# Chapter 5

# Concept of Energy Supply Management

## 5.1. Research Background and Objective

Brunei Darussalam has abundant reserves of natural resources such as oil and natural gas, but its economy is excessively dependent on them. It plans to move away from a resource-dependent economic structure to avoid a substantial effect on the domestic economy from fluctuations in crude oil prices or a change in the intent of the countries to which the resources are exported, and to prevent an increase in $CO_2$ emissions.

To prevent global warming, the Intergovernmental Panel on Climate Change (hereafter IPCC) is leading the approach to decarbonising. As a global trend, the use of hydrogen energy has received a lot of attention recently, in addition to the introduction of renewable energy sources.

Since Brunei has many potential renewable energy sources and a great amount of hydrogen is generated when oil and natural gas are refined, effective use of those energy resources is required.

This chapter will review the utilisation policy for renewable energy and hydrogen energy resources, the introduction effect, roadmap, and so forth, considering the economy and energy conditions in Brunei.

## 5.2. Economic and Energy Conditions in Brunei Darussalam

### 5.2.1. Economic Conditions in Brunei Darussalam

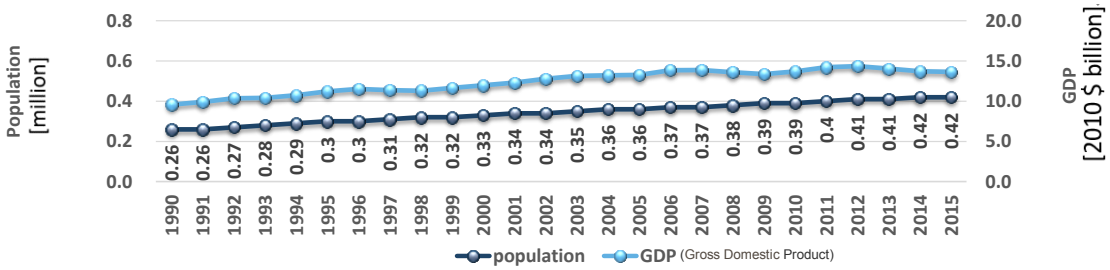
In Brunei's economy, resource prices fell broadly because of the worldwide financial crisis in 2008 and 2009, so economic growth was negative. In 2010, oil prices recovered and the economic growth was positive in 2011. However, production of oil and natural gas did not increase as much as expected in 2012 and 2013, so economic growth was negative. These are shown in the Figure 5.1.

Oil prices declined steeply worldwide in 2015, and the fall continued in 2016, forcing Brunei's government to reduce the budget.

### 5.2.2. Energy Conditions

The latest values for reserves, production volume, and export volume of oil and natural gas are in Tables 5.1. The relationship between production and export volume shows that most of the production volume is exported.

**Figure 5.1: Economic Conditions in Brunei Darussalam**




Source: IEA, *World Energy Statistics, 2018* : International Energy Agency
https://webstore.iea.org/world-energy-statistics-2018

**Table 5.1: Oil and Natural Gas Reserves, Production, and Exports**

| Type | Item | Details |
|---|---|---|
| **Oil** | Reserves | 1.1 billion barrels (2016) |
| | Production volume | 121,000 barrels/day (2016) |
| | Export volume | 130,000 barrels/day (2015) |
| **Natural gas** | Reserves | 300 billion cubic meters (2016) |
| | Production volume | 11.2 billion cubic meters (2016) |
| | Export volume | 8.3 billion cubic meters (2016) |

Note: All amounts are approximate.

