantial benefits in terms of greenhouse gas emission reductions and energy security enhancement similar to NGVs. However, a difference is that electricity, which powers an EV, can be generated from diversified sources including renewable energies whereas NGVs runs on fossil fuel that is a limited energy source.

Nonetheless, there are certain obstacles to overcome for increased deployment of the EVs. The first difficulty is the upfront cost mainly due to the battery that accounts for a large part of a vehicle's cost. For instance, a Nissan LEAF has a 24 kilowatt per hour (kWh) battery that costs about $12,000, making up a third of the vehicle's retail price and a Ford Focus Electric has a battery whose costs range between $12,000 –

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[64] In China, natural gas consumption in transport has been promoted under the Natural Gas Utilization Policy which took effect in 2012.

[65] IEA - Electric Vehicles Initiative (2015), 'Global EV Outlook 2015.'

[66] IEA- Electric Vehicles Initiative (2013), *Global EV Outlook*, Glossary, p.38.

Battery electric vehicle: an all-electric vehicle propelled by an electric motor powered by energy stored in an on-board battery.

Plug-in hybrid electric vehicle: a hybrid electric vehicle with a high-capacity rechargeable battery that is capable of using electricity as its primary propulsion source. The internal combustion engine typically assists in recharging the battery or serves as a back-up when the battery is depleted.

Fuel cell electric vehicle: a vehicle that runs on a fuel cell that generates an electrical current by converting the chemical energy of a fuel, such as hydrogen, into electrical energy.

Hybrid electric vehicle: a vehicle that combines a conventional internal combustion engine propulsion system with an electric propulsion system to achieve improvements in fuel economy.

15,000.[67]

The second hurdle is practical issues that consumers cannot be sure about driving the EVs. Their concerns are mainly caused by range limitations, access to charging infrastructure, and time needed to charge. As is often pointed out, range limitations make consumers worry about power shortages before reaching the nearest charging point. As for the possible range of the EVs, a Nissan LEAF offers 228km (84miles) range with the 24kWh lithium-ion battery and 280km (107miles) with the 30kWh lithium-ion battery, which is around one fifth of the range of a comparable internal combustion engine vehicle. The EVs with larger battery packs are able to offer longer range but come with higher retail prices.[68] This weakness could be covered if non-residential charging points are provided appropriately. However, infrastructure development for the EVs seems still slow because not only it is costly but also precise marketing is needed to identify which area needs what types of infrastructure while estimating demand for the EVs. Besides, charging time could limit flexibility and mobility of driving. At present, there are two different types of charging points, either slow or fast. For the slow charging points, it takes from 4 to 12 hours for a full charge. Even for the fast modes, time to charge ranges from 0.5 to 2 hours.

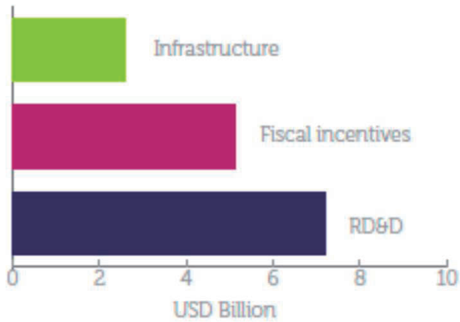
For these reasons, expanding a share of the EVs may be difficult to get driven by market forces alone. Instead, government intervention may be necessary to facilitate deployment of the EVs on both the demand and supply sides. First of all, the government could show a firm commitment and take an initiative to electrify vehicles, for instance, by setting up a national target. For the demand side, financial incentives such as subsidies, rebates or tax credits would make the EVs affordable for consumers. Giving priority access to parking or free parking could also be a useful measure to motivate the public to drive the EVs.

On the supply side, the government is also expected to play an important role. Charging infrastructure development is a precondition for the EVs to be more widely accepted. To reduce the burden of upfront costs, the national government could provide the private sector or local governments with financial support or incentives for development and operation of non-residential charging points. Designating specific regions/areas that the government aims to promote EV development in could be helpful to invite investment in that the public backup is assured.

[67] IEA- Electric Vehicles Initiative (2013), Op.cit., p.25
[68] Ibid., p.25.

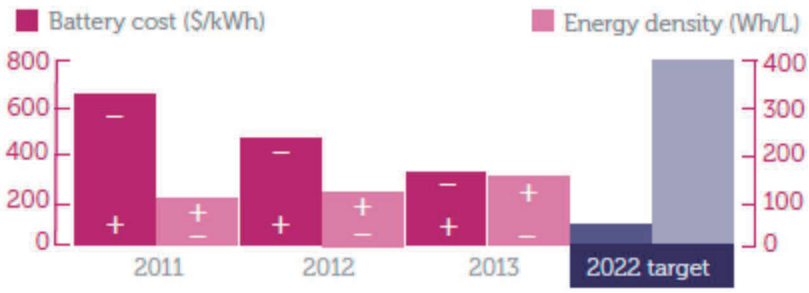
The most critical part that needs the assistance of the government for the EVs expansion is research, development and demonstration (RD&D). Figure 3-9 illustrates cumulative spending between 2008 and 2014 by infrastructure, fiscal incentives, and RD&D for the 16 member governments that participate in IEA's Electric Vehicles Initiative and presents that the government expenditure on RD&D is outstanding. This is reasonable because RD&D efforts are fundamentally essential for the early stage of the EVs market.

Figure 3-9 Cumulative Spending by Category (2008-2014)



Source: IEA - Electric Vehicles Initiative (2015), 'Global EV Outlook 2015.'

Figure 3-10 PHEV Battery Progress



Source: IEA - Electric Vehicles Initiative (2015), 'Global EV Outlook 2015.'

More specifically, a relatively high ratio of RD&D is spent for batteries and fuel cells since they make up the largest part of the EV price. There is substantial room for the battery to improve in terms of costs, performance, weight, volume, and safety. Such expenditures have actually helped battery costs decline. The United States Department of Energy reported that plug-in battery costs had reduced significantly from $1,000 – $1,200/kWh of useable energy in 2008 to $485/kWh in 2012 and set a goal to achieve

$125/kWh in 2022.[69] The IEA study also shows that battery costs have declined while energy density has increased (Figure 3-10).

Table 3-4 presents a summary of clean energy vehicle policies taken by the APEC member economies. A wide range of measures have been implemented to promote the clean energy vehicle use although most of the economies have not set a specific target of market penetration of the EVs. For the economies with policy targets of the EVs, these figures are taken into consideration for the scenario analysis in the next section.

Table 3-4 Clean Energy Vehicle Policy

	Target	Measures
Canada		- British Columbia: Clean Energy Vehicle Program Initial Maximum Point of Sale Incentive: BEV ($5000), FCV ($6000), PHEV battery capacity above 15kWh ($5000), PHEV below 15 kWh but below 4kWh ($2500) - Quebec: Drive Electric Program Offer up to $8,000 for purchasing an EV of PHEV as well as financial assistance for installation of home charging station. - Ontario: Electric Vehicle Access to High Occupancy Vehicle Lanes PHEV and EV with green license plates are able to drive in the high occupancy vehicle lanes.
Chile	EV: 70,000 by 2020	
China	New Energy Vehicles (EV, PHEV, and FCEV): 5 million by 2020	- National and local government subsidy for consumers who purchase NEVs - Exemption from taxes and other fees - Subsidy for construction, operation, and upgrading of NEVs charging stations
Indonesia		- Jakarta: a switch to CNG for local government and public transport vehicles and committed to full conversion of three-wheeled taxis to CNG by the end of 2016
Japan	HEV: 20-30% by 2020 and 30-40% by 2030 of new passenger vehicle sale PHEV: 15-20% by 2020 and 20-30% by 2030 BEV: 15-20% by 2020 and 20-30% by 2030 FCEV: 1% by 2020 and 3% by 2030 Clean diesel: 5% by 2020	- National subsidy for consumers who purchase EV, PHEV, FCEV, clean diesel vehicles - Subsidy to develop electric vehicle supply equipment - R&D of battery equipped in EV and PHEV

[69] The United States Department of Energy (2013), 'U.S. Battery R&D Progress and Plans.'

	and 5-10% by 2030	
Korea	EV: 200,000 by 2020 FCEV: 90,000 by 2020 and 630,000 (10% of new passenger car sale) by 2030	- R&D to develop the range extended EVs
Malaysia		- Import tax and excise duty exemption for EV - Soft loans and tax exemptions for the development of infrastructure - Soft loans for pre-commercialization activities by domestic vendors that adopt and adapt to new technologies
New Zealand		- Exemption from the road user charges for EV until 2020
Russia		- All gas stations across Russia must have electric car chargers by November 2016 with no financial support
USA		- Funding for PHEV deployment programs - Federal tax credit and incentives including rebates and tax credits at state and local level - Grants to institutions of higher education and other qualified training and education institutions - EV Everywhere Workplace Charging Challenge: to raise profile of the benefits of workplace charging
Viet Nam		- Encourage buses and taxis to shift to the use of CNG and LPG

Source: The Institute Energy Economics, Japan

China has implemented quite a few of policies to expedite EV deployment, aiming to lower air pollution. In China, the EVs such as hybrid and fuel cell vehicles, known as new-energy vehicles (NEVs), are categorized as a strategic emerging industry and the government officially announced a boost of technological innovations in the manufacturing of NEVs and promotion of the NEV use.[70] Accordingly, the government set favorable policies to subsidize the production and purchase of the NEVs helped the NEV industry and deployment grow rapidly especially in 2015.[71]

In September 2015, China issued policy direction to strengthen battery charging networks and infrastructure because a lack of infrastructure was considered to be a

[70] China Daily (2015), 'Central govt gives a jolt to new-energy auto industry,' November 9, 2015.
[71] The favorable measures for consumers included not only subsidies but also exemption of taxes and other fees, and provision of free license plates for the EVs in some cities.

barrier to meet the target of 5 million NEVs by the end of 2020.[72] Then, in the following month, China announced that they would build 12,000 EV charging stations and 4.8 million charging points by 2020. Furthermore, in February 2016, China revealed a change of the strategy from dependence on subsidies to a focus on battery technology development. In other words, the government will shift funds from supporting NEV production to rewarding companies that produce new technologies and hit sales targets.[73] For reference, electricity is estimated to replace diesel use by about 32.5 million tons in 2020 and 40 million tons in 2030.[74]

Korea has also been actively bringing in more clean energy vehicles to reduce greenhouse gas emissions and create new business opportunities for its auto industry. With a goal of more than one million eco-friendly vehicles by 2020, the government encourages especially FCEVs to be developed, aiming to lower the price of a FCEV to around $30,000 by 2018 through gracious subsidy. About 500 hydrogen stations are planned to be set up by 2030. In March 2016, as the first fundamental step to achieve 630,000 FCEVs by 2030, the government announced that they would replace some 26,000 CNG buses with FCEVs in cooperation with Hyundai and set up hydrogen fuel stations at about 200 CNG filling stations nationwide.[75] In addition, the government intends to deregulate the hydrogen energy industry and support companies in R&D to expand the production share of major parts such as measurement sensors and hydrogen storage tanks for FCEVs from the current 40-60% to more than 80% by 2020.

Electric motorcycles may need attention for further research since they could have certain impacts on reducing oil demand in road transport for some APEC economies where motorcycles are popular such as Chinese Taipei, Indonesia, and Viet Nam. In Chinese Taipei, the primary mode of transport is a scooter and an electric scooter with swappable batteries went on sale at $4,140 in 2015.[76] The electric scooters run in a range of about 97km with two swappable batteries. Riders are able to change batteries at the manufacturer's charging stations in seconds, but it is the only way to recharge the scooters and ties the riders to the manufacturer's charging station network and

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[72] For instance, the following policies are mandated:
- Local governments shall not restrict the sales or use of NEVs.
- All newly built apartments are mandated to have parking lots with charging facilities.
- 10% of public parking lots must install charging facilities.

[73] Financial Times (2016), 'China shifts gears to drive electric car development,' February 25, 2016.

[74] Yan Ran (2014), 'Status and Prospects for China's Oil Demand and Reserve,' presented at the 8th IEEJ/CNPC Research Meeting on November 21, 2014.

[75] The Chosun Ilbo (2016), 'Korea to Get Hydrogen-Powered Buses,' March 17, 2016

[76] BBC News (2015), 'Electric scooter with swappable batteries hits market,' 18 June 2015. There are about 15 million scooters for the economy with a population of 23 million.

pricing plans.

3-3 Scenario Analysis

This section attempts to study how effective the policy measures described in the previous two sections could be in reducing oil demand. For this objective, oil demand in road transport including passenger vehicles, heavy-duty vehicles, and motorcycles is projected until 2030 and scenario analysis is applied to calculate how much it could decline as a result of fuel economy improvement and/or deployment of clean energy vehicles.

Methodology

Oil demand in road transport is projected from 2013 to 2030 under four different scenarios. The "current policy" scenario supposes that both policy measures - fuel economy standards (carbon emissions-based vehicle scheme for Singapore) and more clean energy vehicle deployment – are implemented and the targets are achieved as they are planned aforementioned. Conversely, the second "non-policy" scenario looks at situations where fuel economy and the share of clean energy vehicles would remain the same as the current level until 2030. In other words, no further policy actions would be taken to improve fuel efficiency or to introduce clean energy vehicles in the road transport sector throughout the outlook period. The third "fuel economy improvement" scenario assumes that fuel economy of passenger vehicles would be improved by 1% for all APEC member economies by 2025. Since most economies have not implemented fuel economy standards for heavy-duty vehicles, the improvement for passenger vehicles is taken into consideration. The fourth "alternative vehicle" scenario estimates oil demand in road transport when the share of clean energy vehicles including EVs and NGVs in new vehicle sales is to be expanded to 1% by 2025 for all APEC member economies. In addition, the ratio of oil import reduction evaluated in US dollars to GDP is also calculated in all scenarios.

Oil consumption in road transport is obtained by multiplying the fuel economy of the vehicles in stock, average mileage of vehicles, and the number of registered vehicles which takes the number of clean energy vehicles into account. *Asia/World Energy Outlook 2015* published by the Institute of Energy Economics, Japan, in October 2015, is the source for the number of registered vehicles and the average mileage. Fuel economy of the vehicles in stock is estimated by referring to new vehicles in the market and fuel economy of new vehicles. The number of new and decommissioned vehicles is considered based on the lifetime of vehicles in the market in order to project the registered number of passenger vehicles and trucks. The number of registered vehicles and average mileage of vehicles are assumed the same across the scenarios each year.

Result and Analysis

Table 3-5 shows the estimated oil demand in road transport in 2030 for each scenario. Differences in oil demand between each scenario and the "non-policy" scenario are also presented in the columns on the right side, which indicate how much oil consumption is saved if some measures to curb oil demand are taken.

Table 3-5 Estimated Road Oil Demand in 2030 by Scenario

unit: kb/d

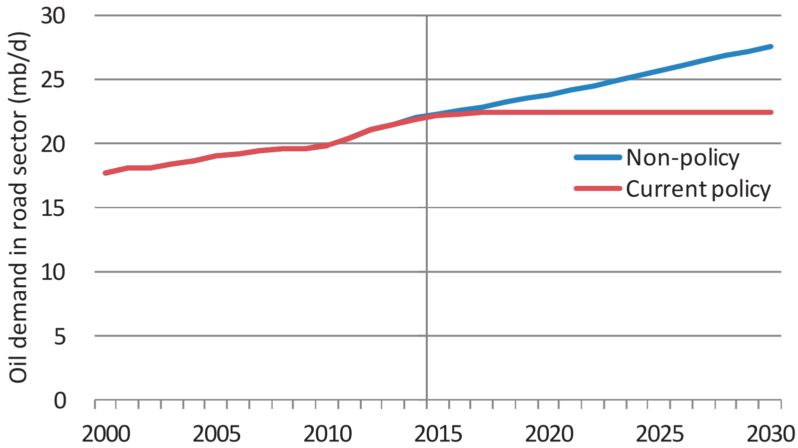
	2015	2030				Difference from Non-policy		
		Non policy	Current policy	Fuel economy improvement	Alternative vehicle	Current policy	Fuel economy improvement	Alternative vehicle
AUS	545	623	623	621	621	0	-2.6	-2.7
BD	9	11	11	11	11	0	-0.1	0.0
CDA	972	1051	880	1044	1043	-170	-6.6	-7.9
CHL	156	220	215	219	219	-5	-0.7	-1.0
CT	238	261	253	260	260	-8	-0.9	-0.9
HKC	44	53	53	53	53	0	-0.1	-0.2
INA	901	1481	1481	1478	1478	0	-3.4	-3.5
JPN	1264	1014	666	1008	1008	-348	-5.9	-6.1
MAS	416	436	436	433	432	0	-2.8	-3.8
MEX	1051	1457	1416	1452	1452	-41	-5.6	-5.8
NZ	85	96	96	96	96	0	-0.4	-0.4
PE	119	215	215	214	214	0	-0.3	-0.5
PRC	4255	7097	5497	7062	7057	-1600	-35.2	-39.7
ROK	595	625	505	623	623	-120	-2.4	-2.4
RP	160	273	273	273	273	0	-0.6	-0.5
RUS	1027	1237	1237	1231	1231	0	-5.2	-6.1
SIN	45	51	49	51	51	-2	-0.1	-0.1
THA	378	410	410	410	409	0	-0.7	-1.1
USA	9857	10637	7882	10615	10615	-2755	-21.6	-21.9
VN	221	339	339	339	339	0	-0.6	-0.6

Source: The Institute of Energy Economics, Japan

In the "current policy" scenario, oil demand in road transport is likely to decline most among the scenarios. Figure 3-11 illustrates projections of the oil demand in road transport by 2030 under the "current policy" scenario and "non-policy" scenario for the APEC region. The "non-policy" scenario indicates that the oil demand in road transport is projected to grow at 1.5% annually, increasing from 21.4 million barrel per day (b/d) in 2013 to 27.5 million b/d in 2030. Meanwhile, if current policies are all carried out as planned, the APEC's oil demand in road transport is expected to increase by merely 1.0

million b/d from the 2013 level to 22.5 million b/d in 2030 with an average annual growth rate of 0.3%. The difference between the two scenarios is likely to be expanded to roughly 5.0 million b/d in 2030, that is, a 22.4% reduction is observed in the "current policy" scenario compared with the "non-policy" scenario. In the "current policy" scenario, significant reductions in oil demand are found in the APEC member economies that have announced a target to achieve higher fuel economy standards and to increase clean energy vehicles with a specific market penetration goal.

