

Chapter 4

Road Map for the Implementation of the Master Plan of Temburong

February 2021

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Chapter 4

Road Map for the Implementation of the Master Plan of Temburong Ecotown

1. Introduction

ERIA has been studying the development of an ecotown in Temburong district per request from Brunei Darussalam.

Brunei Darussalam is expected to start developing the Temburong ecotown according to the 'Temburong Ecotown Master Plan in Brunei Darussalam', prepared by ERIA and Nikken Sekkei Civil Engineering Ltd in 2018.

In 2019, ERIA continued to support the Ministry of Energy, Manpower and Industry, with the Ministry of Development (MOD), in developing the Temburong ecotown through the study focusing on energy efficiency in the commercial sector and low carbon for the road transport and power generation sectors, as well as the preparation of the road map of the ecotown development.

The scope of the study for this report is the preparation of a road map of the Temburong Ecotown Development Master Plan with the following four separate terms through close communication with the Ministry of Energy, Manpower and Industry and MOD:

1. By 2021 (ASEAN Year of Brunei Darussalam)
2. By 2023 (APEC [Asia-Pacific Economic Cooperation] Year of Brunei Darussalam)
3. Middle term (by 2030)
4. Long term (by 2040)

This report is part of the output expected from the Study on Temburong Ecotown Development Phase 4.

2. Background of Temburong Ecotown Development

2.1. Brunei Vision 2035

Wawasan Brunei 2035 is the country's national vision towards 2035, as announced by the government in January 2008.

- It aims to develop Brunei into a nation widely recognised for its quality of life amongst the top 10 nations globally and its well-educated and highly skilled people.
- It aims to transform Brunei from an economy heavily dependent on oil and natural gas into a more economically diversified and dynamic nation.
- It aims to increase renewable energy use up to 10% of the national total energy consumption as conveyed in its Vision 2035.

In February 2017, the government announced the next phase of economic policies, reflecting progress towards Wawasan Brunei 2035. These policies will (i) stimulate other industries to overcome the dependence on oil and natural gas, (ii) implement measures to support domestic entrepreneurs, (iii) implement incentives for small and medium-sized enterprises, and (iv) make effective use of them when the ASEAN Economic Community is established.

2.2. Heart of Borneo Programme

In 2007, Indonesia, Malaysia, and Brunei announced the Heart of Borneo Programme, in which they promised to protect Borneo Island's central areas of forest covering about 220,000 square kilometres.

The objectives of the programme until 2020 are to (i) establish a protected area of 24 million hectares, (ii) prevent damage to all valuable forests, (iii) promote alternative sustainable long-term financial programmes that provide support for replacing deforestation activities to local people and governments, and (iv) strengthen the ecosystem's products and services.

The Heart of Borneo contains about 58% of Brunei's territory, including the mountainous region, which is the southern part of Temburong district. According to the programme, ecotourism promotion could leverage the protection of untouched forests in Temburong district. The national park in Temburong district covers 50,000 m², but tourists are allowed only in about 100 m² (tower canopy area and waterfalls area).

