Executive Summary

1. Background and Objectives

The electrification of mobility is now in fashion and some countries are announcing bans on internal combustion engines. From the viewpoint of production to consumption of energy, electric cars are not always zero-emission vehicles, if the supplied electric power comes from fossil resources. In addition, the spread of electric supply stations is indispensable to the introduction of electric vehicles. However, the rapid expansion of supply stations is difficult.

On the other hand, vehicles with improved fuel efficiency like hybrid and plug-in hybrid electric cars have appeared and those cars are also effective for the reduction of greenhouse gas (GHG) emissions. Conventional infrastructure can be made available for these cars and the reduction of GHG emissions can be expected by the promotion of biofuels that are produced from domestic resources in East Asia Summit (EAS) countries. Further the improvement of emissions reduction can be expected by increasing the proportion of biofuels.

Against this background, this report investigates the following two subjects: (1) evaluation of CO_2 emissions reduction by mobility electrification, and (2) supply potential of next generation biofuels from non-conventional resources during fiscal years 2018–2019. In the first subject, the best way of effective GHG emissions reduction is clarified based on scenarios assuming various electrified vehicles ([xEV]: hybrid electric vehicles [HEV)] plug-in hybrid electric vehicles [PHEV], and battery electric vehicles [BEV]) and the introduction of biofuels. The second subject discusses the high concentration of biofuels in perspective, the supply potential of unconventional biomass resources, biofuel production from unconventional biomass, and life cycle assessment (LCA) for biofuel production.

Based on these results, we propose the possibilities on the reduction of energy consumption in the transport sector and the introduction of next generation biofuels in the EAS countries. The outcome will contribute to the EAS energy research roadmap (Pillar 3: Climate Change Mitigation and Environmental Protection Corresponding to ASEAN Plan of Action for Energy Cooperation (APAEC) 2016–2025, 3.5 Programme Area No.5: Renewable Energy, and 3.6 Programme Area No.6: Regional Energy Policy and Planning).

2. Methodology

The working group consisted of invited energy experts, including policymakers and engineering scientists from each country. This study covers the following topics.

2.1. Evaluation of CO_2 emissions reduction by mobility electrification

Energy and electric vehicle-related policies and basic information were investigated in three countries (India, Indonesia, and Thailand). The governments' xEV introduction targets (how many, by when) were identified to settle the conditions for a scenario simulation based on the information collected. Some scenarios for the xEV mix simulation

were proposed by considering all the types of xEVs to find out a reasonable and most effective xEV mix. The effectiveness of xEV mix scenarios in terms of the reduction of oil consumption and CO_2 emissions whilst using biofuels and natural gas was evaluated. The total cost of the introduction of xEVs, including infrastructure cost, was also compared to judge and propose the most appropriate solution as a policy recommendation.

We also surveyed governments' efforts for introducing motorised vehicles in the Philippines.

2.2. Supply potential of next generation biofuels from non-conventional resources

In Indonesia, the amount and production area of forest resources, agricultural waste, municipal solid waste (MSW), and algae available for power generation and biofuel production were investigated. In addition, we surveyed the development status of next-generation biofuel production technology.

Promising non-conventional raw materials for producing bioethanol were clarified based on their composition. Factors that are effective for reducing potential energy consumption and GHG emissions in the bioethanol manufacturing process from non-conventional raw materials were also examined. The environmental impact assessment of biofuel production was investigated by LCA.

3. Results and Discussion

3.1. Evaluation of CO_2 emissions reduction by mobility electrification

We analysed current and future energy issues of the introduction of electric vehicles of each country based on the supplied data from three countries (India, Indonesia, and Thailand) and discussed possible measures. The simulation was carried out by setting the scenario for each country according to the actual situation of each country. Summaries are shown below.

India

Electrified vehicle and alternative fuel introduction scenarios:

- Business as Usual (BAU) Scenario (Base)
  In this scenario, the status quo is maintained and is characterised by the continuation of the existing trends.
- Alternative Fuels Scenario (AFS)
  This scenario is characterised by policy impetus for increasing the share of compressed natural gas (CNG)-fuelled vehicles coupled with the attainment of increased targets for ethanol blending with petrol and biodiesel blending with diesel.
- Moderate Electrification Scenario (MES)
  In the medium electrification scenario, the electrification target is reasonably high compared to the BAU scenario. This scenario covers the increasing adoption of

battery electric vehicles (BEVs) and hybrid electric vehicles (HEVs). Electrification takes place across all categories of road vehicles including taxis, passenger cars, tricycles, and buses.