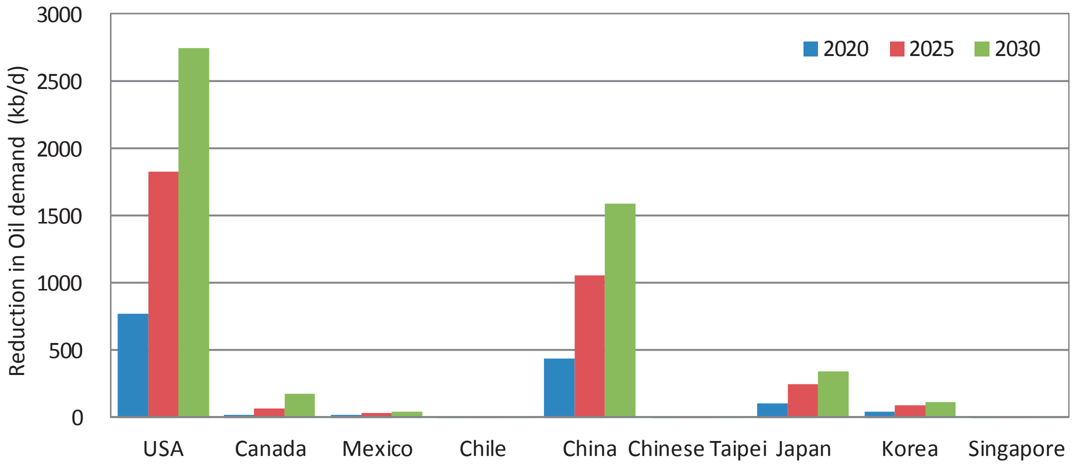
Figure 3-11 Difference in Road Oil Demand between Current and Non-Policy Scenarios



Source: The Institute of Energy Economics, Japan

Under the "current policy" scenario, the United States is expected to have the biggest oil demand reductions during the outlook period, followed by China, Japan, Canada and Korea (Figure 3-12). What can be deduced from this figure is that the larger the auto market the economy has, the more effective the policies to save oil use are expected to be. In terms of relative improvement, however, Japan is likely to see the highest improvement of 52.2% in the "current policy" scenario compared with the "non-policy" scenario, followed by the United States (35.0%), China (29.1%), Korea (23.8%), and Canada (19.4%). The average annual growth rate of oil demand in road transport between 2015 to 2030 is negative for the United States (-1.5%), Canada (-0.7%), Japan (-4.2%), and Korea (-1.1%), which indicates that the road oil demand of those four economies in 2030 would decrease from the 2015 level. China's road oil demand is likely to increase until 2030, but the full implementation of the planned measures would lower the growth rate to 1.7% from 3.5% of the "non-policy" scenario. Reduced oil demand is also observed for the remaining economies in the figure although it is not as substantial as the economies with larger auto markets.

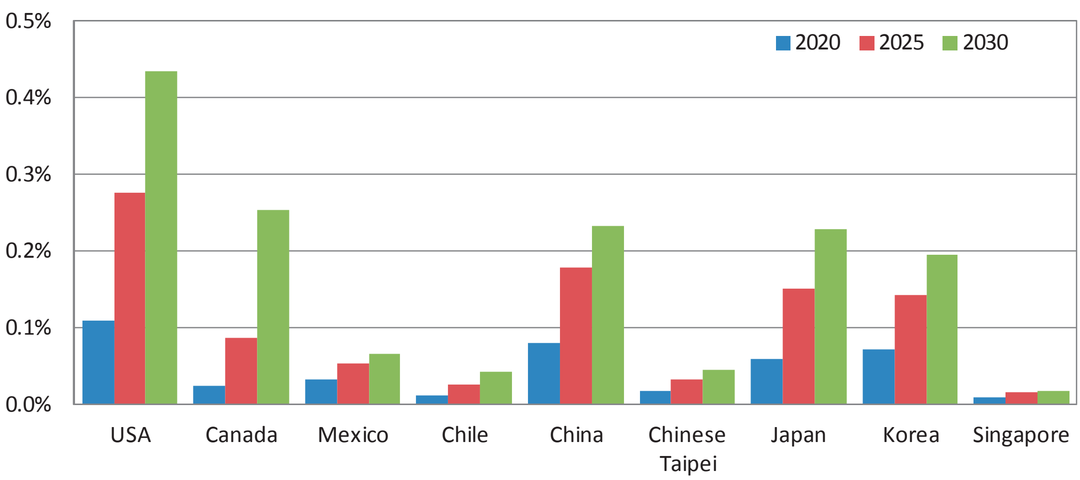
Figure 3-12 Oil Demand Reduction in the "Current Policy" Scenario Compared to the "Non-Policy Scenario"



Source: The Institute of Energy Economics, Japan

While the oil demand reductions of the United States and China stand out, the measures taken in Canada, Japan, and Korea also seem to be effective when they are evaluated in regards to decreases in expenditure of oil imported relative to GDP (Figure 3-13). If an economy is an oil importer, oil demand reduction would help oil import decline, which would consequently lower expenditure of imported oil. As oil demand in road transport is saved towards 2030, the ratio of imported oil reductions relative to GDP is expected to increase. Canada, Japan, and Korea are likely to see around 0.2% of savings relative to GDP in 2030 under the "current policy" scenario although that of the United States would be higher than 0.4%.

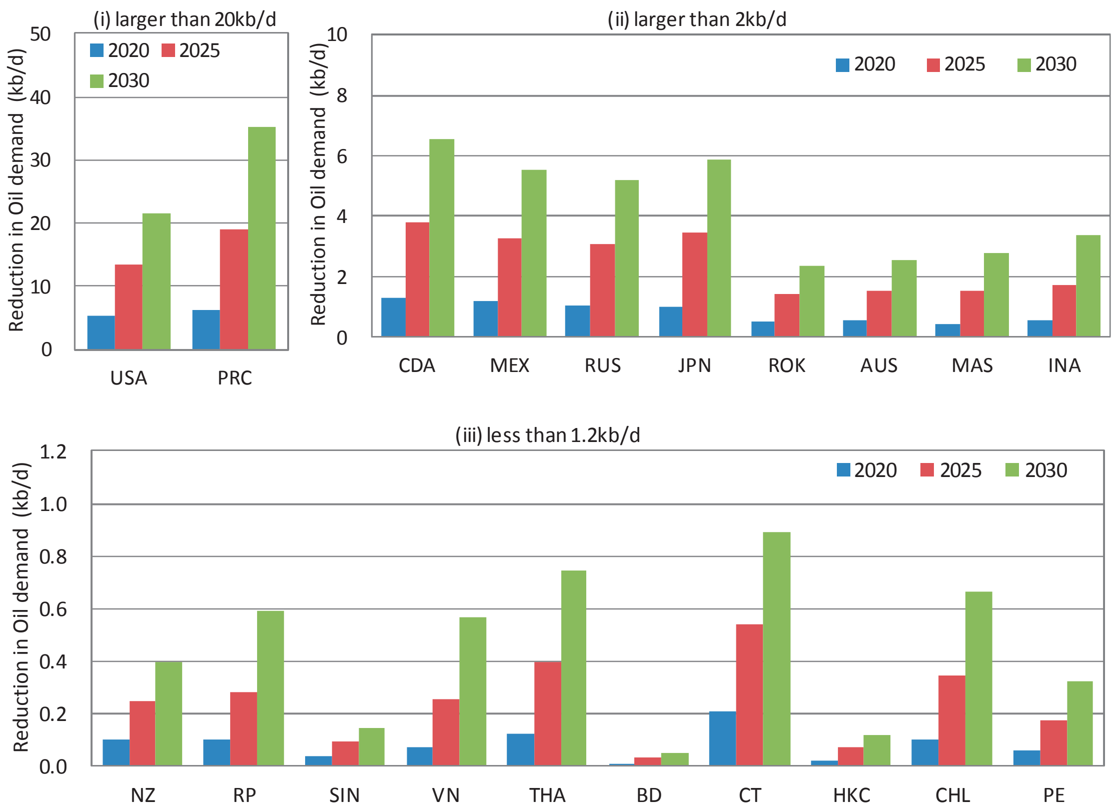
Figure 3-13 Oil Import Reduction in the "Current Policy" Scenario Relative to GDP



Source: The Institute of Energy Economics, Japan

Figure 3-14 illustrates the "fuel economy improvement" scenario which assumes 1% improvement of fuel economy of new passenger vehicles towards 2025. The figure consists of three groups, depending on the degree of oil demand reduced in 2030; (i) economies with oil demand reductions larger than 20 thousand b/d, (ii) that of economies with larger than 2 thousand b/d, and (iii) that of economies with less than 1.2 thousand b/d. While the United States and China will be the biggest two economies to have substantial oil demand reductions, China is likely to curb oil demand use in road transport more than the United States under this scenario. For the second group, in addition to Canada, Japan, and Korea, the other economies such as Mexico, Russia, Australia, Malaysia, and Indonesia are expected to achieve considerable decreases in oil demand in 2030. For the third group, in spite of the small declines in absolute value, the saved amount of oil is certainly expected to go up if fuel economy improves by 1%. The economies where public transport systems have been developed extensively such as Singapore and Hong Kong, China, may see limited drops in oil demand of road transport.

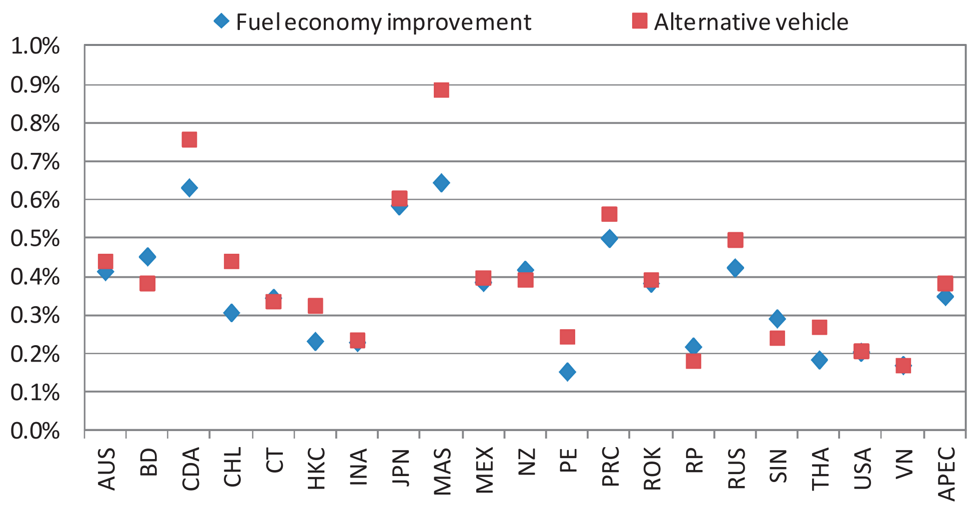
Figure 3-14 Oil Demand Reduction in the "Fuel Economy Improvement" Scenario Compared to the "Non-Policy Scenario"



Source: The Institute of Energy Economics, Japan

The oil demand trend towards 2030 is unlikely to result in significant differences between the "fuel economy improvement" scenario and the "alternative vehicle" scenario for each economy. Figure 3-15 plots a percentage change of oil demand reductions of the two scenarios in comparison to the "non-policy" scenario in 2030. For both scenarios, road oil demand in 2030 is estimated to decline by less than 1% for all member economies and about 0.4% for the APEC region compared to the "non-policy" scenario. Such decreasing rates are scattered for each economy partially due to differences in prospects for the number of vehicles and the current situations in terms of fuel economy and the number of clean energy vehicles in stock. Although it is difficult to conclude which scenario is most effective, this outcome implies that the measure assumed in both scenarios would work effectively to a similar extent.

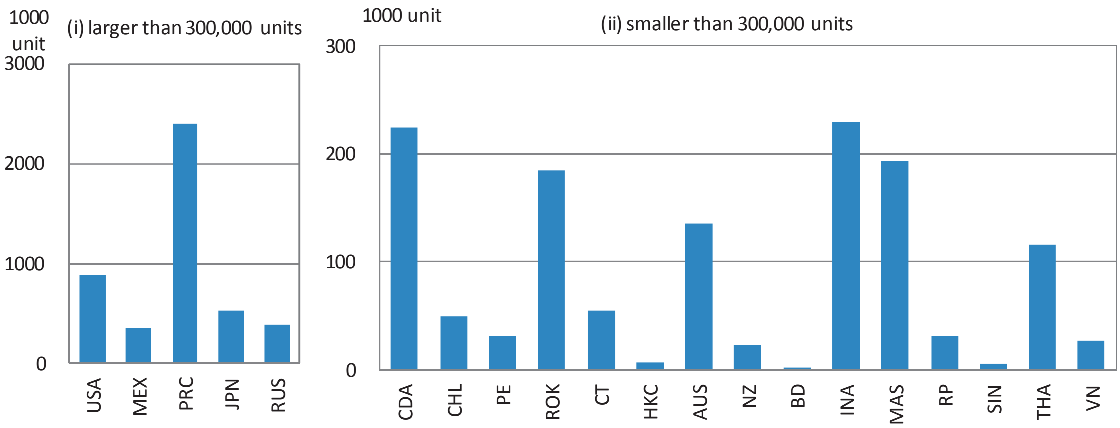
Figure 3-15 Relative Oil Demand Reduction of the "Fuel Economy Improvement" Scenario and the "Alternative Vehicle" Scenario Compared to the "Non-Policy" Scenario



Source: The Institute of Energy Economics, Japan

Nevertheless, clean energy vehicles are still facing various barriers to becoming affordable and available for consumers. Unless a technological breakthrough to lower costs happens or a government commitment to facilitate penetration of clean energy vehicles in the market is continuously provided, clean energy vehicles will remain beyond the reach of most of the public in the medium-term. Figure 3-16 demonstrates incremental growth in the number of the clean energy vehicles in stock in the "alternative vehicle" scenario compared to the "non-policy" scenario. Since this is in proportion to the prospects for the number of new vehicle sales of each economy, an economy with a higher number of new vehicle sales tends to have greater increased number of clean energy vehicles in stock in the future regardless of the current situations. Accordingly, it does not seem reasonable to think that the economies where the clean energy vehicles make up the very marginal or no share of the market at present will achieve such considerable growth in 15 years. For this reason, the "fuel economy improvement" scenario appears to be more practical to consider. A policy of setting up certain fuel economy standards for vehicles to be sold in the domestic market would play a critical role to curb oil demand in road transport until the clean energy vehicles overcome the obstacles ahead.

Figure 3-16 Incremental Growth of Clean Energy Vehicles in Stock in the "Alternative Vehicle" Scenario Compared to the "Non-Policy Scenario"



Source: The Institute of Energy Economics, Japan

Chapter 4 Biofuel Use in Transport Sector

4-1 Overview of Biofuel Use

Biofuels are produced from organic materials, known as biomass, through agricultural or anaerobic design rather than traditional geological processes. The recent interest in biofuels is driven by three key global challenges: energy security, economic development and the mitigation of climate change. Many economies see it as a way to reduce dependency on foreign oil which has been going through massive price fluctuations in recent years. Biofuel production provides new markets for farmers and is seen as a way to create more jobs, particularly in economies with a strong agricultural base. They may also produce less greenhouse gas emissions than fossil fuels, although many experts argue this may not be the case. First generation biofuels are made from sugars and vegetable oils found in arable crops. Biomasses include plant material, food service by-products, animal and industrial wastes. Bioethanol and biodiesel are the most commonly used liquid biofuels for transportation. Both products can be used in their pure forms or blended with gasoline and petroleum.

Bioethanol is a type of alcohol that is made from the fermentation of carbohydrates found in sugar and starch. Common feedstocks which have high amounts of these include sugarcane, maize, wheat and corn. As such, the costs of production are very sensitive to feedstock prices. Bioethanol can be used as fuel for vehicles and is often blended with gasoline to create an ethanol blended fuel. These are referred to using an "E", followed by a number that represents the percentage of ethanol added to the gasoline (e.g.: E10 contains 10% ethanol and 90% gasoline). Many vehicles are able to run on blended gasoline although some engines may not be compatible with it. Today, the United States and Brazil are the top producers and consumers of ethanol fuel.