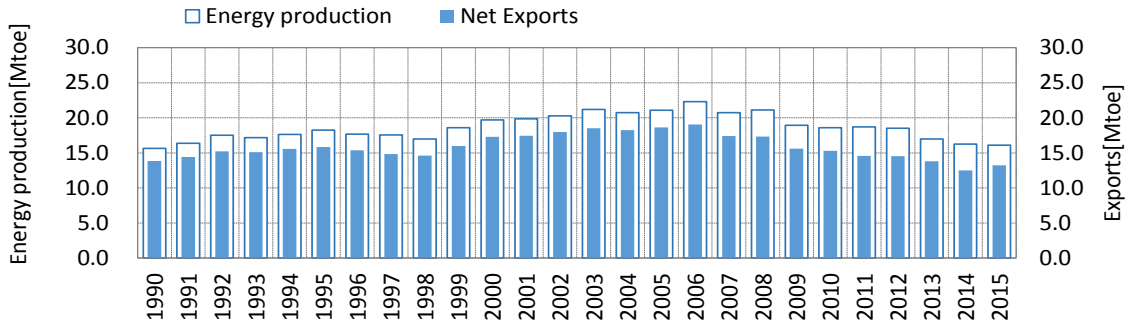
Source: MOFA, *World Statistics,* Wakamatsu-cho, Shinjuku-ku, Tokyo: Statistics Bureau, Ministry of Internal Affairs and Communications.
https://www.mofa.go.jp/mofaj/area/brunei/data.

**Table 5.2: Brunei Darussalam Exports, 2016**

| Type | Details |
|---|---|
| **Item** | Oil, liquefied natural gas. (approx. 88%); machinery and transport equipment, etc. (approx. 5%); others (approx. 7%) |
| **Export counterpart** | Japan (35.5%), Republic of Korea (13.8%), India (9.3%), Thailand (8.9%), Singapore (6.6%) |

Source: MOFA, *World Statistics,* Wakamatsu-cho, Shinjuku-ku, Tokyo: Statistics Bureau, Ministry of Internal Affairs and Communications.
https://www.mofa.go.jp/mofaj/area/brunei/data.

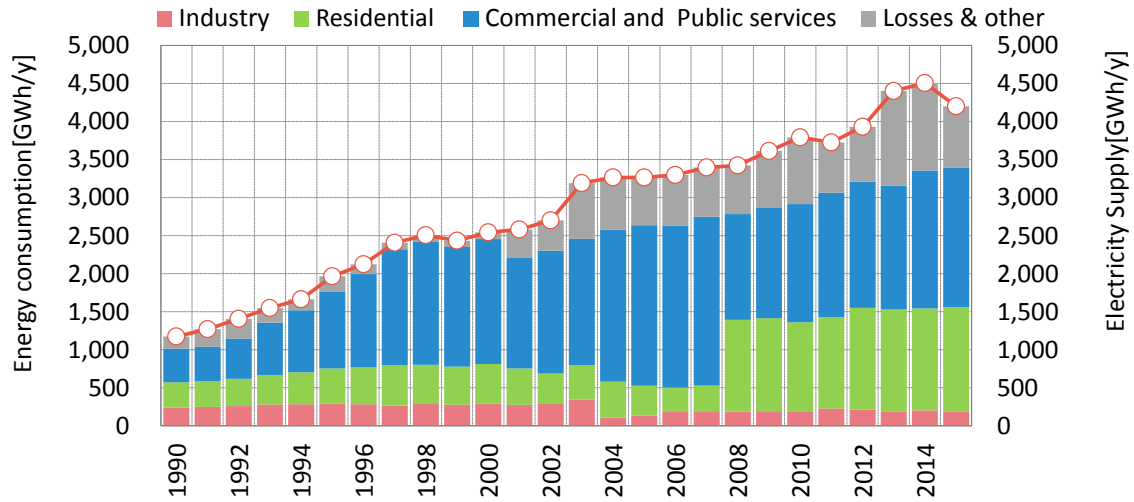
**Figure 5.2: Change in Energy Production Volume and Export Volume in Brunei Darussalam**




Mtoe = million tons of oil equivalent.
Source: IEA, *World Energy Statistics, 2018* : International Energy Agency
https://webstore.iea.org/world-energy-statistics-2018

On the other hand, energy consumption increases year after year. Figure 5.3 shows that the energy consumption volume for industrial use remained flat while the energy consumption volume for residential use increased. Brunei has seen a remarkable increase in losses and other items since 2000, exceeding 10%, which indicates poor efficiency. However, this ratio exceeds 10% in all Southeast Asia countries.