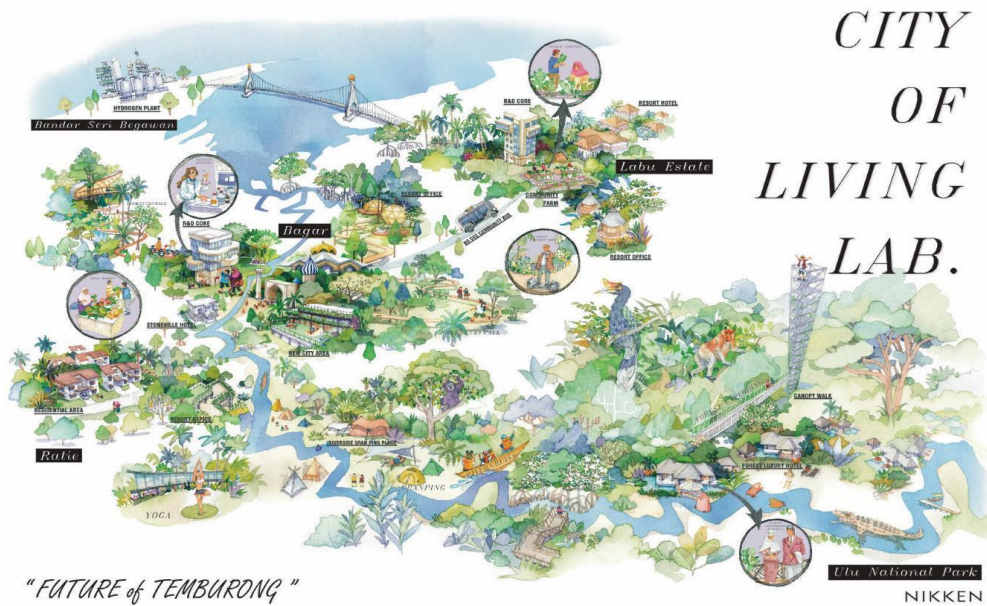
2.3. Temburong District Plan 2006–2025

In August 2010, the Town and Country Planning Department, OD established the Temburong District Plan 2006–2025 to guide and manage developments to meet key objectives of environmental management, social development, economic development, and rural and urban land use up to 2025. Sustaining the district's community development is one of the district plan's core strategies by providing adequate community facilities whilst preserving the richness of its forestry, biodiversity, and other natural resources.

2.4. Master Plan for Temburong Ecotown Development

ERIA and Nikken Sekkei Civil Engineering Ltd., combining the Temburong District Plan 2006–2025 and the idea of utilising hydrogen for fuel cell (FC) buses and other vehicles, formulated a master plan for the Temburong ecotown development. The master plan includes creating a 'Living Labo' related to the Heart of Borneo concept.

Figure 4.1: Future Image of City of Living Lab in Temburong Ecotown



Source: ERIA and Nikken Civil Engineering Ltd. (2018)..

2.5. Simulation study on energy mix for power generation in Temburong ecotown

Following the ecotown development plan for Temburong, a study was conducted in 2015–2016 to measure the impact of the application of energy efficiency technologies for buildings and installation of solar photovoltaic (PV) with electricity storage as power supply system based on the Temburong District Plan, 2006–2025. In the study, energy demand based on the buildings to be constructed in the ecotown was estimated in case the buildings were conventional buildings and were energy efficient. The electricity demand for the conventional and ecotown developments, including existing load, are estimated at 179 GWh and 146 GWh, respectively.

For the best mix of power generation, the following three scenarios were examined:

- Case 1: Diesel 12 MW with solar PV
- Case 2: Diesel 6 MW with solar PV
- Case 3: Only solar PV

The study recommended using diesel power initially and gradually shifting the power generation mix to greater solar PV use with a storage system. (Start with case 1 and shift to case 3.)

The simulation study also concluded that although all scenarios were feasible solutions, Brunei's solar radiation status can be weak during rainy and cloudy weather. In 2016, between March and May, the operation rate of solar PV was weak at 9%–13%.

To accomplish case 3, which is without diesel power generation, the available mix of solar PV in terms of the initial cost is for solar PV to have a capacity of 120 MW, even though this

combination, levelized cost of electricity (LCOE) will be as high as US\$40–50 cents. Then the combination of diesel power will be compromised at least in the initial stage, and more cost down of the solar PV system is expected.

3. Development Framework for Temburong Ecotown

3.1. Future vision and approaches for Temburong ecotown

For sustainable and balanced development with nature conservation, the Temburong ecotown sets the future vision of a carbon-neutral society to preserve wildlife in Borneo. It proposes strategic development through the following approaches or keywords:

- Living lab: diverse community, creative work and lifestyle
- Carbon-neutral: renewable energy, sustainable mobility system, sustainable architecture, agroforestry, and small economy
- Learning tourism: feature Temburong and Borneo, showcases of smart technology

The technological part of the ecotown concept is based on the following three principles:

1. Applying energy efficiency technologies to buildings to achieve lower energy demand;
2. Using renewable energy, such as solar PV; and
3. Utilising FC technology using hydrogen to operate buses and other motor vehicles

3.2. Socio-economic framework

3.2.1. Population Framework for Temburong District

The Temburong ecotown master plan estimated the future population of Temburong district, considering the new bridge connecting the capital city Bandar Seri Begawan (BSB) and Temburong. Table 4.1 shows the future population of 2030 and 2040.