Biodiesel is generally produced from vegetable or animal fat combined with an alcohol which can then be mixed with regular diesel. Common feedstocks include palm, coconut, rapeseed, jatropha and used cooking oils. The feedstock goes through a chemical reaction with alcohol, known as transesterification, and is broken down into glycerin and methyl esters. Blended biodiesel follows the same naming convention as ethanol but is represented with a "B" (e.g.: B20 contains 20% biodiesel and 80% petroleum diesel). Production and consumption is highest in the European Union where there are currently 120 plants producing 6.1 million tons annually.

Prices for biofuels are driven by fossil fuel prices and government support schemes.

In general, biofuel prices cannot remain competitive without subsidies because of the large amounts of infrastructure, research and development costs involved. The main drivers for government support are climate change, energy security, generating employment opportunities and protecting the domestic agricultural markets. Many economies have implemented mandatory blending rates, subsidies, tax incentives, grants and tariffs.

Due to the fact that bioethanol can be produced from agricultural feedstocks, there are growing concerns about increased food prices, supply and land usage. To help alleviate these issues, more research in second generation and advanced biofuels has been taking place in recent years. These biofuels attempt to convert cellulose, hemicellulose and lignin into liquid fuel. Feedstocks consist of residual non-food parts of crops, such as stems and husks, as well as industry wastes such as wood chips. It is extremely difficult to extract fuel from these feedstock compared to traditional sources as it requires more treatments and processes. Algae can also be converted into biodiesel by extracting its lipids while the carbohydrate contents can be fermented into bioethanol. Algae grows much faster than food crops, does not require fresh water resources, is biodegradable and can be grown in open ponds or land unsuitable for agriculture.

4-2 Biofuel Policy in the APEC Region

This section gives a brief summary of each economy's biofuel policy with a focus on the transport sector and biofuel blending targets. It will also examine how economies meet road transportation demand through production, imports and exports.

4-2-1 Australia

Policy overview

Australia's energy policy framework was developed with the aim of providing accessible, competitively priced and sustainable energy to consumers while increasing export potential. These policies will be regularly reviewed every 4 years beginning in 2016 to ensure the framework remains relevant in light of new technologies, trends and market changes. Domestic biodiesel production taxes will increase each year by 6.554%, reaching 32.77% in July 2020.[77] Tax credits are provided for petrol, biodiesel, ethanol

[77] Roger Farrell (2015), Australia Biofuels Annual. USDA Foreign Agricultural Service, Global Agricultural Information Network,

and other fuels. These credit rates are reviewed twice a year.

The federal government has limited ethanol blending to a maximum of 10%, with the exception of concentrations above 85%.[78] E10 ethanol is the most common biofuel although there is currently no federal-level mandate in Australia. Instead, some states have implemented their own mandatory blend rates. For example, in October 2008, the New South Wales government required wholesale companies and retailers with more than 20 outlets to sell 2% ethanol blended petrol. The current blend mandate has grown to 6% and the government hopes to further increase this in the near future. A biodiesel blending mandate of 2% has been in place since January 2010.

Target

Biodiesel has the potential to become a mainstream fuel within Australia's heavy-duty vehicle sector, potentially capturing 76% of this market by 2050.[79] It is estimated that biofuels will account for approximately 20% (including bio jet fuel) of total transport fuel by 2050.[80] In Queensland, the government will initiate a 2% bioethanol mandate in July 2016 as part of a 10 year roadmap. An E3 mandate will then be introduced in 2017, increasing to E4 after an additional 18 months.[81] A 0.5% biodiesel mandate will begin in 2017 and increase to 2% in 2019. In addition to these blend targets, technology, investments and research are all a core part of Queensland's goals.

Feedstock and Biofuel Use

In Australia, ethanol feedstocks include waste starch, red sorghum and molasses (a byproduct of refining sugarcane or sugar beets into sugar). Bioethanol is easily accessible for consumers, with over 600 service stations offering E10 blends across the country. Domestic biodiesel is predominantly produced from tallow and used cooking oil,

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http://gain.fas.usda.gov/Recent%20GAIN%20Publications/Biofuels%20Annual_Canberra_Australia_8-3-2015.pdf

78 Biofuels Association of Australia (2015), *Ethanol in Australia,* http://biofuelsassociation.com.au/biofuels/ethanol/ethanol-in-australia/

79 Commonwealth of Australia (2011), Strong growth, low pollution: *Modelling A Carbon Price.* Treasury, Ministerial and Communications Division, http://carbonpricemodelling.treasury.gov.au/content/report/downloads/Modelling_Report_Consolidated_update.pdf

80 Commonwealth of Australia (2012), Energy White Paper, *Australia's energy transformation* Department of Resources, Energy and Tourism, http://www.aip.com.au/pdf/Energy_%20White_Paper_2012.pdf

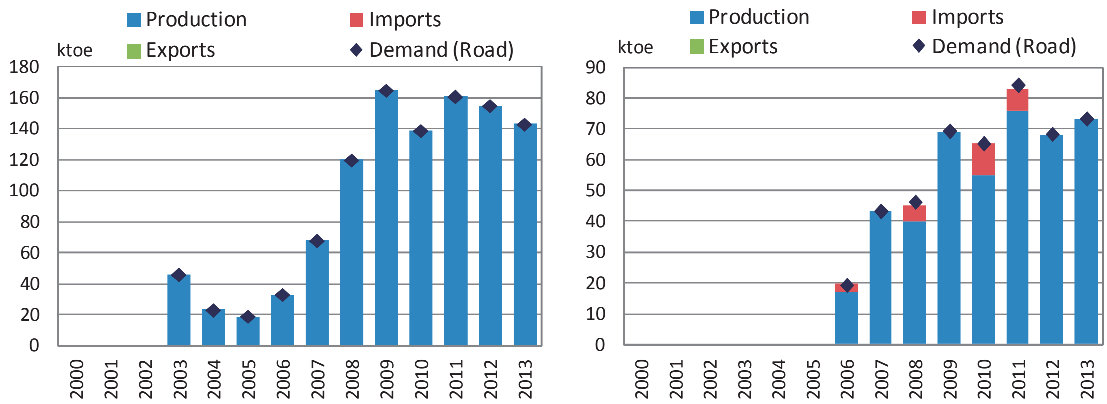
81 Biofuels Association of Australia (2015), *Re: Towards a clean energy economy: achieving a biofuel mandate for Queensland – Discussion Paper*, https://www.dews.qld.gov.au/__data/assets/pdf_file/0012/299865/biofuels-association-australia-biofuel-submission.pdf

although small amounts of canola and poppy seed oil are also used. Higher B20 blends are only available for fleet users and they must contact the Biofuels Association of America (BAA) in order to obtain it.[82]

Road demand for bioethanol and biodiesel has been increasing in Australia. Australia is self-sufficient in meeting bioethanol demand while some biodiesel must be imported. Imports are mainly from Singapore and Indonesia, with small amounts from Argentina and Canada.[83]

Figure 4-1 Biofuel Demand-Supply Balance in Australia

Bioethanol Biodiesel



Source: IEA (2015). *Energy Balance of OECD Countries 2015*

4-2-2 Canada

Policy Overview

In Canada, energy policy is a joint responsibility of federal and provincial governments and is regulated by both levels of government. In July 2007, the federal government announced the ecoENERGY for Biofuels Initiative which invests up to CAN$1.5 billion over 9 years to promote biofuel production.[84] The initiative offers incentives to producers of renewable alternatives to gasoline and diesel. The ecoEnergy

[82] Biofuels Association of Australia (2015), *Biodiesel Blends,* http://biofuelsassociation.com.au/biofuels/biodiesel/oems-and-approved-blends/
[83] Roger Farrell (2015), Australia Biofuels Annual. USDA Foreign Agricultural Service, Global Agricultural Information Network, http://gain.fas.usda.gov/Recent%20GAIN%20Publications/Biofuels%20Annual_Canberra_Australia_8-3-2015.pdf
[84] NRC (Natural Resources Canada) (2015), website ‘ecoENERGY for Biofuels Program’ page, http://www.nrcan.gc.ca/energy/alternative-fuels/programs/12358

incentive rates for ethanol and biodiesel production for fiscal year 2016/2017 are CAN$0.03/liter and CAN$0.04/liter respectively. Incentive rates are reduced each year and this program is scheduled to end in March 2017.

Target

The Renewable Fuel Regulations that took effect in December 2010 requires fuel producers and importers to have an average blend of least 5% in gasoline and at least 2% in diesel fuel. In addition, five provinces have set their own mandates as seen in the table below.

Table 4-1 Canadian Provincial Blend Mandates

Province	Ethanol Blend for Gasoline	Renewable Fuel Blend for Diesel
British Columbia	5%	4%
Alberta	5%	2%
Saskatchewan	7.5%	2%
Manitoba	8.5%	2%
Ontario	5%	2%, 3% in 2016, 4% in 2017

Source: USDA Global Agriculture Information Network (GAIN) Report (2015). *Canada Biofuels Annual 2015*.

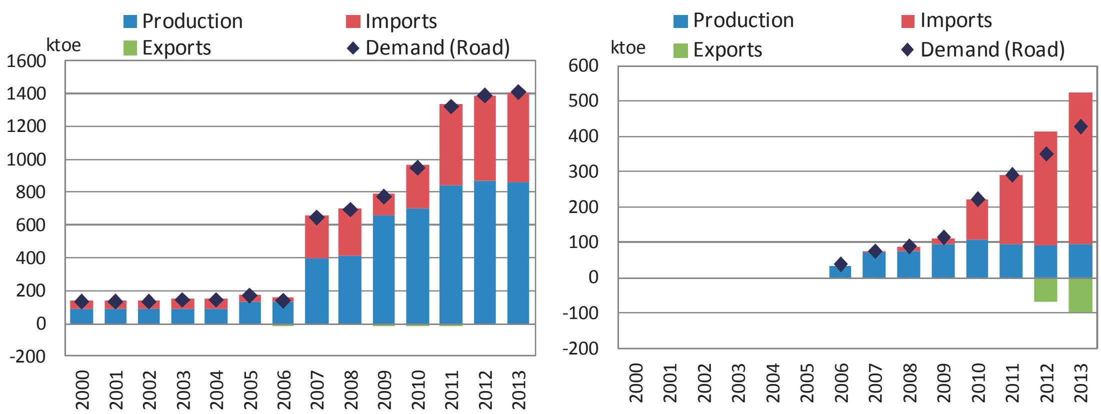
Feedstock and Biofuel Use

In Canada, the main feedstocks for bioethanol production are corn and wheat, depending on the availability of these products. Other commonly used feedstock include waste starch, red sorghum and molasses (a byproduct of refining sugarcane or sugar beets into sugar). There are several kinds of feedstock to produce biodiesel in Canada. Today, canola accounts for more than half of the feedstock used followed by recycled oils and animal fats.

With government initiatives to promote biofuel use in place, demand for biofuels surpasses domestic production rates. Biofuel blending mandates cannot be met because of a lack of sufficient production capacity. As a result, Canada imports biofuels from the United States. In spite of being a net importer of biodiesel, Canada continues to exports biodiesel to the United States because of the biodiesel blender tax credit and Renewable Identification Numbers (RINs). In the United States, companies that blend biodiesel to meet Renewable Fuel Standard requirements can reduce their tax liability by USD$1/gallon of biodiesel blended into diesel. The blenders share a portion of the credit with suppliers through contractual arrangements. Biodiesel produced from Canadian feedstock are one of the few types approved for commercial sale in the United States biodiesel markets. For these reasons, Canadian producers are incentivized to ship biodiesel out to the United States while receiving cheaper imports.

Figure 4-2 Biofuel Demand-Supply Balance in Canada

Bioethanol Biodiesel



Source: IEA (2014). *Energy Balance of OECD Countries 2015*

4-2-3 Chinese Taipei

Policy overview

Chinese Taipei has very limited domestic energy resources and relies heavily on imports to satisfy its energy demand. Total energy import dependence was approximately 98% in 2014.[85] In response, the Taipei City Government plans to increase energy independence by using renewable energy. All biofuel producers are required to register with government authorities under the Petroleum Administration Act. Overall, there is limited information within Chinese Taipei legislation regarding specific biofuel production targets and blends.

Target

The Taipei City Government implemented a B1 biodiesel mandate in 2008 which was subsequently increased to B2 in 2010. However, the B2 blend rate and production goals have been temporarily suspended for policy review. Consumers complained that the use of biodiesel in Taiwan's humid climate caused clogged fuel tanks. The Bureau of Energy responded to these safety concerns by ordering the state-owned energy

[85] EIA (U.S. Energy Information Administration) (2015), website 'Taiwan' page, https://www.eia.gov/beta/international/country.cfm?iso=TWN

enterprise, CPC Corporation, to phase out B2 over a 3 month period in 2014.[86]

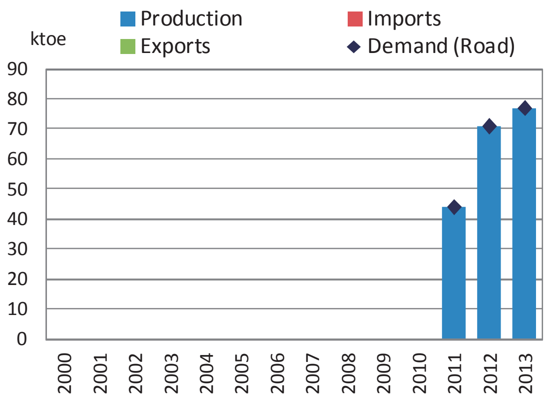
It is still unclear if biodiesel mandates will be implemented in the future. Had the B2 blend implementation been successful, a blend of B5 would have been introduced in 2015. Despite these issues, the Taipei City Government is currently considering reintroducing an E3 ethanol mandate. An E3 Gasohol Program is currently being tested in select Taipei and Kaohsiung cities.

Feedstock and Biofuel Use

In order to avoid competing with existing food crops on arable land, Chinese Taipei focuses primarily on cellulosic feedstock for biodiesel. According to the Waste Disposal Act, kitchen wastes from households and non-enterprise street venders can be used for approved purposes such as biodiesel production. Approximately 26,000 tons of waste cooking oil was recycled in the first half of 2015, of which 16,000 tons were converted locally into biodiesel.[87] All remaining waste cooking oil is exported to other countries, most commonly Korea.

Figure 4-3 Biofuel Demand-Supply Balance in Chinese Taipei

Bioethanol



Source: IEA (2015). *Energy Balance of Non-OECD Countries 2015*

The feedstock for bioethanol is primarily sugar cane but also includes beets, cassava manioc and eucalyptus. There has been ongoing research to find alternative feedstocks. Several offshore and freshwater fuel farms have been built to research giant

[86] The China Post (2012), 'CPC to phase out biodiesel over the next three months', 7 May 2014, http://www.chinapost.com.tw/taiwan/national/national-news/2014/05/07/407134/CPC-to.htm
[87] Taipei Times (2015). 'EPA touts biodiesel made from recycled cooking oil', 8 July 2015, http://www.taipeitimes.com/News/taiwan/archives/2015/07/08/2003622544

algae, California brown kelp, and water hyacinth.

No data for biodiesel production was found with IEA, however EIA data shows that biodiesel production began in 2007, peaking at 1000b/d in 2011 and averaging 517b/d from 2007-2012.[88] Bioethanol began production in 2009-2010 which may not have been shown in Figure 4-3 because production levels were only 100b/d. EIA data also suggests that in response to blending mandates, small amounts of biofuels may have been imported to meet consumption demands.

4-2-4 Hong Kong, China

Policy overview

Hong Kong, China is a land-scarce society with a very high population density and no indigenous source of energy. In recent years, air pollution has become a serious problem. The government endorsed the Air Quality Objectives in 2014 and also partnered with the Guangdong Province of China in setting emission reduction goals for 2020. Overall, biofuels are not a big part of Hong Kong, China's low-carbon and air quality goals. Instead, the focus is on fuel efficient cars, public transportation and reducing traffic congestion.

Biodiesels in Hong Kong, China have a labelling requirement for blends above 5% and must undergo quality tests under the Motor Vehicle Biodiesel Specifications Cap 311L legislation. To promote the use of biodiesel in transportation, pure biodiesel is duty free[89]. There are currently no policies or widespread use of bioethanol in Hong Kong, China.

Targets

The government aims to reduce its carbon footprint by 50-60% in 2020 compared to 2005.[90] However, biofuel adoption is purely on a voluntary basis because no specific regulatory provisions or targets have been set. A pilot scheme was implemented in 2012 where a 5% biodiesel blend was used in select government vehicles and vessels. Since

[88] EIA (U.S. Energy Information Administration) (2015), website 'Taiwan' page, https://www.eia.gov/beta/international/country.cfm?iso=TWN

[89] Government of Hong Kong Special Administrative Region (2015), *Use of Biodiesel in Motor Vehicles* Environmental Protection Department, http://www.epd.gov.hk/epd/english/environmentinhk/air/prob_solutions/use_biodiesel_motor_vehicles.html

[90] Government of Hong Kong Special Administrative Region (2015), *Climate Change*, GovHK http://www.gov.hk/en/residents/environment/global/climate.htm

then, an increasing number of state departments have been using biodiesel on a trial basis, including the Police Department, Airport Authority and more. The Hong Kong Government has also been aiming to reduce the number of diesel powered vehicles and promote liquefied natural gas (LNG) vehicles instead.