- Aggressive Electrification Scenario (AES)
  In this scenario, the electrification target is much higher than the BAU scenario and includes the active adoption of battery electric vehicles (BEVs) and hybrid electric vehicles (HEVs) for passenger mobility. Electrification levels will be higher across all categories of road vehicles including taxis, passenger cars, tricycles, and buses.
- Moderate Electrification cum Hybrid Promotion Scenario (HPS)
  In the HPS, the share of new sales of hybrid electric vehicles is higher than that of MES.
- Aggressive Electrification condition and Only Electrification Scenario (OES)
  This scenario is a hybrid of the BAU scenario and the aggressive electrification scenario described above.

Results based on simulation:

- The electrification scenarios alone do not have much effect in reducing CO_2 emission levels.
- The alternative fuels scenario (AFS) and moderate electrification cum hybrid promotion scenario (HPS) have the maximum impact in terms of CO_2 emissions.
- The electrification scenario shows a reduction in CO_2 emissions from tank-to0wheel, but it leads to a reduction in CO_2 emissions when the EV's additional electricity demand is met by electricity generated from renewable energy.
- In this study, the penetration of xEV is assumed mainly in the two-wheeled, three-wheeled vehicles, and automotive segments. Heavy commercial vehicles, light commercial vehicles, and buses account for about 70% of the transport sector’s energy consumption in India. The reduction of energy consumption in this category is an important issue for the future.
- The existing installed capacity of the Indian power sector is in excess of demand. In order to realise power supply with renewable energy in this situation, the increase in power demand due to the introduction of electrified vehicles can be the driving force.

Thailand

Electrified vehicle and alternative fuel introduction scenarios:

- Business as Usual (BAU) Scenario (Base)
  Refer to the current trend of the road transport system plus the success of Thailand's biofuel policy including ethanol share shift to gasohol E15 and biodiesel B7.6 for commercial grade diesel, and the introduction of 1,800 hybrid buses.
- Alternative Fuels Scenario
  Gasohol E20 and Biodiesel B10 will succeed in the market in 2037.
- Plug-in xEVs Expansion (1.2 million xEVs) Scenario
  On-road plug-in xEVs (PHEV:BEV = 50:50) achieve 1.2 million units by 2036.
- Hybrid Expansion Scenario (HEV Thailand Board of Investment Plan)
  Total HEV sales achieve 320,000 units by 2023, and 4.7 million units by 2036.
- Hybrid Expansion Scenario (HEV Extreme)
  HEVs dominate 50% sales of passenger cars (gasoline originated) by 2036, noted 7.1 million on-road HEVs by 2036.
- Combination Scenario
  The following two cases were simulated:
  (1) Combination of Alternative Fuels and HEV BOI promotion
  (2) Combination of Alternative Fuels and extreme HEV expansion

Results based on simulation:

- The impacts of energy efficiency of HEV is higher than the difference in well to tank emissions between fossil fuel and biofuels.
- The share of diesel cars will be reduced with increasing EVs share (biodiesel reduced; ethanol increased).

Indonesia

Electrified vehicle and alternative fuel introduction scenarios:

- Business as Usual (BAU) Scenario (Base)
  This scenario assumes that biofuel use will be maintained at 2018 conditions. The simulation conditions are 0.5% per year fuel economy improvement, no CNG vehicle introduction and 2015 biodiesel directive up to B20, but no ethanol use for all new vehicles of a certain manufacturing year.
- Biofuel Scenario
  The mandatory biodiesel content of diesel blends was set to 30% by 2020 and bioethanol content in gasoline measures was set to 10% by 2020 and 20% by 2025. The conditions of the simulation are 0.5% per year fuel economy improvement of all vehicles, no introduction of CNG vehicles, implementation of biodiesel directive up to B30 and bioethanol directive up to E20, motorcycles are compatible with ethanol.