Table 4.1: Population Framework of Temburong District

Year Area	2001	2011	2016	2030	2040
	Census	Census	Census	Projection	Projection
Population of Temburong district	8,563	8,852	10,251	17,800	26,400
Annual growth rate of Temburong district	-	0.33%	2.98%	4.02%	4.02%
Population of Brunei Darussalam	332,844	393,372	417,256	471,000	488,800
Annual growth rate of Brunei Darussalam	-	1.68%	1.19%	0.87%	0.37%

Sources: 1. Data for 2011 and 2016: City Population HP.

2. Data of Temburong District for 2030: ERIA and Nikken Sekkei Civil Engineering Ltd (2018).

3. Data for Temburong District for 2040: Study Team analysis based on Temburong Ecotown Master Plan.

4. Data of Brunei Darussalam for 2030 and 2040: United Nations, Department of Economic and Social Affairs, Population Division (2019).

3.2.2. Demand for Electricity in Temburong District

Table 4.2 estimates electricity demand in Temburong district based on the future demand analysis of electricity conducted in the 'Simulation Study on Energy Mix for Power Generation in Temburong Ecotown' (Kimura, 2017), in consideration of various planned developments and the estimated future population in the Temburong Ecotown Master Plan.

In 2016, the actual electricity demand in Temburong district was 66 GWh, whilst the electricity demand in 2030 is based on the simulation study. The demand for 2023 and 2040 was estimated based on the electricity demand per person in 2030. The demand for 2040 was estimated considering the population increase and electricity demand in 2030 due to ecotown development in the simulation study.

Table 4.2: Demand for Electricity in Temburong District

Year	2016	2023	2030	2040
Demand	66 GWh	111 GWh	146 GWh	178 GWh

Source: Authors' analysis, based on Kimura (2017).

4. Scenario for Temburong Ecotown Development

Per the master plan for the Temburong ecotown development, a development scenario for Temburong ecotown was formulated by the following separate periods:

1. By 2021 (ASEAN Year of Brunei Darussalam)
2. By 2023 (APEC Year of Brunei Darussalam)
3. Middle term (by 2030)
4. Long term (by 2040)

Paying attention to (i) energy; (ii) tourism; (iii) university, research and development (R&D), and industry; and (iv) Bangar Urban Centre, the Study Team prepared the following scenarios:

1. By 2021 (ASEAN Year of Brunei Darussalam)

[Energy] To take advantage of the ongoing programme of creating an international supply chain of hydrogen, demonstrative operation of FC bus services will be started by using hydrogen produced of associated gas of oil extraction.

[Ecotourism] At the same time, in this phase, to take advantage of the completion of the BSB–Temburong Bridge, the development of tourist infrastructure and attractions supporting ecotourism in the Temburong district will be accelerated.

[University, R&D, and industry] In this phase, the construction of the new campus of University Islam Sultan Sharif Ali (UNISSA) will be started after the BSB–Temburong Bridge is open.

[Bangar Urban Centre] In this phase, the preparation of an implementation programme for improving the Bangar Urban Centre will be started, including improving inner roads and construction of the river port facility.

2. By 2023 (APEC Year of Brunei Darussalam)

[Energy] For increasing use of hydrogen produced from natural gas, the provision of basic infrastructure, such as hydrogen stations, will be expanded to increase the use of FC bus operation. For this purpose and for shifting to the increased dependency on renewable energy, a solar PV power generation plant will be constructed in Temburong district.

[Ecotourism] In this phase, more attractions for ecotourism will be developed to accommodate more ecotourists.