Biofuel Use and Feedstock

Commercially, biodiesel is produced using vegetable oil as feedstock, but because of its high costs there has been a shift towards utilizing non-edible plant oils and waste cooking oil. There are currently 3 local biodiesel production plants, one of which is ASB Biodiesel. The ASB Biodiesel plant opened at the end of 2013, during which 20% of its waste oil was collected domestically and the rest was imported from Singapore and Malaysia.[91] The company is hoping to source 45% of its oil feedstock domestically in the future. Due to low domestic demand, most production is exported to Europe.[92] The company is hopeful that by 2016/17, most of its biodiesel will be consumed locally.

The reason for the low biodiesel demand in Hong Kong, China is the lack of blending mandates, compatible distribution pumps and higher cost compared to normal petroleum diesel. In addition, not all vehicles are able to run on biodiesel blends. Another barrier is that producers must bid for used cooking oil against Chinese buyers. Unable to compete, producers have resorted to illegally reprocessed cooking oil known as "gutter oil" for its dangerous health effects. Many "gutter oil" scandals have arisen in China, Chinese Taipei and Hong Kong, China and the government has responded by proposing stricter regulations on edible fats and oil. Today, only registered collectors are allowed to collect it.

IEA data suggests that negligible amounts of bioethanol was consumed or produced in Hong Kong, China.

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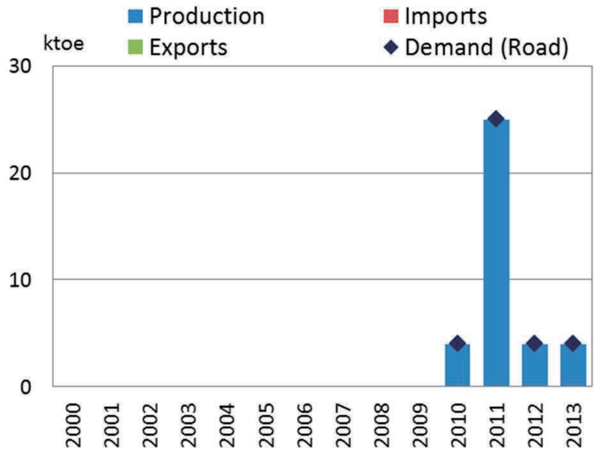
[91] Bloomberg Business (2013), 'ASB Biodiesel Opens Waste Oil Plant to Supply Hong Kong Drivers', 23 October 2013, http://www.bloomberg.com/news/articles/2013-10-23/asb-biodiesel-opens-waste-oil-plant-to-supply-hong-kong-drivers

[92] HKTDC (Hong Kong Trade Development Council) (2014), website 'The Good Oil' page, http://hkmb.hktdc.com/en/1X09WJ3C/venture-hong-kong/The-Good-Oil

Figure 4-4 Biofuel Demand-Supply Balance in Hong Kong, China

Biodiesel



Source: IEA (2015). *Energy Balance of Non-OECD Countries 2015*

4-2-5 Indonesia

Policy Overview

Indonesia's biofuel development has 3 primary goals: alleviate unemployment, bolster economic activity and reduce domestic fossil fuel consumption. The government has taken a very proactive approach in implementing various subsidy programs, pricing formulas and support schemes to encourage biofuel use. Overall, Indonesia has no regulation on biofuel itself but has several policies on biodiesel feedstock (palm oil).

In response to the drop in crude oil prices, they revised their pricing scheme in March 2015 to encourage more biodiesel consumption. To protect the domestic market, the New Plantation Fund was created, managed by Crude Palm Oil (CPO). Through this funding mechanism, a levy on palm oil exports was implemented in order to provide stable funding for biofuel subsidies. Since July 2015, a USD$50/ton tax has been levied on palm oil exports and USD$30/ton on processed palm oil products, including biodiesel.[93] With these export levies, the annual take could reach USD$711 million. Half of the income from taxes on palm oil exports is used for subsidizing the price of biodiesel, allowing it to be priced at comparable levels to regular diesel. The remainder goes towards supporting farmers through investments in research, replanting and human resources development. However, this export tax may be dropped and subsidy

[93] Thom Wright and Arif Rahmanulloh (2015), Indonesia Biofuels Annual. USDA Foreign Agricultural Service, Global Agricultural Information Network

schemes are currently being reviewed.

The Indonesian bioethanol program ended in 2010 as the domestic ethanol market never fully developed due to insufficient pricing schemes. The government has recently set new bioethanol targets with the hopes of obtaining increased energy diversity.

Target

The Biofuel Blending Mandate sets annual blend and production targets leading up to the final goal of a 25% blend in 2020. The most recent changes took place in March 2015 where the biodiesel blend rate increased from 10% to 15% in transportation and industry. The Ministry of Energy has a goal of consuming 3.5 million tons of biofuel in 2016 which is double the 1.7 million tons produced in 2014. Blending targets in Indonesia have historically been set too high. In reality, blending has been significantly below target levels due to supply shortages, infrastructure weakness and funding shortfalls. Biofuel subsidies have not been provided for the majority of 2015 due to ongoing revisions to reference prices. An additional challenge is that due to Indonesia's geographical landscape, it is difficult to distribute biodiesel to outlying islands.

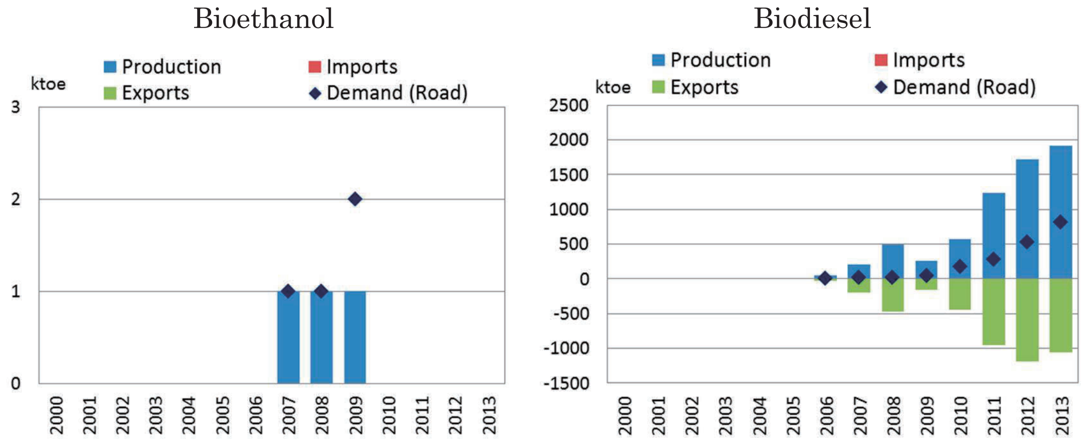
While it is unlikely that these targets will be met, the overall outlook for 2016 is much more positive than in previous years. Multiple blending facilities, storage tanks and other related infrastructure have recently been completed. With the establishment of the New Plantation Fund, a steady funding stream should be able to ensure more competitive biodiesel prices. The government is hopeful that the B15 biodiesel blend will be readily available in major population centres by 2018.

Through Regulation 12/2015, the Indonesian government aims to obtain a 20% minimum bioethanol production within transportation. To meet this goal, subsidies for bioethanol used in transportation are provided. There are no requirements for ethanol blending and it is unlikely that it will be implemented due to the focus on biodiesel and lack of infrastructure.

Feedstock and Biofuel Use

Indonesia is a major producer of palm oil and it comes as no surprise that it is the main feedstock for biodiesel refinery. This economy exports a large amount of biodiesel, although the country has recently shifted its focus to domestic consumption. The economy's biodiesel production has been steadily increasing since 2006 although a drop in production was observed in 2009-2010 due to adverse weather conditions.[94] Overall, they are self-sufficient and output is expected to continue growing in the future. The EIA predicts that biodiesel consumption will increase to 2.7 billion litres in 2016, while the Indonesian Biofuel Producers Association predicts biodiesel use of 7.9 billion litres.[95]

Figure 4-5 Biofuel Demand-Supply Balance in Indonesia



Source: IEA (2015). *Energy Balance of Non-OECD Countries 2015*

Molasses is the main feedstock for Indonesian bioethanol. Molasses is relatively expensive because it is commonly used as animal feed and chemical feedstock. The cancelled bioethanol program caused production and consumption to drop in 2010. Very small amounts of bioethanol are still being produced today. However, it is only for industrial purposes and is therefore not reflected in Figure 4-5 above. This bioethanol is mostly exported to Japan and the Philippines. It is unlikely that there will be any changes in the fuel ethanol market, demand or policy in the foreseeable future.

4-2-6 Japan

Policy Overview

Due to Japan's limited land space and low energy self-sufficiency, the economy has been actively pursuing a more diversified energy portfolio with several initiatives towards renewable energy. However, the main focus is on heat and power generation rather than biofuels for transportation.

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94 MPOC (Malaysia Palm Oil Council) (2012), website 'Weather Effects on Palm Oil Production: Supply Outlook 2012/2013; page, http://www.mpoc.org.my/upload/P5_LingAhHong_POTSKL2012.pdf

95 Sungate Analytics (2015), 'Global Biodiesel Consumption in 2016', 1 December 2015, http://www.sungate-analytics.com/blog/2015/11/24/global-biodiesel-consumption

The Japanese biofuel industry began growing in 2008 when the Law to Promote the Usage of Biomass introduced tax breaks and financial assistance to encourage the use of bioethanol. That same year, the Quality Control of Gasoline and Other Fuels Act was amended to provide tax incentives for fuel containing 3% bioethanol. Then, in 2010 the Sophisticated Methods of Energy Supply Structure Act was implemented with the aim of increasing the biofuel consumption. The most recent change occurred in the 2014 Temporary Measures Concerning Customs Act where gasoline imports derived from biomass became tariff free until March 31, 2018. Biofuel quality is regulated through Japan's Sustainability Standard which requires bioethanol to have a CO_2 Life Cycle at least 50% below that of gasoline.[96]

Target

Under the 2010 Sophisticated Methods of Energy Supply Structure Act, Japan aims to introduce 500 million liters of biofuels to Japan by 2017. Ethanol is currently only available in a few prefectures, but Ethyl Tertiary Butyl Ether (ETBE) blended bio-gasoline is available throughout Japan. The Petroleum Association of Japan is planning to supply 1,940 million liters of ETBE by 2017. Of this amount, 1,800 million liters are to be imported from the United States.

Feedstock and Biofuel Use

The direct blend rate for ethanol is 3%, while the ETBE blend rate is at 7%. The Gasoline Quality Assurance Law was revised in 2012 allowing the sale of 10% direct blends and 22% ETBE. Japan is not self-sufficient and requires imports to meet its biofuel demands. At this time, Brazil is their sole supplier of bioethanol feedstock because their sugarcane ethanol was the only blend able to meet the CO_2 Life Cycle Sustainability Standard requirements. Widespread biofuel adoption is challenging because distribution channels for ethanol blended gasoline are only available in a few prefectures. To counter this, the government is investing in fuel station and feedstock collection infrastructure.

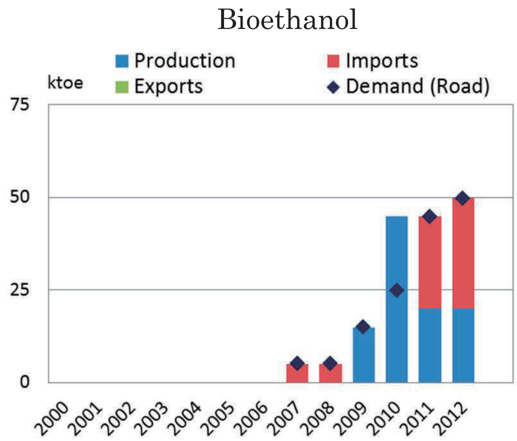
The feedstock for biodiesel is primarily used cooking oil and the blend rate is currently at 5%. Some municipal governments and regional non-profit organizations have been conducting small scale tests with rapeseed as feedstock. Biodiesel is mostly used to generate power and the majority is imported from Malaysia where there is no

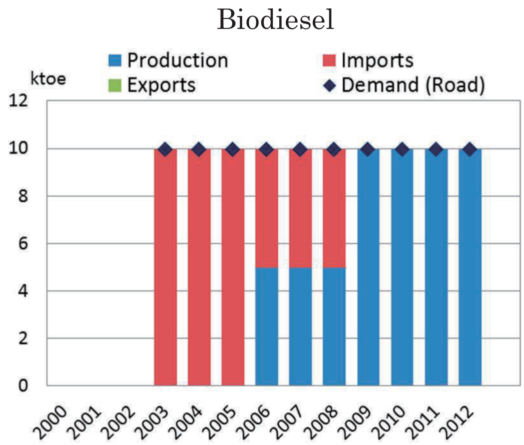
[96] Midori Iijima (2015), Japan Biofuels Annual. USDA Foreign Agricultural Service, Global Agricultural Information Network

import tariff. Consumption of biodiesel in transportation is very low and is not expected to increase.

Japan has low food self-sufficiency and is sensitive to issues concerning rising food prices. To counter this, there has been greater emphasis on the research and development of cellulosic biofuels. A private company in Osaka has been making ethanol from wood and lumber feedstock since 2007. Approximately 94% of these wood pellets are imported from Canada and they are primarily used for thermal power. In 2010, a joint research project was initiated to investigate the use of algae as feedstock for transportation diesel. They hope to be able to commercialize this technology by 2020 and meet 10-20% of the domestic demand for diesel. Jet fuel derived from algae is also being researched.

Figure 4-6 Biofuel Demand-Supply Balance in Japan





Source: EIA International Energy Statistics (2015)

4-2-7 Korea

Policy Overview

In 2007, the government turned its attention on reducing greenhouse gas emissions by requiring oil refiners to mix vegetable oil into diesel fuel. Korea has had limited progress in moving away from fossil fuels and relies heavily on crude oil imports from the Middle East. They hope to diversify their energy portfolio by developing renewable and nuclear energy but there has been slow progress. This is largely due to the heavily saturated energy market where new incumbents struggle to enter.

A challenge that this economy faces is the fact that they have very limited land space. The Bioenergy Crop Research Centre was created to screen and designate land for crop developments. A demonstration supply of B20 biodiesel was created in 2002 which faced strong opposition from car makers and oil refineries due to concerns over engine compatibility. Two years later, a biodiesel standard was created to help alleviate fuel quality concerns. During 2004-2006, B20 and B5 biodiesel was tested and it was found that the latter blend had no adverse effects on vehicle performance. Since then, biodiesel use has steadily increased and is fully exempted from fossil fuel tax to improve cost competitiveness.[97]

Target

At the end of 2014, Korea's 4th Basic Plan was announced. By 2035, the economy aims for 11% of the total energy supply to be from renewable energies. The Green Energy Vision was also introduced with the goal of reducing CO_2 emissions by 30% before 2020 and 37% by 2030.[98] The Ministry of the Knowledge Economy (MKE) then announced plans for biofuel research and development towards 2030. Korea's government expenditure on energy research is one of the highest among OECD members. In the short term, research will be focused primarily on first generation biofuels and will change to advanced biofuels in the long term. There are plans to increase the biodiesel blend rate to 3% by 2018 but many petroleum companies are opposed to it.[99] The supply of biofuel is targeted to grow 5.0 Mtoe per year leading up to 2030.

Feedstock and Biofuel Usage

The mandatory biodiesel blend rate was increased to 2.5% in August 2014 but the actual volume of domestically produced biofuels was unable to meet this target.[100] The feedstock for biodiesel in Korea is primarily imported Malaysian palm oil and Argentinian soybeans. Domestic waste cooking oil and rapeseed is also used. Limited land and food resources within Korea have put the focus on alternative feedstock, especially microalgae. There are multiple research projects currently in place with

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[97] Jin-Suk Lee, Joon-Pyo Lee, Ji-Yeon Park, Jung-Hwa Lee, and Soon-Chul Park (2011), 'Status and perspectives on bioenergy in Korea', *Renewable and Sustainable Energy Reviews*. Vol 15, Issue 9, December 2011

[98] Jin-Suk Lee and Kyu-Young Kang (2012), 'Progress on Transportation Biofuels in Korea', *Commercializing Liquid Biofuels from Biomass*, Issue 31, September 2012, http://task39.sites.olt.ubc.ca/files/2013/05/IEA-Bioenergy-Task-39-Newsletter-Issue-31-Korea-September-2012.pdf

[99] Biofuels Digest (2014), 'Biofuel Mandates Around the World: 2015', 31 December 2014, http://www.biofuelsdigest.com/bdigest/2014/12/31/biofuels-mandates-around-the-world-2015/

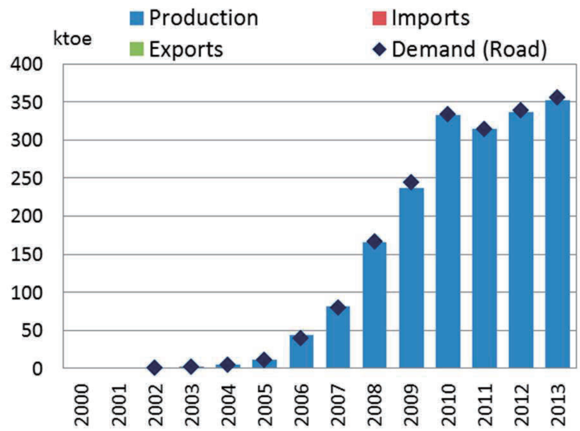
[100] Korea IT Times (2014), 'Oil Refiners Face Challenges due to Biodiesel Regulation', 22 December 2014, http://www.koreaittimes.com/story/43491/oil-refiners-face-challenges-due-biodiesel-regulation

expected completion dates in 2020. The 2012 Promofuel Project focuses on discovering new feedstocks for advanced biodiesel production such as rubber seed and fish oil.[101]

There is currently no mandatory blend rate for bioethanol and stakeholder group acceptance is low. Strong opposition from car makers and oil refineries has hindered the commercialization of bioethanol. Current fuel distribution structures in Korea are also not compatible with ethanol gas. These factors, combined with the lack of a mandatory blending rate, have resulted in ethanol imports being used primarily for industrial purposes.