Furthermore, simulations were performed under the conditions of B30 introduction and no bioethanol introduction and B20 and E20 introduction.

- CNG Implementation Scenario
  The scenario included using CNG for heavy vehicles and taxis. CNG heavy vehicles in the five major cities accounted for 48% of the new heavy vehicles and all taxi sales were assumed to be CNG-based. In this scenario, the introduction of CNG heavy-duty vehicles and taxis were combined with the implementation of the Biofuels Directive and the government's EV plan. The parameters of this scenario are fuel economy improvement of 0.5% per year for all vehicles, 48% of all new taxis, buses, and trucks in the cities of Palembang, Bandung, Medan, Jakarta, and Surabaya being CNG capable the introduction of B30 and E20, and government EV plans.
- Vehicle Electrification (xEV) Scenario
  It investigates a government plan to introduce an electric-based vehicle (xEV) consisting of a battery electric vehicle (BEV), a hybrid electric vehicle (HEV), and a plug-in hybrid electric vehicle (PHEV). As an individual xEV change scenario, we simulated a modified EV plan assuming that the xEVs of all private cars are HEVs, PHEVs, and BEVs, respectively.

Results based on the simulation:

- In comparison by transportation fuel type, CO_2 emissions from electricity is significantly higher.
- PHEV and BEV acceleration scenarios have only slightly higher CO_2 emissions than HEV acceleration scenarios.
- The effect of reducing oil consumption is in the order of bioethanol introduction >> CNG > xEV ~ biodiesel.

Recommendations

Based on the results of the simulation, the working group made the following recommendations regarding the effective introduction of electrified vehicles common to all countries.

(1) The combination of vehicle electrification (xEV mix basis) and alternative fuels utilisation, such as biofuels, should be promoted as it is the most effective in reducing oil consumption and/or CO_2 emissions.

(2) xEV mix (including HEV) consideration for vehicle electrification has a positive effect on promoting the use of biofuels.

(3) The use of CNG as an alternative fuel for heavy duty vehicles, in combination with the electrification of light duty vehicles is a reasonable solution for reducing oil consumption/CO_2 emissions by replacing diesel fuel mainly.

(4) The known effect of BEV introduction on oil consumption and/or CO_2 emissions reduction is limited as BEVs are type of new vehicle population.

(5) Well-to-wheel basis CO_2 emissions of BEV are not always lower than HEV (or even compared to internal combustion engine vehicles) depending on the CO_2 emissions of power generation and reducing CO_2 emissions of power generation is an issue.

(6) The cost of implementation is lower with a combination of xEV mix and alternative fuels utilisation due to the higher costs of the introduction of BEVs with charging infrastructure construction, cost effectiveness of oil consumption and/or CO_2 emissions reduction as well.

In addition, it is presumed that the demand for each type of biofuel will change in the future with the introduction of electrified vehicles. The policy of electrified vehicle introduction should be discussed together with the power generation plan and biofuel introduction policy.

3.2. Supply potential of next generation biofuels from non-conventional resources

In this topic, members focused on two subjects: (1) the promising resources for producing next generation biofuel, and (2) the optimum process selection for producing bioethanol. The conclusions are shown as follows:

The promising resources for producing next generation biofuel

- Non-conventional resources for biofuel production in Indonesia were investigated.
- Supply potential is limited to several areas. The Riau province of central Sumatra has the greatest potential.
- Non-conventional resources for biofuel production include forest residues, wood processing waste, and agricultural waste.
- The availability of wood processing waste depends on its type and the area where it is discharged.
- As agricultural waste, rice straw, rice husk, empty fruit bunch, and palm frond are expected to be supplied in a considerable amount.
- To produce gasoline and diesel fuel, co-processing of palm oil and palm-derived bio crude oil with petroleum fractions have been developed at petroleum refineries.
- Ethanol production from lignocellulose is currently only working on small-scale test plants.
- Municipal solid waste (MSW) is mainly disposed of in landfill sites, causing environmental problems. MSW may be used as an energy resource for power generation. Therefore, the utilisation of MSW can contribute to global warming gas emissions control at power generation by the control of coal use.
- Indonesia has a long coastline, so it is suitable for algae cultivation and fuel production from algae. However, fuel production from algae is only at the research stage.