[University, R&D, and industry] The construction of the new campus of UNISSA will be continued. A new industrial park will be developed in Lab Estate to diversify economies in Temburong district.

[Bangar Urban Centre] The programme for improving Bangar Urban Centre will be continued by implementing the construction of the second bridge of Bangar and the preparation of Riverside Park.

3. Middle term (by 2030)

[Energy] The demonstrative use of hydrogen produced from natural gas will be expanded for FC bus operation. The excess hydrogen, after being used to operate FC buses, will be exported internationally.

[Ecotourism] In this phase, a hotel and convention complex will be developed to attract and accommodate high-end ecotourists.

[University, R&D, and industry] The construction of the new campus of a science and engineering university or science and engineering faculties of an existing university will be started. In collaboration with the new campus education and research function of the Science and Engineering Higher Education, an R&D Centre (R&D complex) will be developed in Lab Estate to diversify economies in Temburong district.

[Bangar Urban Centre] The Bangar Urban Centre Improvement Programme will be continued by constructing a new hospital or expanding its existing hospital and industrial estate.

4. Long term (by 2040)

[Energy] The commercial use of hydrogen produced from natural gas will be started to expand FC bus services in mainland Brunei and for FC passenger car operation.

[Ecotourism] In this phase, another hotel and convention complex will be further developed to upgrade the ecotourist destinations in Temburong district.

[University, R&D, and industry] In collaboration with the new campus education and research function of the science and engineering university or faculties, the R&D Centre (R&D complex) will be expanded in Lab Estate. This is to take advantage of the ongoing experimental operation of hydrogen production and FC vehicle systems, and ecotourism activities based on natural forest resources.

5. Road Map for Temburong Ecotown Development

5.1. Energy sector

5.1.1. Direction for the Development of the Energy Sector

a) Energy sources

Brunei's energy policy emphasises less dependency on oil and natural gas and towards the use of more renewable energy.

ERIA's Simulation Study on Energy Mix for Power Generation in Temburong Ecotown (Kimura, 2017) recommended the use of diesel power initially and the gradual shift in power generation mix to more use of solar PV as the costs of solar PV will decrease in the future. Therefore, it set an energy mix for power generation in Temburong district (Table 4.3).

Table 4.3: Energy Mix for Power Generation in Temburong District

Year	2016		2023		2030		2040	
Types	Electricity Generated, GWh	%	Electricity Generated, GWh	%	Electricity Generated, GWh	%	Electricity Generated, GWh	%
Diesel	105	100	53	45.1	0	0.0	0	0.0
Solar power plant	0	0	18	15.5	60	38.5	90	46.9
Biofuels from farmed goods and Forestry Industry	0	0	1	0.9	6	3.8	12	6.3
Transmission from Smart Grid	0	0	45	38.6	90	57.7	90	46.9
Total	105	100	117	100	156	100	192	100

Source: ERIA and Nikken Sekkei Civil Engineering Ltd (2018)..

The master plan study proposed to produce hydrogen using associated gas from gas fields, utilise hydrogen to operate FC buses and vehicles, and generate power from renewable energy sources, such as solar power. This operation of FC buses and vehicles is enabled by Brunei's strategy for hydrogen production and export, which will be experimented from 2020.

Due to the experimentation and the prospective full-scale strategy for hydrogen production and export, FC bus and vehicle operations would have a financial advantage over hydrogen production using solar PV electricity.

b) Efficient management of energy

Smart grids are a new way of distributing energy in which generation (from local energy sources and/or storage devices) is coordinated to supply electricity for satisfying local needs through an energy management system (EMS).

5.1.2. Projects for the Development of the Energy Sector

a) Priority projects of the energy sector

Table 4.4 lists the priority projects for the development of the energy sector in Temburong district. The priority projects with * are key projects to initiate and drive the energy sector's development towards a carbon-neutral society.