Figure 4-7 Biofuel Demand-Supply Balance in Korea

Biodiesel



Source: IEA (2015). *Energy Balance of OECD Countries 2015*

4-2-8 Malaysia

Policy Overview

In 2006, Malaysia implemented the National Biofuel Policy with the goal of obtaining more sustainable energy sources and to increase palm oil prices. This helps lower end stocks which can stabilize the price of crude palm oil. Malaysia has had a mandatory B7 biodiesel blending mandate in place since January 1, 2015 which was an increase from the previous B5 policy.[102] According to the 2007 Biofuel Industry Act, B5 was supposed to have been implemented in 2008 but was delayed until 2011. In fact, B5 was only fully implemented at the end of 2014. There were multiple setbacks leading up

[101] EBTP (European Biofuels Technology Platform) (2015), website 'Global Biofuels – an Overview', http://www.biofuelstp.eu/global_overview.html

[102] Abdul Ghani Wahab (2015), Malaysia Biofuels Annual. USDA Foreign Agricultural Service, Global Agricultural Information Network

to these blending increases, mostly resulting from the slow utilization of blending facilities. Fuel subsidies were in place until December 2014 when fuel prices were set based on the average price of crude oil during the previous months. Further research and development has been taking place for second generation fuels but due to limited investment, commercial product development has not been achieved.

Target

The 11th Five Year Malaysian Plan (2016-2020) came into effect with projections towards 2020. The Malaysian government hopes to have a B15 blend in place by that time, potentially boosting biodiesel production to 2.17 billion litres. Until then, the government aims to educate consumers about the benefits of biofuels and eliminate any misconceptions regarding engine compatibility. Public transport is also being encouraged as most buses run on diesel. The blend rate is expected to grow to 10% in October 2016 but car manufacturers are strongly opposed to the changes. It is unclear at this point in time if the blend rate will be adjusted as scheduled. If it does, consumption could increase to over 557 million litres and production would grow to 703 million litres in 2017.[103]

Feedstock and Biofuel Usage

The primary feedstock for biodiesel is palm oil. Gasoline fuelled cars account for 80% of new car sales while diesel fuelled cars are less popular and are limited to trucks and buses. A study conducted by the World Bank showed that transportation energy consumption in Malaysia is among the highest of 11 Asian economies.[104] It goes on to suggest that the economy's energy intensity may continue to worsen due to the lack of fuel choices for consumers. The transport sector currently relies primarily on fossil fuels, with petroleum based diesel and gasoline accounting for over 70% of the total energy consumed in transportation.[105] Malaysia is self-sufficient and has an abundance of spare biodiesel refineries with a forecasted capacity of 24.4% in 2016. Biodiesel is exported out of the economy to the European Union and China, but export levels have been decreasing since 2013 due to lower demand.

There is no significant production of ethanol at this point in time because the costs

[103] Sungate Analytics (2015), 'Indonesia and Malaysia Biodiesel Outlook', 6 November 2015, http://www.sungate-analytics.com/blog/2015/11/6/indonesia-and-malaysia-biodiesel-outlook

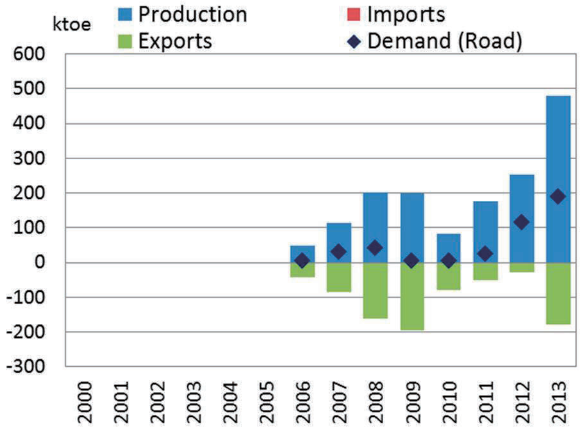
[104] Govinda Timilsina and Ashish Shrestha, (2009), 'Transport sector Co2 emissions growth in Asia: Underlying factors and policy options', *Energy Policy*, Volume 37, Issue 11, November 2009

[105] H.C. Ong, T.M.I Mahlia, and H.H. Masjuki (2012), 'A review on energy pattern and policy for transportation sector in Malaysia', *Renewable and Sustainable Energy Reviews*, Volume 16, Issue 1, January 2012

are too high. Some initiatives to use palm oil mill effluent (POME) as feedstock have begun but additional research is required before it can be implemented.

Figure 4-8 Biofuel Demand-Supply Balance in Malaysia

Biodiesel



Source: IEA (2015). *Energy Balance of Non-OECD Countries 2015*

4-2-9 New Zealand

Policy Overview

New Zealand is focusing on developing a forestry sector bio-economy. The government believes that using bioenergy from forests or wood and grass crops is more efficient in terms of land use compared to seed energy crops. This is because the entire biomass can be utilized for lumber, wood pellets, heating, wood products etc. The economy has a lot of hill grazing and low productivity pastoral land that has the potential for being used as short rotational fuel crops.

In 2006, the Ministry of Transport and the Energy Efficiency Conservation Authority (EECA) investigated the effects of bioethanol and found that blends of up to 10% have no adverse effects on vehicle parts. Other investigations were conducted on biofuel supply, economics and distribution methods. Bioethanol is currently exempt from excise tax.

Targets

At this point there are no specific bioethanol or biodiesel blend targets. The government aims for 50% emission reductions from 1990 levels by 2050, although the focus is primarily on reducing agricultural and energy related greenhouse gases.[106] The New Zealand Bioenergy Strategy was created in September 2010 to promote employment, economic growth and bioenergy production from the forestry industry. Through this strategy, the government hopes to supply 30% of their transport fuel from the forestry sector by 2040.[107] This plan has been broken down into 3 phases and they are currently in the Bioenergy Strategy Development Phase (2015-2020). During this time, the focus will be on building demonstration projects and trial crops. The investment into these projects is estimated to be over NZD$5-6 billion.[108] Prior to this was the 2010-2015 Strategy Building Phase. The final segment is the Expansion Phase where the development of fuel crops, energy forests and bio-refineries will take place in 2020-2040.

Feedstock and Biofuel Usage

Biofuel consumption and production is very limited in New Zealand, consisting of less than 0.1% of total transportation energy in 2014.[109] The most common feedstock for biodiesel in New Zealand is used cooking oil mixed with rapeseed and tallow. Rapeseed is generally only as a rotational crop and overall, there are very few purpose-grown energy crops. The majority of domestic producers make B5 and B20 blends, the latter of which are used by large commercial vehicles. A B100 blend is also available.

While New Zealand is self-sufficient in biodiesel production, it requires bioethanol imports to meet domestic demand. Bioethanol blends of up to 10% are available. The feedstock of bioethanol is domestic whey mixed with imported Brazilian sugarcane. The National Institute of Water and Atmospheric Research (NIWA) is currently building a demonstration pond for algae biofuels.

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106 Kirk Torr (2014), *Country Report: New Zealand*, IEA Bioenergy Task 42 Bio-refining, 2014, http://www.iea-bioenergy.task42-biorefineries.com/en/ieabiorefinery/Country-Reports.htm

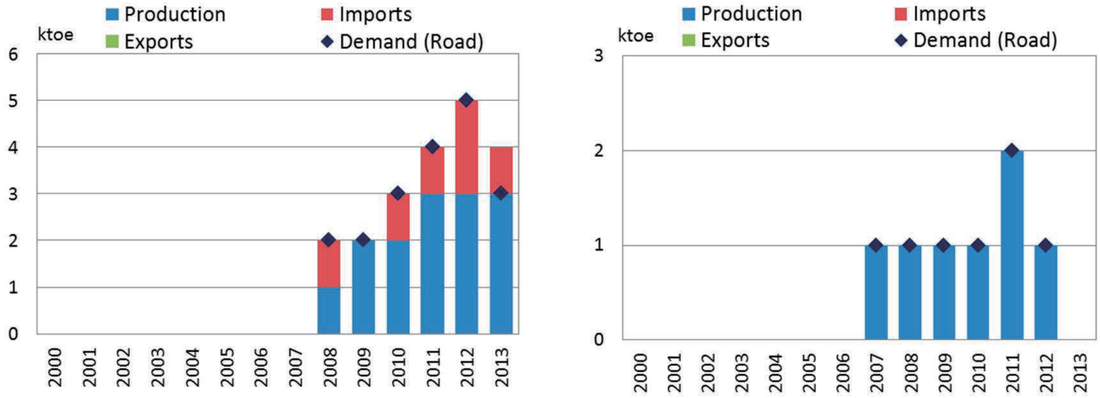
107 BANZ (Bioenergy Association of New Zealand) (2016), *New Zealand Bioenergy Strategy*, http://www.bioenergy.org.nz/documents/resource/NZBioenergyStrategy2010.pdf

108 Bioenergy Association of New Zealand) (2010), A Picture of Bioenergy Opportunities for New Zealand: *Leading to the development of a New Zealand Bioenergy Strategy*, http://www.bioenergy.org.nz/documents/resource/bioenergyopportunitiesfornz.pdf

109 Ministry Business Innovation and Employment (2014), Energy in New Zealand, 2014, http://www.mbie.govt.nz/info-services/sectors-industries/energy/energy-data-modelling/publications/energy-in-new-zealand/previous-editions/Energy-in-New-Zealand-2014.pdf/view

Figure 4-9 Biofuel Demand-Supply Balance in New Zealand

Bioethanol Biodiesel



Source: IEA (2015). *Energy Balance of OECD Countries 2015*

4-2-10 People's Republic of China

Policy Overview

China's overarching green energy targets are set out in the 2015 National Climate Change Plan. The goal is to produce 130 billion cubic meters of biofuels by 2020 but it is unclear how the government intends to reach this target.[110] The government withdrew policy support for grain-based ethanol in 2010 and there are currently no subsidies being provided. The government has set high biofuel targets and despite overall production increasing, it was still below targets outlined in the 12th Five Year Plan (2011-2015). The new 13th Five Year Plan (2016-2020) will put even stronger emphasis on environmental issues and clean energy, as well as protection of cultivated land for grain security.

China has a large population but limited arable land, leading the economy to pursue land acquisition deals in other economies. Production volumes are tightly controlled and are restricted to specific producers/distributors. These conflicting policies make it difficult for biofuels to reach their full potential in China. Like many other economies, China is focusing on encouraging new energy and electric vehicles in response to the pollution problems. In July 2014, the State Council eliminated the purchase tax on new energy vehicles.

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[110] Andrew Anderson-Sprecher and James Ji (2015). China – Peoples Republic of, Biofuels Annual. USDA Foreign Agricultural Service, Global Agricultural Information Network

Targets

China has set a target of making 300 million tons of cellulosic and non-grain based ethanol by 2020. Carbon intensity will be reduced 40%-45% by 2020 and 15% of its energy will be from clean sources.[111] It seems unlikely that this can be achieved due to a lack of infrastructure to transporting feedstock and it is estimated that only 10 million tons can be made by the target date. Liquid biofuels are targeted to reach 130 billion cubic meters of production by 2020. The current ethanol blend rate is at 10% and until the full 13th Five Year Plan is released, it is unclear if a nation-wide mandatory blend will be implemented. A mandatory blend rate could help meet the 2020 goals outlined in the National Climate Change Plan.

Feedstock and Biofuel Usage

In the past, bioethanol was created from grain, but now cassava, sweet potato and sorghum are more common. Grain-based ethanol is made from corn and wheat, while cellulosic ethanol utilized corn cobs and stalks.[112] The industry is heavily regulated and dominated by large oil companies, making it difficult for new entrants. E10 blends are most common although the actual blend rate may vary from 7%-13% depending on the province.[113] There are 6 provinces that have fully adopted an E10 mandate and the government hopes to further expand bioethanol consumption. Some cities are currently in bioethanol pilot testing stages. The 2016 production is projected to increase 2.6% from the previous year where an estimated 3.08 billion liters was made for transportation.[114]

Biodiesel is only approved for transportation fuel use in select cities and there is no national minimum blend mandate in place due to low production levels. The maximum blend rate is currently 30% but most trial programs are running 2%-5% mixes. Production is forecasted to stay relatively flat in the near future as companies have been struggling to stay profitable. The USDA report states that approximately 30% of biodiesel is used in transportation, 50% for industry and 20% for agricultural machinery and fishing boats. Within transportation, overall diesel consumption increased 6% from

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111 BBC News (2015), 'China climate change plan unveiled', 30 June 2015, http://www.bbc.com/news/science-environment-33317451

112 Liping Kang (2014), *Biofuel Experiences in China, Governance and Market Development Updates,* ICET (Innovation Center for Energy and Transportation) http://www.biofuelstp.eu/spm6/docs/liping-kang.pdf

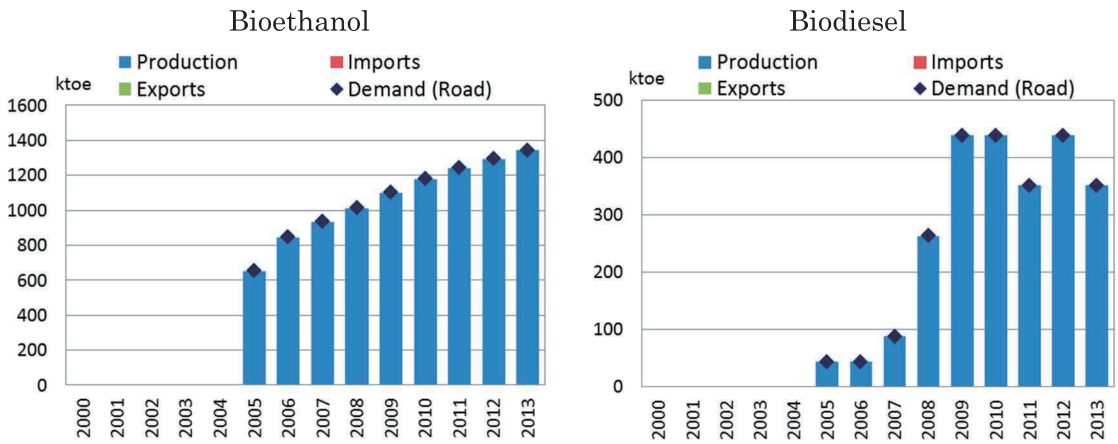
113 Shuyang Si, James Chalfant, Cynthia Lin Lawell, and Fujin Yi (2015), 'The Effects of China's Biofuel Policies on Agricultural and Ethanol Markets', http://www.des.ucdavis.edu/faculty/Lin/China_biofuel_policy_mkt_paper.pdf

114 Andrew Anderson-Sprecher and James Ji (2015), China – Peoples Republic of, Biofuels Annual. USDA Foreign Agricultural Service, Global Agricultural Information Network

2015 but biodiesel is only 0.2% of total usage.

The low production levels of biodiesel can be attributed to high feedstock costs. Biodiesel is made from used cooking oil and there is strong competition from buyers purchasing it for illicit means. The government has recently been trying to control the illegal reprocessing and resale of used cooking oil. Another contributing factor to the high cost of this feedstock is the lack of economic drivers and policy instruments.[115]

Figure 4-10 Biofuel Demand-Supply Balance in China



Source: IEA (2015). *Energy Balance of Non-OECD Countries 2015*

4-2-11 Peru

Policy Overview

Peru currently has a B2 biodiesel and E7.8 blending mandate in place.[116] The Biofuels Market Promotions regulation lays out the legal framework for promoting biofuels and focuses primarily on employment, fuel diversification, agriculture and the environment. The Regulation for Biofuels Market Promotion outlines the biofuel content that can be distributed and sold, while the Regulation of the Commercialization of Biofuels oversees trade.

Target

There are plans to increase the mandatory blend rates for both biodiesel and

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[115] Chang Shiyan, Zhao Lili, Govinda R. Timilsina, and Zhang Xiliang (2012), *Development of Biofuels in China, Technologies, Economics and Policies,* World Bank, 2012, http://www-wds.worldbank.org/servlet/WDSContentServer/WDSP/IB/2015/09/28/090224b0828be6fc/1_0/Rendered/PDF/Development0of0onomics0and0policies.pdf

[116] Biofuels Digest (2014), 'Biofuel Mandates Around the World: 2015', 31 December 2014, http://www.biofuelsdigest.com/bdigest/2014/12/31/biofuels-mandates-around-the-world-2015/

bioethanol but no confirmation has been given as to whether or not it will be implemented. Blend rates were proposed to increase to E10 and B5 but petroleum producers are strongly opposed to these changes.[117] Raising the blend mandate could displace gasoline which would then have to be exported potentially at a loss.