The optimum process selection for producing bioethanol

- There are many non-conventional biomass types that can be expected to yield ethanol comparable to starch crops.
- Productivity of lignocellulosic ethanol is difficult to estimate accurately because

there are many development factors in the whole process.

- Many elemental technologies are currently under development.
- Estimated ethanol yield is 30%–40% of lignocellulosic biomass (dry base). By the utilisation of pentose (C5 sugar), the ethanol yield can be improved (1.4 times as compared with the case of using only hexose).

- By utilising lignin, the environmental impact can be reduced, and economics can be improved.
- When lignocellulose ethanol is used at high concentrations, the effect of GHG emissions on ethanol production becomes larger. For ethanol production, it is more important to select raw materials and optimisation of processes with less environmental impact.

3.3. Recommendations

- The supply potential of non-conventional biomass resources depends on the region. Therefore, the location of the fuel production facility should be considered in consideration of the biomass production area.
- Most production technology of next generation biofuel from non-conventional resources is still at the research and development stage. Therefore, research and development should be continued to provide data that can accurately estimate production efficiency, environmental compatibility, and economy.
- In the short term, reducing the ratio of fossil fuels in stages is effective for alleviating the environmental impact. Energy production by sharing non-conventional biomass and fossil resources is a practical method as it does not require high-hurdle technology. Specifically, liquid fuel production by co-processing palm oil or bio crude oil derived from palm oil and petroleum, co-gasification or co-firing power generation of biomass and coal may be mentioned.

4. Conclusion as Policy Recommendations

Passenger cars are the mainstream of the current introduction of electrified vehicles. In order to reduce energy consumption and greenhouse gases in the transport sector as a whole, it is necessary to take measures for each genre of passenger cars, heavy commercial vehicles, and motorcycles.

For the introduction of electrified vehicles, HEVs that can actively utilise biofuels without being restricted by infrastructure should be introduced in the short term. Along with the development of charging infrastructure, PHEVs should be introduced in the medium to long term.

Currently, the introduction cost of electrified vehicles is high. As a solution to this, incentives should be given to reducing vehicle acquisition taxes and introducing electrified vehicles by strengthening taxation on existing vehicles.

Motorcycles are mainly used for short trips in cities and are suitable for electrification. Since there are many registered vehicles in the Association of Southeast Asian Nations (ASEAN) region, we should actively promote electrification.

Natural gas is a promising alternative to petroleum diesel fuel for heavy duty commercial vehicles, where it is difficult to take environmental measures by electrification. Since natural gas can also be used as a fuel for civilian use, the development of supply stations should be planned, together with the development of urban infrastructure.

The effect of reducing greenhouse gas emissions by electrified vehicles strongly depends on the energy composition of power generation. Breaking away from coal-fired power is the key to success.

The introduction of biofuel is effective in reducing GHG emissions and oil consumption. Combined with the electrification of vehicles, a synergistic effect can be obtained. In order to be competitive in terms of price, it is necessary to continue to consider incentives for biofuel supply and the reduction of fuel tax for consumers.

The current electrification of vehicles is mainly to replace gasoline passenger cars. As the replacement of diesel vehicles with electrified vehicles progresses, it is expected that the demand for biodiesel fuel will change to bioethanol fuel. In response to changes in demand for biofuels, it is necessary to balance production and inventory in domestic markets and import and export in ASEAN to balance the supply and demand.

The next-generation fuel, lignocellulosic ethanol, has not yet been fully optimised for production processes or demonstrated on a commercial scale. In the future, we should search for biomass resources that bring about high productivity, establish energy-efficient production processes with high production efficiency, reduce energy consumption in production processes by using by-products (lignin), and create production sites to ensure economic efficiency. It is necessary to consider economic improvement by site selection and combined use of first-generation raw materials to improve productivity.

Instead of plantation development, which sometimes causes environmental damage, we must consider the use of agricultural and forestry waste.

The electrification of vehicles and the introduction of biofuels should be promoted according to a firm policy based on a medium- to long-term perspective that is not influenced by the political situation at the time. Accurate data collection from the transport and agriculture and forestry sectors are also essential for the calculation when formulating policies.