**Figure 5.3: Change in Energy Consumption**




GWh = Gigawatt hours.
Source: IEA, *World Energy Statistics, 2018*: International Energy Agency
https://webstore.iea.org/world-energy-statistics-2018

### 5.2.3. Target in the Future of Use in Energy

Brunei aims to reduce the amount of energy used in 2035 by 63% in comparison with the business-as-usual scenario (BAU) of 2005. The Energy white Paper in Brunei by Energy Department, updated in 2014, shows that the electricity-generating capacity of renewable energy sources will account for 10% of total power generation by 2035.

With high levels of solar radiation, Brunei plans to promote the introduction of photovoltaic power generation and replace diesel power generation in Temburong with photovoltaic power generation by 2019. In parallel, the introduction of waste power generation will be promoted as industrial waste has adverse effects because of the small size of the country.

Brunei encourages renewable energy sources, such as a photovoltaic power generation demonstration project, and a feed-in tariff scheme (0.25BND/kWh) for renewable energy is in place. As this scheme enables the government to buy electric power from local solar power generation firms and ordinary households with solar panels, the promotion of introduction of renewable energy is expected.

## 5.3. Latest Hydrogen Technical Trends

### 5.3.1. International Hydrogen Supply Chain Experimental Project

Brunei is an oil and gas producing country, and its economy is heavily dependent on the export income of oil and Liquefied Natural Gas (LNG). However, a project has started that is to extract hydrogen from by-product gas generated when gas is liquefied and to export all its hydrogen to Japan. Use of this hydrogen is carbon-free.

In an attempt toward building an international hydrogen supply chain by 2020, which is expected to be the next generation power source, the New Energy and Industrial Technology Development Organization is conducting the experimental business of exporting hydrogen from Brunei to Japan. Construction on the hydrogenation plant began on 21 April 2018 (Figure 5.4).

The cost of transporting hydrogen is an issue in building a hydrogen supply chain. To store and transport hydrogen, it needs to be compressed at about 700 atm (standard atmosphere: 1 standard pressure (1 atm = 101.325 kPa) ) or cooled to –252.9 degrees Celsius to become liquid. Since these processes are expensive, more affordable technology and techniques for transporting hydrogen in normal conditions need to be developed.

**Figure 5.4: Hydrogenation Plant in Brunei Darussalam and Dehydrogenation Plant in Kawasaki**

Hydrogenation plant in Brunei Darussalam

Dehydrogenation plant in the coastal area of Kawasaki

Source: New Energy and Industrial Technology Development Organization.
http://www.nedo.go.jp/english/

### 5.3.2. Hydrogen Production Technology

The latest technical trends of hydrogen technology to date are summarised based on the assumption that the hydrogen technology will be introduced to Brunei in the future. Hydrogen production technologies are roughly divided into hydrocarbon-based hydrogen (by-product hydrogen, natural gas reforming) and $CO_2$-free hydrogen (utilisation of renewable energy). Table 5.3 lists further-segmented categories.

In Brunei, hydrogen is produced by steam reforming, based on the gas generated by Brunei LNG (Liquefied Natural Gas)'s plant. Hydrogen could also be produced using renewable energy or biomass.

### 5.3.3. Hydrogen Energy Introduction Case

Advanced cases for hydrogen energy introduction are collected and summarised. The main cases are shown below.

**(1) Nagasaki Huis Ten Bosch in Japan**

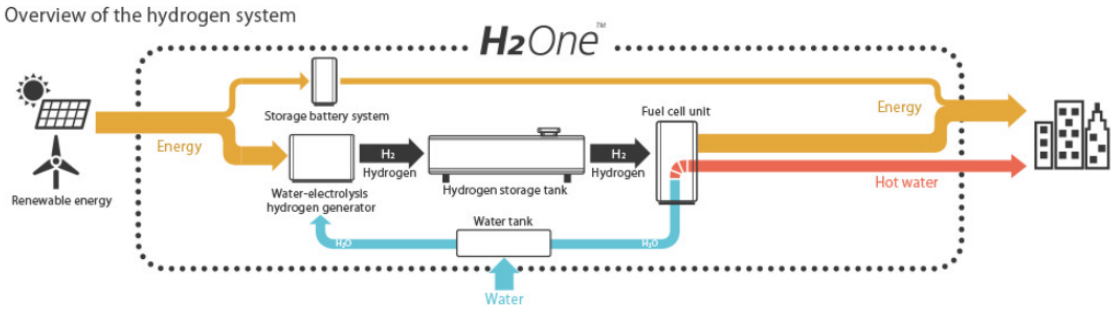
As a popular model for an area without sufficient energy infrastructure, a hotel in Huis Ten Bosch produces and stores hydrogen using surplus photovoltaic power in summer when the days are long and generates power through fuel cells in winter. It uses the stored hydrogen to supply electric power to the hotel building throughout the year.