Table 4.4: Priority and Key Projects of the Energy Sector in Temburong Ecotown

Name of Project	Implementation Period
[EN-1] * Project of Construction of Hydrogen Production and Hydrogenation Plant in Brunei	2019
[EN-2] * Programme of Creation of International Supply Chain of Hydrogen (including Exportation of Hydrogen to Japan)	2020–2021
[EN-3] * Project of Construction of Solar Park (Photovoltaic Power Station) Phase 1	2022–2023
[EN-4] Project of Construction of Solar Park (Photovoltaic Power Station) Phase 2	2024–2030
[EN-5] Project of Construction of Solar Park (Photovoltaic Power Station) Phase 3	2031–2040

Source: Authors' formulation based on Temburong Ecotown Master Plan and Temburong District Plan 2006–2025.

b) Outlines of key projects of the energy sector

- **[EN-1] * Project of Construction of Hydrogen Production and Hydrogenation Plant in Brunei**

In November 2019, a hydrogen production and hydrogenation plant was constructed in Brunei by the Advanced Hydrogen Energy Chain Association for Technology Development, which was jointly established by Chiyoda Corporation, Mitsubishi Corporation, Mitsui & Co. Ltd, and Nippon Yusen Kabushiki Kaisha. This plant was designed to produce hydrogen made of associated gas and to produce liquid hydrogen at normal temperature by utilising the Organic Chemical Hydride Method.

Figure 4.2: Hydrogenation Plant in Brunei



Source: Chiyoda Corporation (2017).

- **[EN-2] * Programme of Creation of International Supply Chain of Hydrogen (including Exportation of Hydrogen to Japan)**

Liquid hydrogen at normal temperature to be produced by the hydrogenation plant of [EN-1] – The project can be easily transported to other countries by conventional chemical tankers, but not special tankers for low temperature liquid hydrogen or hydrogen gas. Therefore, now it is possible for Brunei to produce such liquid hydrogen at normal temperature (called SPERA hydrogen) for export. In an experimental programme, liquid hydrogen at normal temperature will be exported to Japan. When liquid hydrogen arrives in Japan, it will be transformed to hydrogen gas by a hydrogenation plant in Kawasaki City, Japan.

Changing the world's energy landscape.

SPERA Hydrogen can be inexpensively transported over long distances from any global location. It can be stored in mass quantities for extended periods of time without loss, making it well suited for strategic reserves. In the foreseeable future, SPERA Hydrogen will be produced from natural energy resources. SPERA Hydrogen has the potential to revolutionize the flow of energy while protecting the global environment.

Energy consumer

Dehydrogenation plant

Storage/reserve tanks

Toluene

SPERA Hydrogen (MCH)

Regional city

Hydrogen station

Distributed cogeneration

Oil refinery

Chemical plant

Thermal power generation (single fuel burning with hydrogen, or mixed fuel burning with natural gas)

Hydrogen

SPERA Hydrogen (MCH)

Hydrogenation plant

Water electrolysis

Solar power

Wind power

Producer of large-scale renewable energies

Producer of fuels
(natural gas, petroleum, coal)

Hydrogen plant (reforming, gasification, byproduct hydrogen)