Peru's climate and landscape are ideal for growing sugarcane and the government expects that an additional 45,000 hectares of arable land will be planted with sugarcane in the future.[118] However, locals are concerned over the economic viability of growing sugarcane and are hesitant to produce it.

Feedstock and Biofuel Usage

The ethanol industry is relatively new in Peru with operations commencing in August 2009. There are currently 2 factories in the economy, both of which use domestically grown sugarcane as feedstock. Producers find better prices in foreign markets which are more willing to pay premiums for environmentally friendly grown feedstock. These exports are mostly sent to the European Union with some going to Canada. They are unable to export to the United States at this time due to Environmental Protection Agency regulations against ethanol imports from fields cultivated after 2007. Production for 2016 is forecast at 160 million liters with domestic consumption estimated at 172 million liters.[119]

Peruvian bioethanol uses palm oil as feedstock and the government has been encouraging cocoa farmers to grow it as an alternative crop. Domestic biodiesel production fell sharply in 2015 due to competition from Argentina. Local fuel distributors prefer to import cheaper biodiesel from Argentina. Peru's competition regulator, IDECOPI, initiated an anti-dumping investigation on Argentinian imports of B100 biodiesel in April 2015. A USD$208.20/ton anti-dumping duty on Argentine biodiesel was approved at the end of January 2016. In response, Argentinian biodiesel producers plan to appeal these duties.[120] Due to this ongoing issue, it is likely that little

[117] Gaspar E. Nolte (2015), Peru Biofuels Annual. USDA Foreign Agricultural Service, Global Agricultural Information Network

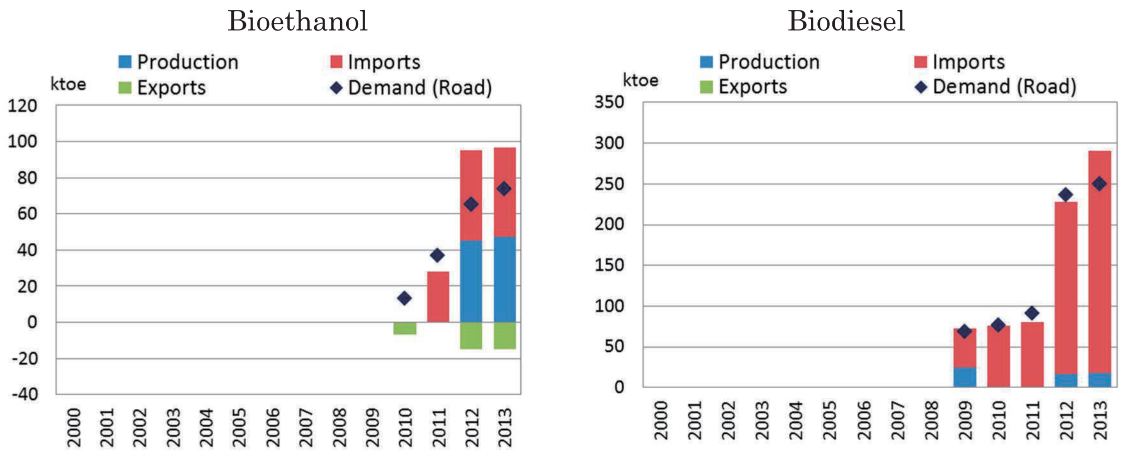
[118] Peru This Week. 'Peru promises 45,000 hectares of irrigated land for farmers', 25 June 2014, http://www.peruthisweek.com/news-peru-promises-45000-hectares-of-irrigated-land-for-farmers-103353

[119] AgroChart (2015), 'Peru. Biofuels Annual. July 2015', 20 July 2015, http://www.agrochart.com/en/news/news/200715/peru-biofuels-annual-july-2015/

[120] Biofuels Digest (2016), 'Argentine biodiesel producers to appeal Peru's anti-dumping duties', 4 February 2016, http://www.biofuelsdigest.com/bdigest/2016/02/04/argentine-biodiesel-producers-to-appeal-perus-anti-dumping-duties/

to no production will take place in 2016.

Figure 4-11 Biofuel Demand-Supply Balance in Peru



Source: IEA (2015). *Energy Balance of Non-OECD Countries 2015*

4-2-12 The Philippines

Policy Overview

The Philippines became the first economy in Southeast Asia to implement biofuel legislation in 2007. The Biofuels Act, also known as the Republic Act RA 9367, set out different levels of ethanol blending targets. In 2009, the ethanol blends for petroleum were set at 5% and grew to 10% in 2011.[121] The Department of Energy (DOE) suspended the E10 implementation for 6 months.[122] A 1% biodiesel blend was also implemented in 2007 which grew to 2% in 2009. It was then scheduled to increase to 5% in 2015 but this has been put on hold due to issues raised over biodiesel storage, distribution and potential corrosive effects on vehicle engines. Biodiesel is made from coconut oil and an ongoing study has been commissioned by the National Biofuels Board to observe the impacts of the B5 blend on the coconut industry, prices and supply.[123]

Domestic ethanol producers are given priority over importers and biodiesel imports are not allowed. The Biofuels Act also outlines fiscal initiatives such as duty-free

[121] Republic of the Philippines (2006), *Republic Act No. 9367*, Department of Energy, http://www.doe.gov.ph/issuances/republic-act/614-ra-9367

[122] Perfecto Corpuz (2015), Philippines Biofuels Annual. USDA Foreign Agricultural Service, Global Agricultural Information Network

[123] Biofuels Digest (2015), 'Philippines not likely to implement B5 in 2015 as study results delayed' 21 September 2015, http://www.biofuelsdigest.com/bdigest/2015/09/21/philippines-not-likely-to-implement-b5-this-years-as-study-results-delayed/

importation and VAT exemptions on agricultural inputs and machinery. Government fiscal agencies also give local producers priority. The Philippine Economic Zone Authority grants registered ethanol companies tax holidays and credits. To further bolster the industry, an amendment to the Cabotage Law was implemented in July 2015 to allow foreign ships to trade at any local port, lowering costs and decreasing traffic in the Port of Manila.

Target

The Biofuels Act has set a target for a 20% ethanol blend in 2020 but the economy has been struggling to meet production requirements domestically.[124] As a result, they have been relying heavily on imported bioethanol from the United States which is subject to high tariffs. This is expected to change in the near future as domestic production capabilities have been steadily improving. In order to strengthen the domestic industry, the Sugarcane Industry Development Act, also known as the Republic Act 10659, was established in March 2015 with the promise of USD$44.4 million in investments towards infrastructure, research and grants. Greater investment in human resource development and sugar supply monitoring systems will also take place under the Act.

While the Philippines has difficulty meeting the E10 blend mandate, they currently have no issues in meeting B5 biodiesel blend requirement. The biodiesel blend rate will increase to 10% in 2020 and 20% by 2030. It may be more challenging to reach the 2020 target due to infrastructure issues.

Feedstock and Biofuel Usage

Sugar cane and molasses are the main feedstock for bioethanol production in the Philippines. Unfortunately, the ethanol processing industry is inefficient by world standards, leading to below average yields and higher production costs. As a result, the Philippines has been importing from the United States, Brazil and Thailand to meet demand.[125] In order to meet the 2020 E20 target, another 20 plants are required if they want to be self-sufficient. Investments stemming from the Sugarcane Development Act should be able to increase production capacity over the next few years.

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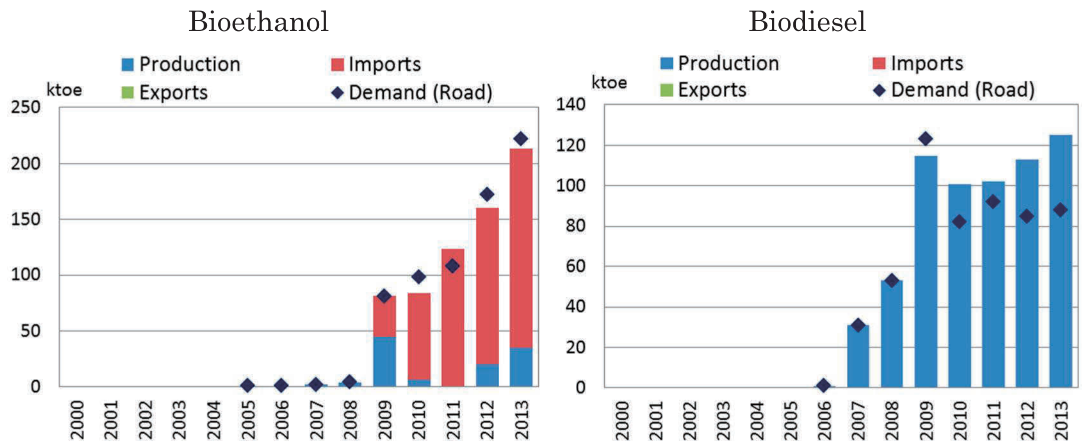
[124] Perfecto Corpuz (2015), Philippines Biofuels Annual. USDA Foreign Agricultural Service, Global Agricultural Information Network

[125] Business World Online, Manila, Philippines (2015), 'Ethanol imports seen rising', 30 October 2014, http://www.bworldonline.com/content.php?section=Economy&title=ethanol-imports-seen-rising&id=97054

Research on using sweet sorghum and lignocellulosic biomass is currently in progress but it will be very difficult to implement. Sweet sorghum requires a large amount of land but the Agrarian Reform Law limits private land ownership. Commercially viable cellulosic fuel is not expected to be available until 2030.

The Philippines was the top coconut oil exporter in 2014 and exports are expected to continue growing if weather conditions are favourable. In 2015, 70% of its coconut oil produce was exported, of which 80% was sent to Europe and the United States.[126] Coconut oil is transesterified into coco methyl ester to create coco-biodiesel. The economy is currently self-sufficient but there may not be enough coconut methyl ester supply to meet the 10% biodiesel blend targets in 2020. Some refineries may add palm oil to the blend mix to meet future demand.

Figure 4-12 Biofuel Demand-Supply Balance in the Philippines



Source: IEA (2015). *Energy Balance of Non-OECD Countries 2015*

4-2-13 Thailand

Policy Overview

In 2012, Thailand set a 10-year Alternative Energy Development Plan with the goal of reducing dependency on fossil fuels, strengthening domestic energy and promoting green energy. A B7 biodiesel mandate was introduced in August 2015. The Future New Fuel for Diesel Substitution policy encourages the cultivation of new energy crops, diesohol and oil conversion technology from 2014 to 2017.[127]

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[126] The Manila Times (2015), 'Coco oil exports surge in 2015', 19 March 2015, http://www.manilatimes.net/coco-oil-exports-surge-in-2015/170450/

[127] Sakchai Preechajarn and Ponnarong Prasertsri (2015), Thailand Biofuels Annual. USDA Foreign Agricultural Service, Global Agricultural Information Network

The government has been actively promoting the use of ethanol. Price incentives are provided by the State Oil Fund for E20 and E85 gasohol consumption, allowing prices to be 20%-40% cheaper than E10 Octane 95 gasoline. Gas stations are offered marketing subsidies of 1-2 baht/liter for E20 and 2-3 baht/liter for E85. An excise tax rate for vehicles compatible with these blends is offered at 17% compared to 30% for E10 vehicles. Starting in 2016, an additional 3% reduction for E85 compatible vehicles will be distributed.

Target

Under the Alternative Energy Development Plan, 25% of total energy consumption in 2021 will be derived from renewable energy.[128] The core of Thailand's biofuel goals is to increase feedstock yield and production levels. A consumption target of 7.2 million liters/day of B100 biodiesel by 2021 have been set.[129] However, Thailand's overall production capacity must be increased in order to meet these targets. To achieve this, the government also aims to increase oil palm acreage to 880,000 hectares by 2021. Average yields are expected to reach 30 Mtoe/ hectare in 2021 while crude palm oil crushing rates will be at least 18%. Pilot tests for B10 and B20 blends for fishing boats and trucks are also scheduled to take place.

The 5 Year Agricultural Restructuring Program (2015-2019) encourages rice farmers to shift towards growing sugarcane for bioethanol production. A consumption target of 9 million liters per day by 2021 is currently in place. The government is also hoping to increase average cassava production levels to 35 million metric tons per year. The target for commercially viable biofuels from new energy crops is 2 million liters per day in 2018 and 25 million liters per day by 2021.

Feedstock and Biofuel Use

Thailand is self-sufficient in biofuel production. Approximately 72% of biodiesel feedstock is derived from various forms of palm oil products.[130] The actual volume of diesel produced depends on weather conditions. Demand for B100 biodiesel is primarily

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[128] IEA (International Energy Agency) (2014), *Thailand Biofuel Policies*, Department of Alternative Energy Development and Efficiency, https://www.iea.org/media/technologyplatform/workshops/southeastasiabioenergy2014/Thailand.pdf

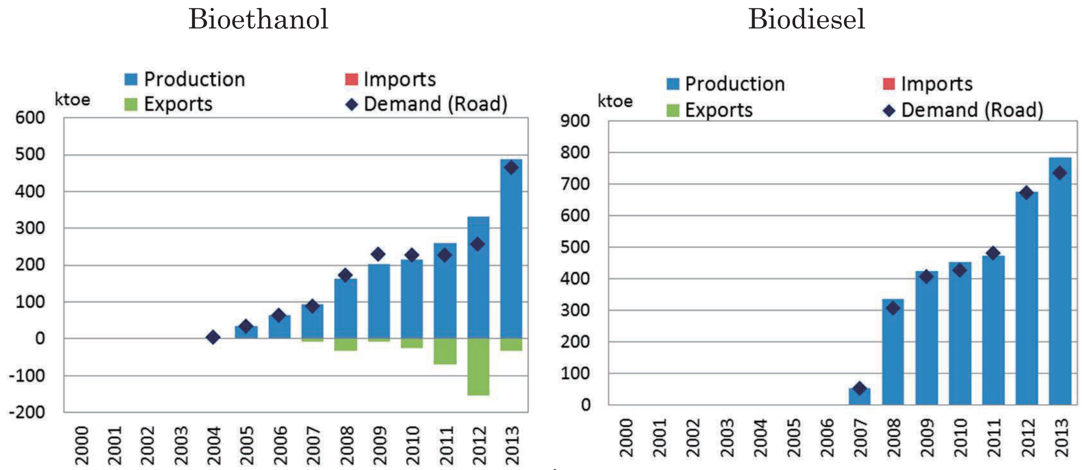
[129] Ethanol Producer Magazine (2015), 'Thailand ethanol production, consumption expected to increase', 10 August 2015, http://www.ethanolproducer.com/articles/12518/thailand-ethanol-production-consumption-expected-to-increase

[130] Sungate (2015), 'Market Views. Global Biodiesel Consumption in 2016', 1 December 2015, http://www.sungate-analytics.com/blog/2015/11/24/global-biodiesel-consumption

driven by the government and the industry is dominated by existing producers, making it difficult for new firms to enter. The B7 biodiesel mandate was temporarily lowered in early 2015 due to skyrocketing palm oil prices that have since stabilized and was reinstated on April 17, 2015. Imports of biodiesels are restricted to protect domestic palm growers. Research on increasing yield, stabilizing palm oil supply and new feedstock technologies are the main priority for Thailand's biodiesel policies.

Molasses is the main feedstock for bioethanol production, comprising 70% of total production. Demand for molasses will likely increase to around 4 million metric tons in 2016 and more fuel stations are selling E10 and E20 fuel. The remainder is derived from non-food grade rice from government stocks, imported Cambodian cassava and sugarcane. As of 2014, there were 10 molasses plants, 7 cassava plants and 5 plants that use both feedstock.[131] Meanwhile, the use of rice stocks in ethanol production may be capped at 0.5 million metric tons per year to support cassava prices. There is currently only one sugar-based ethanol plant but additional facilities will be built under the 5 Year Agricultural Restructuring Program.

Figure 4-13 Biofuel Demand-Supply Balance in Thailand



Source: IEA (2015). *Energy Balance of Non-OECD Countries 2015*

In 2016, total ethanol production is forecasted to increase to around 1.4 billion liters, up 10% from 2015. One additional ethanol plant will be added, increasing the production capacity to 5.2 million liters per day, up 8% from 2015. Some bioethanol is

[131] Thailand Ministry of Energy (2015), *Biofuel Status and Policies,* Bureau of Biofuel Development, Department of Alternative Energy Development and Efficiency, http://www.irena.org/DocumentDownloads/events/2015/Bioenergy%20Statistics%20Presentations/Enterprise%20surveys/Thailand_biofuel%20overview.pdf

exported to Singapore, the Philippines, Korea and Japan. Under the Future New Fuel for Diesel Substitution policy, research on using jatropha and microalgae is underway.