**Table 5.3: Hydrogen Production Technologies Outline**

| Item | Practical viability stage | Stability | Environment | Economy |
|---|---|---|---|---|
| **Hydrogen as by-product** | Many types have already been introduced. | Depends on production volume of original target products. | $CO_2$ is emitted but there is no additional environmental load. | Economic because secondarily produced products are used. |
| **Fossil fuel reforming** | These have already been introduced and are now in the practical stage. | Stable and large-scale production is possible. | $CO_2$ is emitted unless CCS is used. | Technically established, and production is possible at comparatively low price. |
| **Water electrolysis (Thermal plant)** | | | $CO_2$ is emitted during power generation unless CCS is used. | More expensive than natural gas reforming, but comparatively inexpensive. |
| **Water electrolysis (renewable energy)** | Technically established, but costs for power generation using renewable energy must be reduced. | Output may fluctuate depending on the type of renewable energy. | $CO_2$ is not emitted. | Generally expensive because renewable energy is used. |
| **Biomass** | Technically established but the problem is low-cost operation. | Supply places are dispersed. | $CO_2$ emission amount can be regarded as zero. | Costs are high at present. |
| **Heat decomposition** | R&D stage (partially demonstrated). | Stable supply is possible. | Varies, depending on sources of heat to be used. | |
| **Photo catalyst** | Basic research stage (current conversion efficiency is about 0.5%.) | Depends on weather conditions. | $CO_2$ is not emitted. | |

CCS = Carbon dioxide Capture and Storage, $CO_2$ = carbon dioxide, R&D = research and development.
Source: Study team.

**Figure 5.5: System Configuration**




Source: Toshiba. Toshiba Energy Systems and Solutions Corporation.
https://www.toshiba-newenergy.com/en/products/

### (2) Port Island in Kobe in Japan

Electric power and exhaust heat obtained from the hydrogen mixed-combustion gas turbine are supplied to the main facilities of manufacturing industry in Kobe City. The hydrogen mixed-combustion gas turbine supplies electricity (about one-quarter of the total electric power of 4,500 kilowatts [kW] for four facilities and 15% of the annual electric power) and heat (35% of the total heat demand and 55% of the annual heat demand).

Although the gas turbine outputs 1,800 kW (Maximum) using 100% utility gas, the output in the case of hydrogen mixed combustion is reduced to 1,100 kW. Further, countermeasures against NOx (Nitrogen Oxide) must be taken (spraying steam) during hydrogen mixed combustion. The spraying spot should be adjusted to prevent a decrease in efficiency.

**Figure 5.6: Hydrogen Production and Supply Facility**

Source: New Energy and Industrial Technology Development Organization.