Hydrogen production CO₂ conversion

natural gas, petroleum, coal

CO₂

CO₂ EOR

CO₂

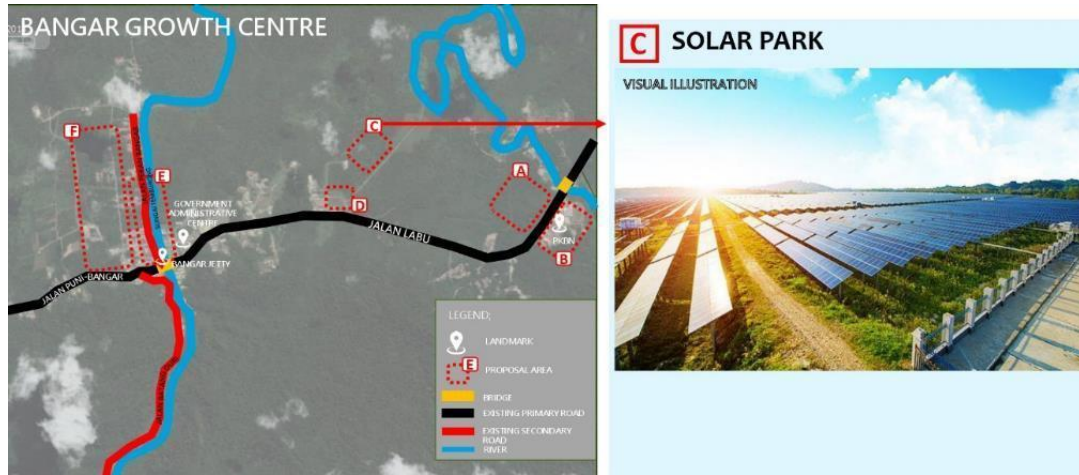
Legend:

- Hydrogen
- Toluene
- natural gas
- SPERA Hydrogen (MCH)

1. MCH: Methylocyclohexane
2. CCS: Carbon Dioxide Capture and Storage
3. EOR: Enhanced Oil Recovery

- **[E-3] * Study on Storage Battery to be Implemented in Temburong District**
The storage battery is a fundamental facility for a successful ecotown with solar power as a primary power source. The field of storage batteries is constantly advancing, and the type of storage battery varies depending on the size, cost, life expectancy, etc. Therefore, it is necessary to determine which type of storage battery will be implemented in Temburong district.
- **[E-4] * Project of Construction of Solar Park (Photovoltaic Power Station) Phase 1 and [E-5] * Project of Construction of Water Electrolysis Plant for Hydrogen Production Phase 1**
A land for establishing the Solar Park has been gazetted under the Ministry of Energy, Manpower and Industry at site C in Figure 4.4. Site C is around 12 ha. With solar PV panels installed in this area, the park can produce approximately 18 GWh, which is 16% of the district's energy demand in 2023.

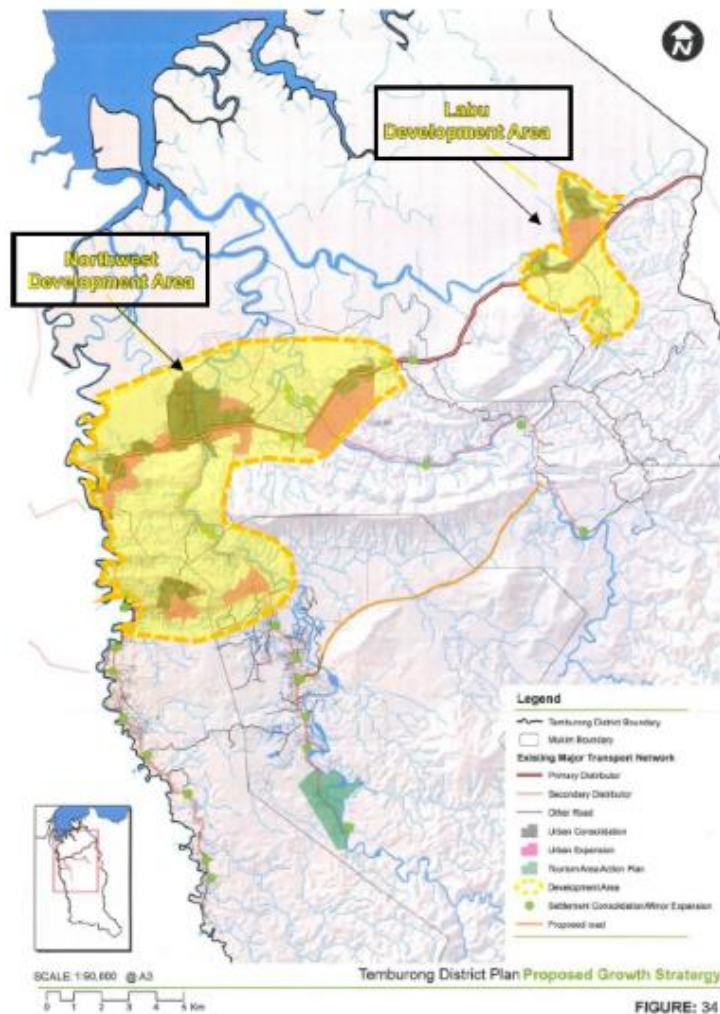
Figure 4.4: Location of Solar Park



Source: Town and Country Planning Department, Ministry of Development (2010).