4-2-14 United States

Policy Overview

The United States adopted the Renewable Fuel Standard in 2005 as an amendment to the Clean Air Act. This policy requires that a certain volume of renewable fuels are used to replace petroleum-based transportation fuel, heating oil and jet fuel. It was further amended in 2007 with the Energy Independence and Security Act (EISA).[132] There are no biofuels tax provisions under this amendment. The United States Environmental Protection Agency (EPA) oversees biofuel policies, production and compliance.

Biofuels are divided into 4 categories: cellulosic, biomass-based, advanced and renewable fuels - each with its own volume requirement. Each category has minimum lifecycle greenhouse gas reduction standards to ensure environmental goals can be achieved and only approved feedstock may be used. The EPA also distributes grants for infrastructure, research and commercial application of biofuels. Obligated parties under the Renewable Fuel Standard must blend renewables into transportation fuels or obtain credits to meet the EPA specified Renewable Volume Obligations (RVO). RVOs are calculated on a yearly basis based on gasoline and diesel production forecasts.[133] In addition to federal mandates, over half of the states have implemented their own regulations, grants and tax incentives.

The Biomass Crop Assistance Program (BCAP) provides financial assistance to agricultural and forest land owners to ensure there is a steady supply of biomass feedstock. Annual payments are given to help establish crops and matching payments are provided for collecting underutilized biomass. The Feedstock Flexibility Program encourages the production of biofuels from surplus sugar stocks and the Biofuel Infrastructure Partnership program provides up to USD$100 million in grants to cover costs such as building fuel pumps, marketing and program evaluations.[134]

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[132] RFA (Renewable Fuels Association) (2016), *Renewable Fuel Standard*, http://www.ethanolrfa.org/policy/regulations/renewable-fuel-standard/

[133] EPA (Environmental Protection Agency) (2016), *Renewable Fuel Standard (RFS) Program*, https://www.epa.gov/renewable-fuel-standard-program/program-overview-renewable-fuel-standard-program

[134] Biofuels Digest (2015), 'USDA Announces $210M for Biofuels Infrastructure', 28 October 2015, http://www.biofuelsdigest.com/bdigest/2015/10/28/usda-announces-210m-for-biofuels-infrastructure/

Target

The 2014-2017 EPA RVO proposal was a year and a half behind schedule and can be found below in Table 4-2. The EPA explains that the delay was due to uncertainty over the Clean Air Act. The biofuels industry was shocked to see that the RVO targets were significantly lower than the 2007 volumes set by congress (Table 4-3). The EPA defends their lower numbers, stating that the EISA's targets were unobtainable due to "blend wall" infrastructure limitations. For more information regarding "blend wall" challenges, please refer to Section 4-4. The energy industry has also drastically changed since the EISA's enactment in 2007. They further argued that they still remain in compliance with the legislation because it follows congress' overarching goal of increasing biofuel production.

There has been great controversy over the production target discrepancies and several industry bodies have expressed disappointment in the EPA proposal. Critics argue that the RFS was created to break down the "blend wall" by pushing for ambitious targets, spurring increased investments and innovation. These low targets fail to combat "blend wall" issues and may actually discourage investments, damaging future production capacity. Other criticisms include the damage to domestic feedstock producers, denial of green energy options for consumers and accuse the EPA of siding with "Big Oil" companies.[135] Multiple industry bodies and biofuel associations joined together in a lawsuit with the U.S. Court of Appeals over the controversial policy in early 2016.[136]

Table 4-2 EPA Proposed Renewable Fuel Volumes (million gallons)

	2014	2015	2016	2017
Cellulosic Biofuel	33	106	206	N/A
Biomass-Based Diesel	1,630	1,700	1,800	1,900
Advanced Biofuels	2,680	2,900	3,400	N/A

Source: EPA United States Environmental Protection Agency, Renewable Annual Fuel Standards (2015)

135 Biofuels Digest (2015), 'EPA Slashes Biofuels Targets for 2014, 2015, 2016 under Renewable Fuels Standard', 29 May 2015, http://www.biofuelsdigest.com/bdigest/2015/05/29/epa-slashes-biofuels-targets-for-2014-2015-2016-under-renewable-fuel-standard/

136 Reuters (2016), 'Factbox: U.S. EPA Faces Lawsuits Over its Biofuels Plan', 12 February 2016, http://www.reuters.com/article/usa-biofuels-lawsuit-idUSL2N15R1R9

Table 4-3 EISA vs EIA Targeted Total Renewable Fuels Volumes (million gallons)

	2014	2015	2016	2017
EISA Production	18,150	20,500	22,250	24,000
EIA Production	15,930	16,300	17,400	N/A

Source: EPA United States Environmental Protection Agency, Renewable Annual Fuel Standards (2015)

Feedstock and Biofuel Usage

The primary feedstock for bioethanol production is corn, mostly from Midwestern United States where corn is the dominant crop. This area is commonly referred to as the Corn Belt and consists of Indiana, Illinois, Iowa, Missouri, Nebraska and Kansas. The United States also imports bioethanol from Brazil and small amounts from Canada. E10 is the most common blend ratio, though it varies from state to state because of varying regulations. Most cars are able to run on blends of up to 10% ethanol and many vehicle manufacturers have been designing cars that can run on higher levels such as E85.

Fueling infrastructure is a major restriction in the United States. Most fueling stations do not sell blends over 10% and those that do are mainly located in the Corn Belt. In response, the Obama Administration tried to install 10,000 blender pumps which could dispense E85, E50, E30 and E20 blends.[137] The USDA distributed USD$100 million in ethanol infrastructure and there are 2,809 E85 ethanol stations as of March 2016 (excluding private stations).[138]

B20 biodiesel is the most common biodiesel blend used in the United States. Higher blends are less common due to a lack of regulatory incentives, pricing and engine compatibility issues. The top biodiesel producing states are Tennessee, Iowa and Illinois. The United States also imports biodiesel. Imports are mainly from Argentina and Canada, totaling 537,000 and 135,000 barrels respectively in November 2015.[139]

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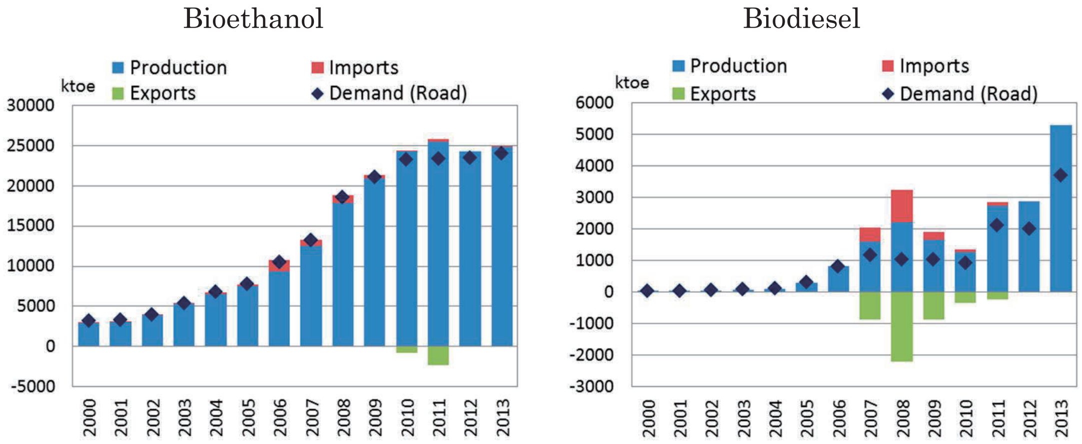
137 Ethanol Produce Magazine (2010), 'USDA to help install 10,000 blender pumps', 21 October 2010, http://www.ethanolproducer.com/articles/7087/usda-to-help-install-10000-blender-pumps

138 EIA (Energy Information Administration) (2016), *Alternative Fuelling Station Locator*, Department of Energy Efficiency & Renewable Energy, Alternative Fuels Data Center, http://www.afdc.energy.gov/locator/stations/results?utf8=%E2%9C%93&location=&fuel=E85&private=false&planned=false&owner=all&payment=all&radius=false&radius_miles=5&e85_has_blender_pump=false

139 Reuters (2015), 'USDA Plans to Inject $100 Million on Ethanol Infrastructure', 28 May 2015,

Soybean oil is the largest biodiesel feedstock, with 464 million pounds consumed in November 2015.[140] Vegetable oils such as corn, canola and palm are also commonly used. Other feedstocks include animal fats such as tallow, poultry and white grease. As of June 2015, there are 228 stations offering B20 and higher biodiesel, excluding private stations.

Figure 4-14 Biofuel Demand-Supply Balance in the United States



Source: IEA (2015). *Energy Balance of OECD Countries 2015*

4-2-15 Viet Nam

Policy Overview

The National Energy Development Strategy was approved in 2007 with long term objectives for 2020 and a 2050 vision. The main priority is to allocate more resources for research because the renewable energy sector is relatively new to the economy. At this point in time, there is limited expertise in renewable energy and oil refinery in Viet Nam. In response, the government is focusing on training and education for professional technicians, managers and skilled workers. In addition to this, the National Program for Development was established with a 2025 vision. It focuses on researching and building trial products while also creating a more favourable investment environment.

As of December 2014, E5 ethanol had already been implemented and used in road vehicles in 7 provinces and cities. This blend has been very successful and biofuels account for over 80% of the market share in the Quang Ngai province where every fuel

http://www.reuters.com/article/us-usa-biofuels-idUSKBN0OD2Z820150528

[140] EIA (Energy Information Administration) (2016) *Monthly Biodiesel Production Report With Data for Nov 2015*, https://www.eia.gov/biofuels/biodiesel/production/biodiesel.pdf

station sells E5.[141] Unfortunately, this success appears to only be limited to central regions as other locations have been strongly resistant to these changes. For example, Hanoi and Ho Chi Minh City had adoption rates of only 6.5% and 10.7% at the end of July 2015.[142] To change this, 7 localities were ordered by the government in late 2015 to sell E5. The Ho Chi Minh City government has suggested adding a preferential policy and price cut for E5 sales, though no official mandate has been implemented.

Targets

Under the National Energy Development Strategy, the targeted share of renewable energy will be 5% of the total primary energy source by 2020 and 11% by 2050. A production target to produce 1.8 thousand tons of E5 and B5 annually by 2025 has also been set under the National Program for Development of Biofuels.[143] The blend rate is currently set at E5, but the government hopes to increase this to E10 on December 1, 2017. A more comprehensive roadmap for blended biofuel ratios will be established in 2018.

Feedstock and Biofuel Usage

The main feedstock in Viet Nam for biodiesel is jatropha, deemed ideal because it is grown on marginal degraded soil, controls soil erosion, improves water filtration, and recycles nutrients back into the soil. It is also a non-edible product which alleviates concerns of food security. B100 production is made from palm oil and alternative feedstocks currently undergoing research include seaweed, rubber seed oil and catfish waste.[144] Biodiesel production began in Viet Nam in 2008 with jatropha cultivation and processing at seven biodiesel plants. Since the creation of the National Energy Development Strategy in 2007, multiple refineries and plants have been built, primarily near feedstock cultivation areas to minimize transportation costs.

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141 Tuoitre News (2015), 'E5 biofuel widely sold in central Vietnam, as planned, but not in south', 21 June 2015, http://tuoitrenews.vn/business/28785/e5-biofuel-widely-sold-in-central-vietnam-as-planned-but-not-in-south

142 Thanh Nien News (2015), 'Vietnam orders more gas stations in big cities to sell biofuels' 3 September 2015, http://www.thanhniennews.com/business/vietnam-orders-more-gas-stations-in-big-cities-to-sell-biofuel-50951.html

143 EEPSEA (Economy and Environmental Program for Southeast Asia) (2015), *Biofuel Production in Vietnam: Cost-Effectiveness, Energy and GHG Balances*, http://www.eepsea.org/o-k2/view-item/id-523/Itemid-192/

144 CPSI (Cleaner Production in Vietnam) (2014), 'Current statute of biofuel production in Vietnam', 11 May 2014, http://sxsh.vn/en-US/Home/LatestNews-10/2014/Current-statute-of-biofuel-production-in-Vietnam-2072.aspx

Viet Nam produces bioethanol from sugarcane, corn and cassava. They were the third largest cassava producer in Asia in 2015. Despite having many policies to support its implementation, the government has struggled to get retailers to switch to the new bioethanol blend. This is likely because there is no significant profit difference between E5 and regular RON 92 gasoline, offering little incentive for retailers to promote bioethanol. There also tends to be more fuel wastage during the blending process which further adds to their reluctance. These factors resulted in E5 demand being lower than expected. There are 7 factories producing ethanol as of 2015, but 3 of them require additional investments in order to reach a 5% blend ratio.[145] Both EIA and IEA data suggest that minimal amounts of biofuel are consumed and produced in Viet Nam.[146] As a result, no biofuel statistics are displayed below.

4-3 Biofuel Projections (OECD-FAO Agricultural Outlook 2015)

This section refers to the Agricultural Outlook 2015 conducted by Organization for Economic Co-operation and Development (OECD) and the Food and Agriculture Organization (FAO) of the United Nations. It demonstrates projected production and consumption of biofuels in the APEC member economies up to 2024.

(a) Bioethanol

Production:

During the outlook period towards 2024, global ethanol production is expected to increase from 114 billion litres in 2014 to 134 billion litres. Two-thirds of this growth is from Brazil. The United States will remain as one of the top producers with modest growth as lingo-cellulosic biomass based ethanol will drive most of the supply growth from 2020 onwards. Thailand's productions are expected to grow significantly to meet growing regional demand during the second half of the outlook period. China's production levels are also expected to increase, driven mostly by blend mandates.

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[145] Do Trong Hieu (2015), *Biofuel Development in Vietnam*. Ministry of Industry and Trade Vietnam, http://www.globalbioenergy.org/fileadmin/user_upload/gbep/docs/2015_events/3rd_Bioenergy_Week_25-29_May_Indonesia/26_5_3_HIEU.pdf

[146] Energy Information Administration (EIA) (2015), *International Energy Statistics, Vietnam*, http://www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm

Table 4-4 Bioethanol Outlook in the APEC Member Economies

	PRODUCTION (million liters)		Growth (%)	DOMESTIC USE (million liters)		Growth (%)
	2012-14 Average	2024	2015-24	2012-14 Average	2024	2015-24
Canada	1,853	2,039	0.08	2,880	3,034	0.52
The United States	53,961	56,691	0.04	52,499	55,063	0.05
Australia	340	348	0.05	327	347	0.05
Japan	356	361	-0.00	1,338	1,774	1.50
Peru	361	377	0.38	331	368	1.63
China	8,064	8,898	1.54	8,185	9,334	2.10
Indonesia	197	207	0.66	156	209	1.31
Malaysia	0	0	-0.01	0	0	1.26
The Philippines	191	294	0.64	519	736	2.43
Thailand	1,242	2,323	5.09	1,092	2,100	4.71
Viet Nam	448	582	2.74	357	475	2.47

Source: OECD-FAO Agricultural Outlook 2015-2024

Consumption

Global ethanol consumption is expected to increase by 21 billion litres by 2024. Overall, consumption levels will be driven by blending mandates. Thailand, the Philippines, China and Viet Nam all have scheduled increases in blending ratios over the projection period. Canada, the United States and Australia face "blend wall" issues which hinder biofuel consumption growth in the medium-term. To counter this, the United States will likely import bioethanol from Brazil to meet government mandated targets.

(b) Biodiesel

Production

Global biodiesel production is projected to reach 39 billion litres by 2024, a 27% increase from 2014. Indonesia will be one of the top producers and will continue to export large quantities of biodiesel. Malaysia will also see a large increase of production, although it will mostly be exported to Brazil and other economies due to low domestic demand. Production in Australia has historically been very low but is expected to grow dramatically because of new blending mandates. Thailand's biodiesel sector saw high growth in recent years but the OECD-FAO predicts that domestic demand may plateau. Peru's low production rate is a result of the ongoing anti-dumping investigation on Argentinian imports of B100.

Table 4-5 Biodiesel Outlook in the APEC Member Economies

	PRODUCTION (million liters)		Growth (%)	DOMESTIC USE (million liters)		Growth (%)
	Average 2012-14	2024	2015-24	Average 2012-14	2024	2015-24
Canada	392	486	0.33	538	794	1.56
United States	5,149	4,723	0.41	5,719	6,633	2.19
Australia	63	280	11.96	72	276	11.04
Peru	98	108	0.03	275	272	1.57
Indonesia	2,044	6,789	7.62	1,007	5,638	9.92
Malaysia	240	619	5.42	105	294	11.28
The Philippines	187	281	2.04	187	281	2.04
Thailand	944	1,001	1.01	944	1,001	1.01
Viet Nam	28	145	10.02	28	145	10.14

Source: OECD-FAO Agricultural Outlook 2015-2024

Consumption

Global biodiesel use is projected to increase 8.3 billion litres by 2024. Indonesian domestic consumption should see strong growth in consumption, with 4.5 billion litres used within transportation. Malaysia and Viet Nam's biofuel mandates will increase domestic demand by at least 10% of 2014 levels. Thailand's growth rate is comparatively small, possibly due to the heavily saturated industry and government-driven demand. In addition, their focus is primarily on improving palm oil output rather than that of biodiesel.

4-4 Future Challenges

Biofuel is a highly disputed subject and several research studies have been conducted to evaluate its impacts on food prices, fuel efficiency, greenhouse gas emissions and food security. However, many of these findings have conflicting results and growing media attention on biofuel policies have made the subject even more controversial. Below is a summary of some of the biggest challenges that biofuel implementation faces.