### 5.4. Proposal for Use and Application of Renewable Energy and Hydrogen Energy in Brunei Darussalam

#### 5.4.1. Use and Application of Renewable Energy

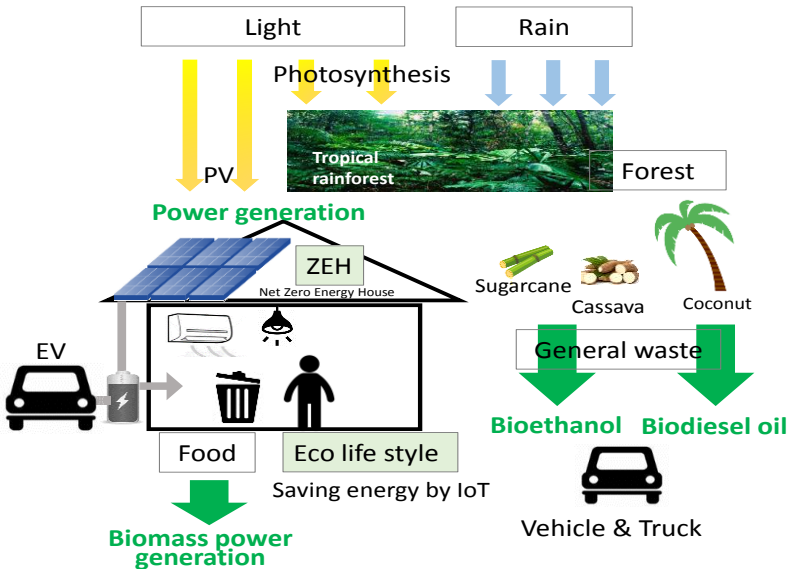
Brunei is naturally rich in sunlight, rain, and forests, and this study assumes effective use of those resources. The creation of new industries (domestic industries) instead of oil and natural gas based business, and the diversification of energy sources (a combination of renewable and hydrogen energy), are required in the future. Therefore, this study proposes a local energy production model for local consumption, in combination with natural energy and the latest low-carbon technology. The proposal is as follows:

- If it takes long to introduce the latest technology, the people should promote to change daily life to eco lifestyle.
- Use of fossil fuel based energy will be reduced by using renewable energy (photovoltaic generation) and promoting ZEH.
- Electric power obtained by photovoltaic generation will be stored and used for households and electric vehicles.
- Residential waste, coconuts will be used for power generation and fuel for vehicles as biomass energy.

#### 5.4.2. Roadmap Showing Achievement of Eco Town

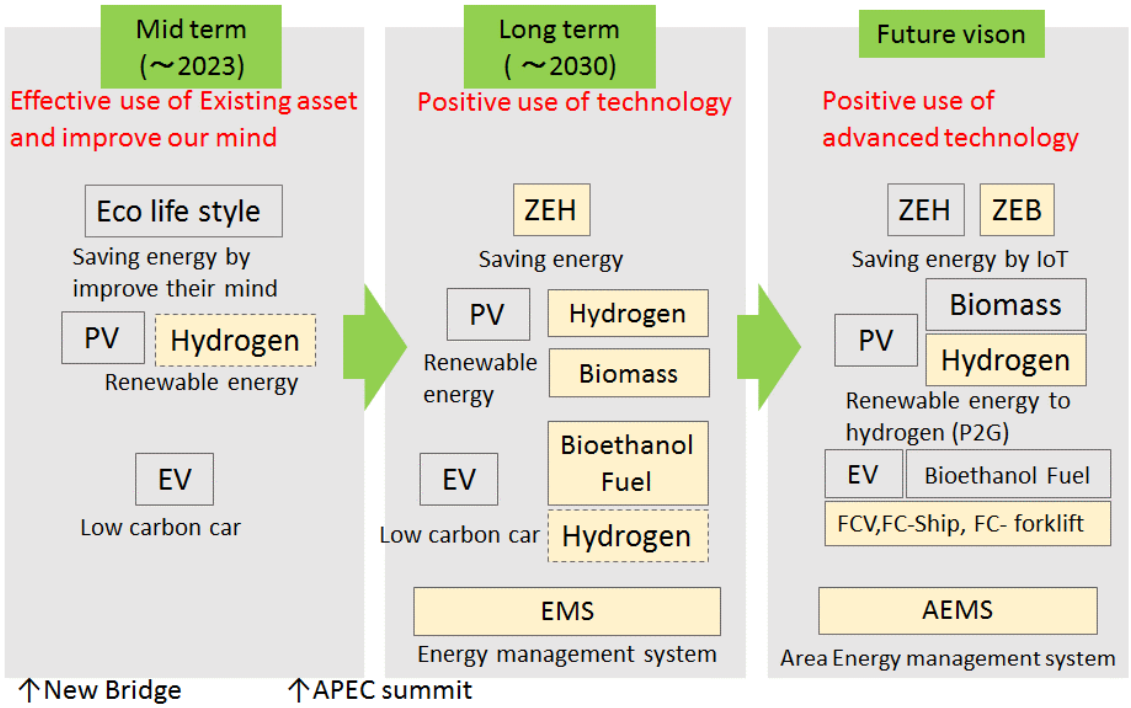
This study created feasible medium- and long-term goals for an eco town in Brunei and future achievement targets. In the medium term (by 2023), the main purpose is to use existing resources aggressively and reform consciousness (eco lifestyle). Effective use of photovoltaic and renewable energy-based hydrogen as existing technologies and the use of EV can be considered. It is hoped that this plan will be publicised at the APEC meeting as a showcase eco town. In the long term (by 2030), the aim is for the whole town to convert to low carbonisation instead of only the facility, in combination with biomass energy and EMS. It is aimed to build towns that do not emit $CO_2$ by introducing the latest technologies in the future.