However, this site is not large enough to accommodate a necessary solar PV power station and water electrolysis plant to support the whole district. Therefore, the Brunei government should identify such a large land for solar PV power stations and water electrolysis plants. It seems possible to identify and gazette such large sites within the developable areas, as shown in Figure 4.5. It is also necessary to identify 140 ha for Temburong district to become 100% sustainable with renewable energy, using solar power as its main power source.

Figure 4.5: Development Areas Proposed in Temburong District Plan, 2006–2025



Source: Town and Country Planning Department, Ministry of Development (2010).

- **[E-6] * Project for Establishment of Storage Battery Phase 1**
Based on the study on storage battery, the type of storage battery should be selected along with the establishment of the Solar Park.

5.2. Transport sector

5.2.1. Direction for the Development of the Transport Sector

As a model of a carbon-neutral society, Temburong district aims to build an eco-friendly town as follows:

- *Suppression of traffic volume*
 - Control entry of vehicles from Temburong Bridge
 - Promote carpooling system
 - Introduce public transportation
 - Encourage a new logistics system, such as drones, which does not depend on vehicles

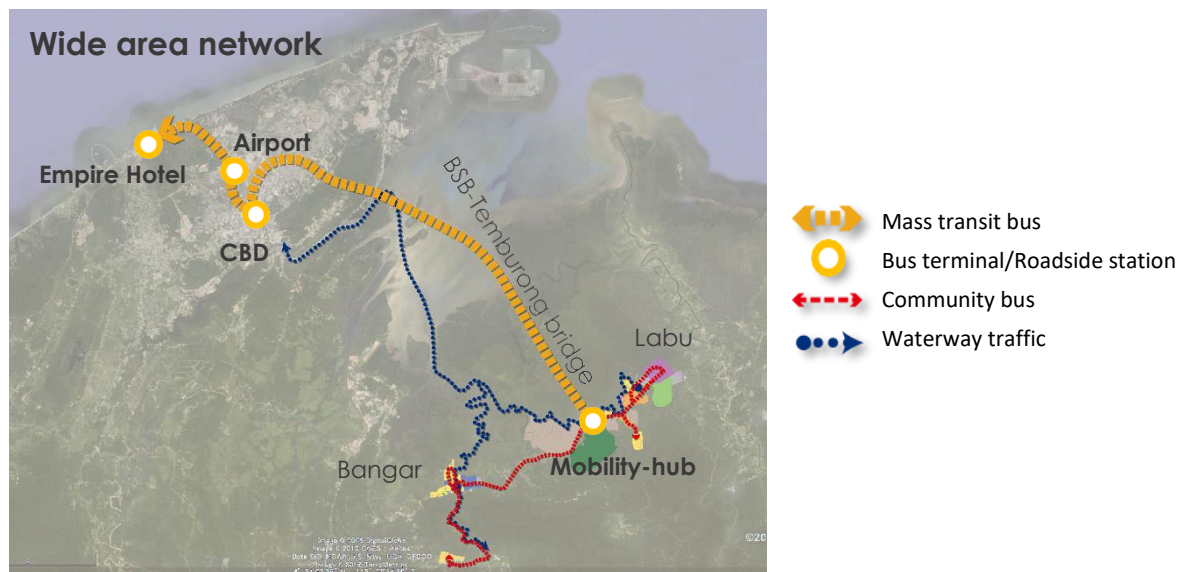
- *Prioritisation of transport devices with small environmental loads*
 - Develop traffic regulation that prioritises electric vehicles (EVs) or FC vehicles
 - Introduce transportation devices that do not depend on automobiles, such as electric motorcycles
- *Introduction of various transport devices to activate ecotourism*
 - Introduce various transportation devices such as autonomous vehicles, boats, buses, taxis, electric motorcycles, and bicycles.