Food vs Fuel Debate - Food Supply Scarcity

As the demand for energy increases, questions have been raised regarding the distribution of limited resources between growing biofuel feedstock and food crops. Many economies have supported biofuels by offering subsidies, tax incentives and mandatory production rates which have had the unintended consequence of impacting food production. In many agriculture-based economies around the world, there are concerns that farmers may be forced to grow biofuel feedstock instead of food crops, creating a food supply shortage. Shortages in animal feed may arise because many common feedstock crops such as corn, sugarcane and vegetable oil are also used as animal feed. Irrigation may also be necessary which can drive up costs and put pressure on water supply and quality.

Biofuel production requires large amounts of land and must compete with other agricultural activities for it. Some studies suggest that there should be adequate amounts of land to meet biofuel and food demands provided that good management practices are adopted. However, the controversial act known as "land grabbing" has been causing negative media attention. "Land grabbing" is when developed economies purchase large amounts of fertile land in developing economies such as Africa. A 2012 report suggests that 66% of land grabs in Africa were for growing feedstocks.[147] Domestic farmers are unable to grow food crops, lowering food security within already resource-scarce economies.

An example of the food supply debate would be the use of cassava. Cassava is a popular ethanol feedstock due to its high starch content and high yield potential per hectare.[148] However, cassava is a staple food crop among the poor and rural households in many parts of Africa and Asia. Corn is widely used for food consumption and is often used in Canada and Europe as animal feed. A possible solution to this issue is to grow more non-food crops such as camelina, jatropha and mustard for biodiesel. Some of these crops are able to grow on marginal land that most food crops are unable to be cultivated on.

Food vs Fuel Debate - Food Prices

Developing economies are more sensitive to higher crop prices compared to developed economies. The Food vs Fuel Debate garnered global attention during the World Food Price Crisis in 2007-2008 where prices increased dramatically and caused great unrest around the world. There was a rapid increase in food prices, leading to several food riots in developing economies. Cereals, oils and fats were priced 2-2.5 times

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[147] EuropAfrica (2011), *(BIO) Fueling Injustice. Europe's responsibility to counter climate change without provoking land grabbing and compounding food insecurity in Africa,* http://www.csa-be.org/IMG/pdf_EuropAfrica_2011_Report.pdf

[148] FAO (Food and Agriculture Organization) (2013), *Biofuels and the sustainability challenge: A global assessment of sustainability issues, trends and policies for biofuels and related feedstocks*, http://www.fao.org/docrep/017/i3126e/i3126e.pdf

higher in 2008 compared to 2002-2004.[149] During the height of this crisis, the World Bank published a research paper in 2008 which found that food prices rose 35%-50% between 2002-2008, of which 70%-75% they attributed to biofuels. Large increases in biofuel production in the European Union and the United States were the driving force behind these changes. The other 25%-30% of price increases were due to high oil prices. An OECD economic assessment published the same year supported these findings, adding that governmental policies (e.g. import tariffs) further drove up food prices.[150]

However, there have been several more recent studies that disagree with the above findings. There is no doubt that a correlation between food and energy markets exists, but the strength of the correlation is widely disputed. Many argue that biofuels actually have little influence on food prices. In fact, the World Bank stated in 2010 that "the effect of biofuels on food prices has not been as large as originally thought" and that they had overestimated its impacts.[151] They released another publication in 2013 which stated that "most of the contribution to food price changes from 1997-'04 to 2005-'12 comes from the price of crude oil, which for maize and wheat is 52% and 64%, respectively".[152] It is difficult to determine the exact extent to which biofuels impact food prices mainly due to differing economic models, annual crop yields and statistics.

Greenhouse Gas Emissions

Reducing greenhouse gas emissions is one of the driving goals behind the implementation of biofuels in many economies. Feedstock crops can help offset emissions by directly removing carbon dioxide as they grow, therefore causing many to consider these fuels as emission-neutral. However, studies have been conducted that question whether or not biofuels truly reduce greenhouse-gas emissions compared to gasoline, and if so, by how much.

This question is extremely difficult to answer because studies vary widely in how and where they collect data, as well as how recently they were conducted. Life-Cycle

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149 FAO (Food and Agriculture Organization) (2013), *Biofuels and Food Security,* Committee on World Food Security, The High Level Panel of Experts on Food Security and Nutrition, http://www.fao.org/fileadmin/user_upload/hlpe/hlpe_documents/HLPE_Reports/HLPE-Report-5_Biofuels_and_food_security.pdf

150 OECD (Organization for Economic Co-operation and Development) (2008), *An Economic Assessment of Biofuel Support Policies*, http://www.oecd.org/tad/agricultural-trade/40990370.pdf

151 TJohn Baffes and Tassos Haniotis (2010), *Placing the 2006/2008 Commodity Price Boom into Perspective*, The World Bank, Development Prospects Group, http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1646794

152 Ethanol Producer Magazine (2015), 'End the Food vs Fuel Debate', 13 May 2015, http://www.ethanolproducer.com/articles/12221/end-the-food-vs-fuel-debate

Assessments take into consideration all input and output throughout the product's life cycle. Due to the vast amount of information, type of feedstock and processing methods, these studies have a wide disparity in results. For example, Farrell's meta-model analysis in 2006 found that maize produced in the United States emits 13% less greenhouse gasses than fossil fuels.[153] On the other hand, Liska's study in 2009 found that it actually had 48%-59% reductions in greenhouse gas emissions.[154]

The greenhouse gas balance of feedstock production varies greatly depending on the methods used to produce the feedstock and process the fuel. For example, nitrogen fertilizers are commonly used but have the negative consequence of releasing nitrous oxide. On average, 122kg/ha/year of fertilizers, 1.9 tons/ha of lime, 2.2kg/ha of herbicides and 0.16kg/ha of insecticides are applied to grow sugarcane in Brazil.[155] Harvesting is approximately 50% mechanized, further adding to the amount of greenhouse gases and pollution involved in growing this feedstock. Sugarcane fields are often burned to accelerate the harvesting process, releasing more carbon and nitrogen compound gases.

The development of fuel crops can also lead to a number of other secondary impacts that are often overlooked. The delivery of biofuels could stress transportation systems, with large biofuel plants requiring an estimated 16-20 tanker trucks or railcars per day to reach markets.[156] Palm oil is the most efficient feedstock source for biodiesel in terms of yield per unit of land, but could damage ecosystems if grown on environmentally sensitive lands. For example, Malaysia and Indonesia are the biggest palm oil producers but in these economies, oil palm is usually planted in drained peatlands. Peat soils are swampy areas that contain high levels of partially decomposed matter, accumulating high levels of carbon and acting as natural carbon sinks. Southeast Asia contains approximately 75% of the world's tropical peat-soil carbon.[157] If it were all drained and

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153 Alexander E. Farrell, Richard J. Plevin, Brian T. Turner, Andrew D. Jones, Michael O'Hare, and Daniel M. Kammen, (2006), *Ethanol Can Contribute to Energy and Environmental Goals*, http://alpha.chem.umb.edu/chemistry/ch471/evans%20files/group%201.pdf

154 Adam J. Liska, Haishun S. Yang, Virgil R. Bremer, Terry J. Klopfenstein, Daniel T. Walters, Galen E. Erickson, and Kenneth G. Cassman, (2009) 'Improvements in Energy Efficiency and Greenhouse Gas Emissions of Corn-Ethanol', *Journal of Industrial Ecology*, Vol 13, Issue 1, http://www.ethanolrfa.org/wp-content/uploads/2015/09/Improvements-in-Life-Cycle-Energy-Efficiency-and-Greenhouse-Gas-Emissions-of-Corn-Ethanol-.pdf

155 Isaias C. Macedo and Joaquim E.A. Seabra (2008), *Mitigation of GHG emissions using sugar cane in bioethanol,* http://sugarcane.org/resource-library/studies/Wageningen%20-%20Chapter%204.pdf

156 Tom L. Richard (2010), 'Challenges in Scaling Up Biofuels Infrastructure', *Science,* Vol 329, August 2010

157 ASEAN Secretariat and Global Environment Centre, *Peatlands in Southeast Asia – A Profile*, ASEAN Peatland Forest Project, http://www.aseanpeat.net/ebook/profile042012/Peat-A-Profile042012.pdf

released, it would be equivalent to 9 years of carbon emissions from global fossil fuel use.[158] Furthermore, emissions from palm oil cultivation in Indonesia accounted for 2%-9% of all tropical land use emissions from 2000-2010.[159]

The 'Blend Wall'

The term 'blend wall' is defined by the American Fuel and Petrochemical Manufacturers (AFPM) as the point in which renewables "exceed the volume that can be practically blended into gasoline and diesel fuel".[160] Moving beyond the blend wall and expanding the use of higher blend rates is very difficult and expensive. Fuel distributors must invest in infrastructure; fuel producers have to increase production rates and the public must change their consumption habits. Unfortunately, many retailers and oil companies are resisting investments into building blender pumps, storage tanks and other infrastructure to accommodate biofuels. New pumps and tanks must be made which the OECD estimated in 2012 to be USD$22,000-$100,000 per station in the United States.[161] Retailers are hesitant to invest in this infrastructure without some form of guarantee that they would see a positive return on investment.

The willingness of investors to finance these infrastructure changes depends largely on the perceived willingness of consumers to adopt the new technology. Consumer demand of biofuels depends highly on regional vehicle compositions. The majority of vehicles, boats and other modes of transportation have engines that are not compatible with fuels exceeding certain blend ratios. Higher blends would require significant changes to the existing vehicle fleet. Recently, more flexible-fuel vehicles are being developed which can use higher blends of ethanol such as E85. However, it takes an estimated 7 years for 50% of the vehicle fleet to change, making the adoption process extremely slow. The limited size of the current flexible-fuel vehicle fleet, lack of biofuel pumps and low price competitiveness make blending mandates difficult to implement.

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[158] PNAS (Proceedings of the National Academy of Sciencs) (2008), 'Climate regulation of fire emissions and deforestation in equatorial Asia', Vol 105. No 51, December 2008, http://www.pnas.org/content/105/51/20350.full.pdf

[159] Carlson, KM & Curran, LM 2013, 'Refined carbon accounting for oil palm agriculture: Disentangling potential contributions of indirect emissions and smallholder farmers' Carbon Management, vol 4, no. 4, pp. 347-349

[160] Global Warming (2015), 'Renewable Fuel Standard: Can EPA Regulate America Beyond the 'Blend Wall'?', 16 June 2015, http://www.globalwarming.org/2015/06/16/renewable-fuel-standard-can-epa-regulate-america-beyond-the-blend-wall/

[161] Frank Rusco (2012), *Biofuels Infrastructure in the United States: Current Status and Future Challenges,* OECD (Organization for Economic Co-operation and Development), http://www.oecd.org/futures/Biofuels%20Infrastructure%20in%20the%20United%20States%20Current%20Status%20and%20Future%20Challenges.pdf

Most automotive companies are extremely opposed to high blend rates, arguing that it damages vehicles. The Coordinating Research Council (CRC) of the United States conducted a test in 2010 funded by the automobile and oil industry. It examined the effects of higher blends such as E15 and E20 gasoline finding that it did cause poor engine performance, emission and durability.[162] Contrary to the CRC's findings, the United States Energy Department ran its own research on E15 fuel and found no significant loss of vehicle performance.[163] These conflicting findings further complicate the issue of biofuels and stakeholder groups are very divided on the issue.

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162 CRC (Coordinating Research Council) (2010), *E15/E20 Tolerance of In-Use Vehicle OBD-II Systems*, http://www.crcao.com/news/Mid%20Level%20Ethanol%20program/index.html

163 U.S. Department of Energy (2012), *Getting It Right: Accurate Testing and Assessments Critical to Deploying the Next Generation of Auto Fuels*, http://energy.gov/articles/getting-it-right-accurate-testing-and-assessments-critical-deploying-next-generation-auto

Chapter 5 Implications: Effectiveness and Challenges of Policies to Lower Oil Demand in Transport Sector

Given heightening global commitment to reduce greenhouse gas emissions, it is becoming more important than ever to curb or decrease oil consumption. While conversion from oil to clean energy such as natural gas and renewable energy has been already carried out in the industry sector and power generation, replacement of oil with alternative fuels in the transport sector has not made progress as much as the others due to obstacles such as costs and technology. Accordingly, oil is likely to remain a major fuel in the transport sector in the medium- and long-term. What is difficult to substitute other energy sources for oil particularly in the road transport makes it more meaningful to reduce oil demand itself or improve fuel use efficiency. Transport oil demand reduction will not only contribute to mitigation of climate change but also to reduce waste of valuable underground assets for economies endowed with oil reserves and exposure to oil supply disruptions and oil purchase for oil importing economies.

This report presented several policies and measures which are expected to help reduce oil demand in road transport although they are not exclusive and there are more potential policy options. It does not seem reasonable to evaluate which policy or measure works better than the others because effectiveness of these policies depends on regional characteristics such as degree of urbanization, economic development, public transport system development, current vehicle ownership and its future perspective, and whether it is implemented by national and/or local governments, sometimes with cooperation of the private sector. Identifying a measure that is feasible and suitable to a community from diverse options is rather important. The following part attempts to give thought to the effectiveness of policies in terms of usefulness to cope with oil supply disruptions, ease of implementation, and cost of implementation, and then notes some challenges.

Effectiveness

Facing oil supply disruptions as a result of natural disaster or geopolitical risks, measures such as rationing (fuel allocation) and mandatory vehicle use control could have high effectiveness. The public is more likely to support these measures but only if they are established on a temporary basis. They may not be appropriate as a long-term strategy since people would find a loophole in the scheme. As for the rationing program, it is critical for the government to provide the public with information about how and when the government plans to fix the oil supply disruptions and restore the regular market so that the public will not panic. Although they are mainly utilized for emergency situations, pre-planning is still essential since they should be ready to implement on short notice.

Carpooling, eco-driving, and labelling have the highest ease of implementation because they are less likely to meet high public opposition and do not require substantial investments. The critical point in implementing these programs is that information is provided to the public in a way to gain interest or encourage participation. Success of these measures relies largely on awareness or judgment of consumers, which consequently affects how much oil would be saved. On the contrary, the policies which are not easy to implement due to highly possible consumer resistance but are expected to restrain oil demand considerably are pricing and taxation measures and fuel subsidy reductions. They are also financially advantageous since the former would increase revenues of the government whereas the latter would reduce financial burden on the government or national oil company.

Improving access to public transport is also very effective but expensive to implement. To make the public transport system useful, urban planning needs to be well- and pre-planned. Additionally, convenience of using public transport such as scheduled frequency, spatial coverage, and comfort has to be incorporated in order to persuade private vehicle drivers to shift their travel mode to public transport.

Challenges

Further efforts to develop and facilitate alternative transport fuels such as biofuels, electricity, and hydrogen are necessary to reduce dependence on oil in the transport sector as the other sectors have shifted to clean energy. Obligating alternative transport fuel use may accelerate such development. While biofuels have already been introduced in many economies, the use of clean energy vehicles is still relatively low. As the scenario analysis of Chapter 3 demonstrated, substantial oil demand reductions would result if economies implement fuel economy standards and set specific national targets for the deployment of clean energy vehicles. Two scenarios of 1% improvement of fuel economy of passenger vehicles and 1% expanded share of clean energy vehicles did not result in substantial differences in the oil demand trend towards 2030. While the share of clean energy vehicles in the transport sector is unlikely to increase significantly in the near future, fuel economy standards may be easier to implement and can play an important role in improving fuel efficiency. As a result, mandatory fuel economy standards for domestically manufactured and imported new passenger vehicles sold are most likely to make a difference in transport oil demand in the future.

Securing finances to make a plan feasible is always a challenging issue under budget constraints. Some measures that necessitate infrastructure development require a certain commitment of investment. The alternative transport fuels especially need financial support in production and sales in the form of subsidies and tax credits, infrastructure development, and R&D due to lack of economics as these fuels are still in the phase of development. In the long-term perspectives, the R&D programs are essential to help advance technology which alleviates or removes obstacles of vehicles running on alternative fuels. Overcoming financial problems is critical to foster measures to reduce oil demand in road transport.

As for administrative tasks, there is a need to coordinate among the national and local governments and agencies, and involve the private companies if necessary in order to enhance effectiveness of policies and benefit the public and the local community. At the national level, for example, multiple ministries that are responsible for energy, land transport, or the environment could be related to policy development on oil demand reduction in road transport. Vertically divided administration may hinder policy decision or cause inefficiency in implementation. If a focal point which plays a role to coordinate is designated, the responsible agent would help to lower vertical and horizontal barriers among the participants. Such organizational arrangement is expected to facilitate policy implementation and increase transparency in the administrative process after all.

Lastly, the government is required to keep consistent policies regardless of oil price fluctuations to show a firm commitment. Priority on measures to curb oil demand could be influenced by oil prices. When the oil price is high and volatile, these measures could be actively pursued. Conversely, priority would be put on other policies if the oil price is relatively low and stable. A reliable stance of the government is also one of the favorable conditions for investors. Continuous government support will be a foundation to restrain oil demand, enhance oil security, and tackle greenhouse gas emissions.