**Figure 5.7: Proposed Renewable Energy Use in Brunei Darussalam**




Source: Study team.

**Figure 5.8: The Roadmap of the Realisation of Eco Town**



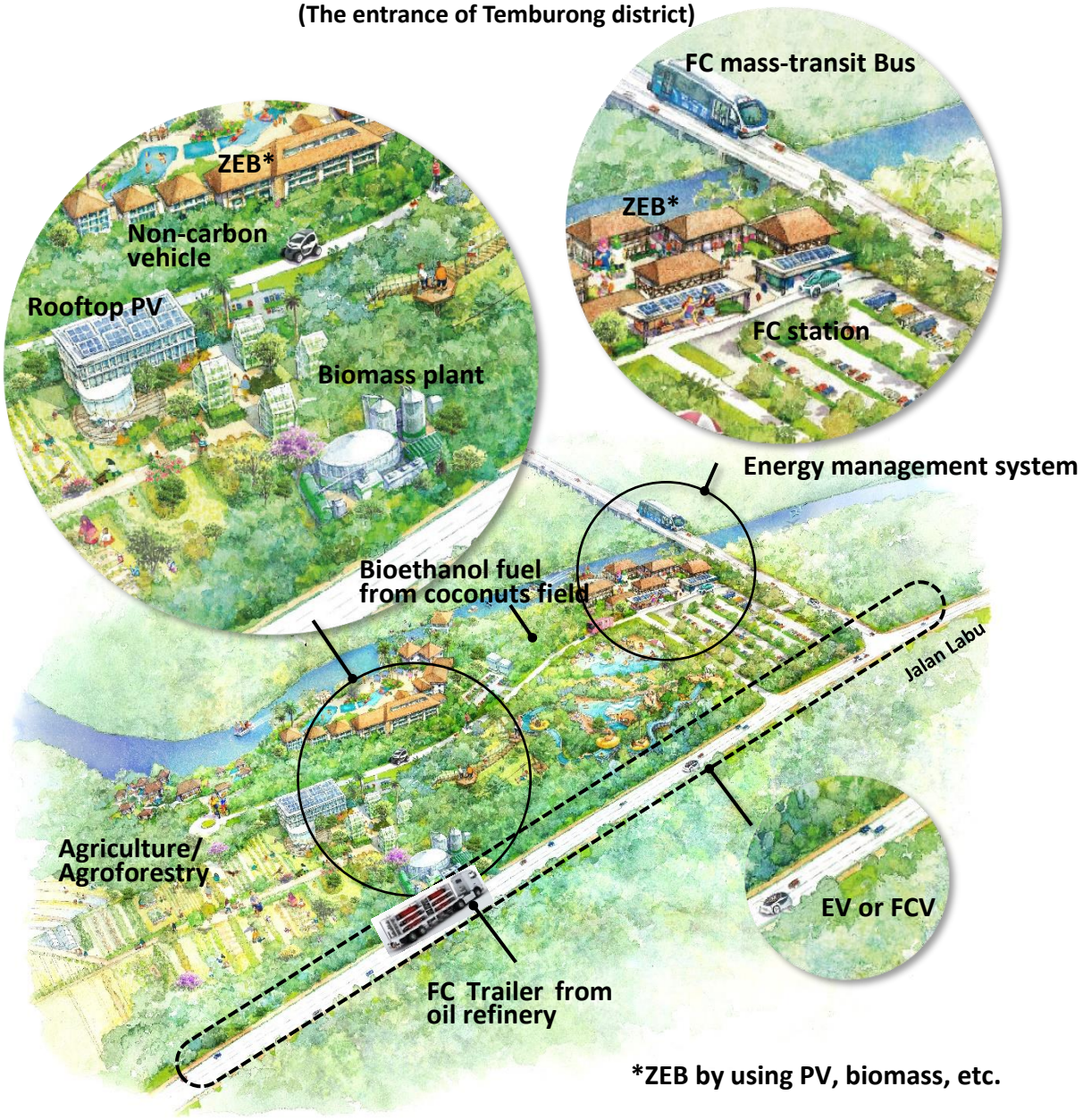

Source: Study team.

### 5.4.3. Proposal of Energy Model Zone in Temburong District

In consideration of the study results until now, the area will be developed based on renewable and hydrogen energy in Temburong district.

**Figure 5.9: Renewable Energy and Hydrogen Energy Showcase in Gate Zone**

**(The entrance of Temburong district)**



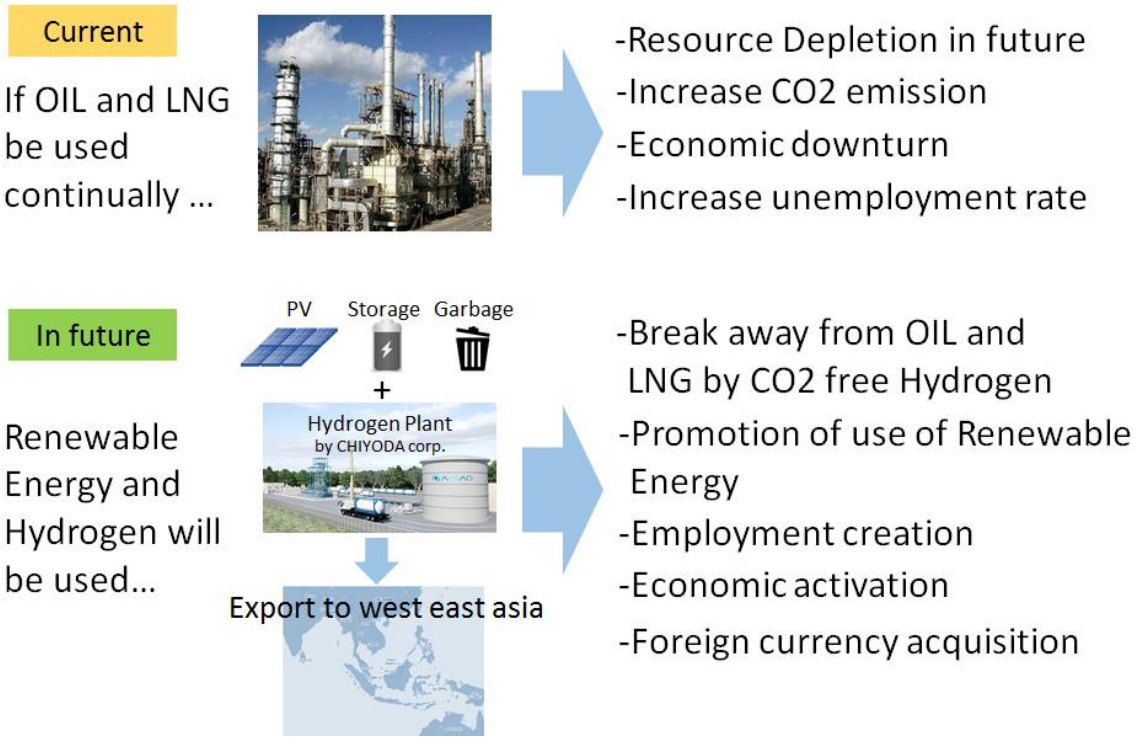

Source: Study team.

### 5.5. Effects Expected by Introduction of Renewable Energy and Hydrogen Energy

The effects of using oil and natural gas continuously or introducing renewable energy and hydrogen energy are summarised in Figure 5.10. Renewable energy and hydrogen energy are expected to create effects such as a reduction in $CO_2$, job creation, and an economic ripple effect.

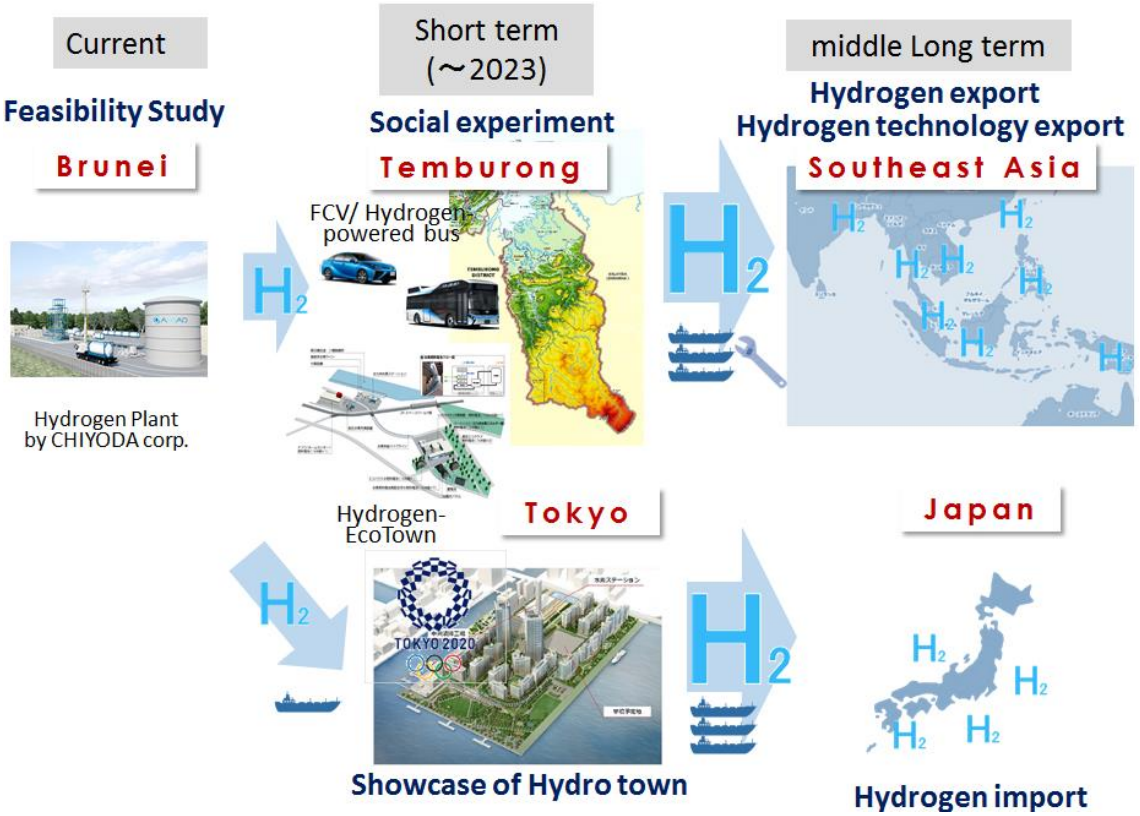
Hydrogen energy will be expanded throughout Brunei to full scale in the short term, and an increase in exports of hydrogen to the main export countries for oil and natural gas in Southeast Asia as well as Japan can be expected in the medium and long term. The Summer Olympics and Paralympics will be held in Tokyo in 2020 and Tokyo plans to showcase itself as a hydrogen-based town. Therefore, it is desirable to make the best use of this opportunity.

**Figure 5.10: Effects of Introduction of Renewable Energy and Hydrogen Energy**




Source: Study team.

**Figure 5.11: Domestic and International Development of Hydrogen**




Source: Study team.