However, to introduce FC vehicles in Temburong ecotown, it is necessary to consider using hydrogen from by-product gas of liquefied natural gas production since it will not be possible to produce hydrogen from renewable energy at the early stage. Chiyoda Corporation, exporting this type of hydrogen, plans to export a maximum of 210 tonnes of hydrogen in 2020 to Japan. For example, if the Brunei government could use 7% of this hydrogen, it is enough to have four FC buses to operate 365 days a year.

Through the construction of the BSB–Temburong Bridge and the introduction of FC vehicles, the following new mobility networks in Temburong district are expected:

- Tourists from BSB, such as the Empire Hotel, BSB airport, or the central business district, visit Temburong via hydrogen-powered mass-transit bus through Temburong Bridge.
- Tourists travel around Temburong district in non-carbon vehicles such as community buses, boats, and taxis.
- In the future, only non-carbon cars will be permitted to drive in Temburong district. This also aims to control the traffic volume (internal-combustion engine cars, buses, and trucks) passing through Temburong from Sabah to Sarawak State in Malaysia.

Figure 4.6: Mobility Network of Temburong and Connectivity with Bandar Seri Begawan



Source: ERIA and Nikken Sekkei Civil Engineering Ltd. (2018).

5.2.2. Projects for the Development of the Transport Sector

a) Priority projects of the transport sector

Table 4.5 lists the priority projects for the development of the transport sector in Temburong district. The priority projects with * are key projects to initiate and drive the development of the transport sector towards a carbon-neutral society.

Table 4.5: Priority and Key Projects of the Transport Sector for Temburong Ecotown

Name of Projects	Implementation Period
[TR-1] * BSB–Temburong Bridge	2020
[TR-2] * Hydrogen Supply Stations for Fuel Cell Buses and Vehicles	2020–2021
[TR-3] * ‘Mobility Hub’ in the Gate Zone	2020–2021
[TR-4] * Mass Transit Bus Services by Fuel Cell Buses between Empire Hotel, Airport, and Temburong Mobility Hub	2022–2023
[TR-5] * Community Bus Services by Fuel Cell Buses within Temburong Ecotown	2022–2023
[TR-6] Expansion of Mass Transit Bus Services by Fuel Cell Buses between Empire Hotel, Airport, and Temburong Mobility Hub	2022–2023
[TR-7] Expansion of Community Bus Services by Fuel Cell Buses within Temburong Ecotown	2022–2023
[TR-8] Expansion of Fuel Cell Bus and Passenger Car Operation both in Temburong District and the Mainland	2024–2030

Source: Study Team.

b) Outline of key projects of the transport sector

● [TR-1] * BSB–Temburong Bridge

The Temburong Bridge Project is a 30-km dual two-lane bridge crossing Brunei Bay that connects Temburong district with Brunei’s other three districts, including the international airport and port. Until this bridge was built, Temburong and the other three districts were connected via the river or by land through Limbang district of Sarawak, Malaysia.

The construction of the bridge started in 2014 and was planned to be completed in 2019 but was completed in March 2020.

Figure 4.7: Route of Bandar Seri Begawan–Temburong Bridge



Source: ERIA and Nikken Sekkei Civil Engineering Ltd (2018).

- **[TR-2] * Hydrogen Supply Stations for FC Buses and Vehicles**

Hydrogen supply stations are necessary before FC buses and vehicles are introduced in Temburong. It is advised to use the hydrogen from by-product gas generated when gas is liquefied to promote FC vehicles from an early stage of ecotown development. In the future, when there is enough solar PV, hydrogen for FC vehicles can also be produced from 100% renewable energy.

The first hydrogen supply station is planned to be established in the Gate Zone.

Figure 4.8: Image of Hydrogen Supply Station



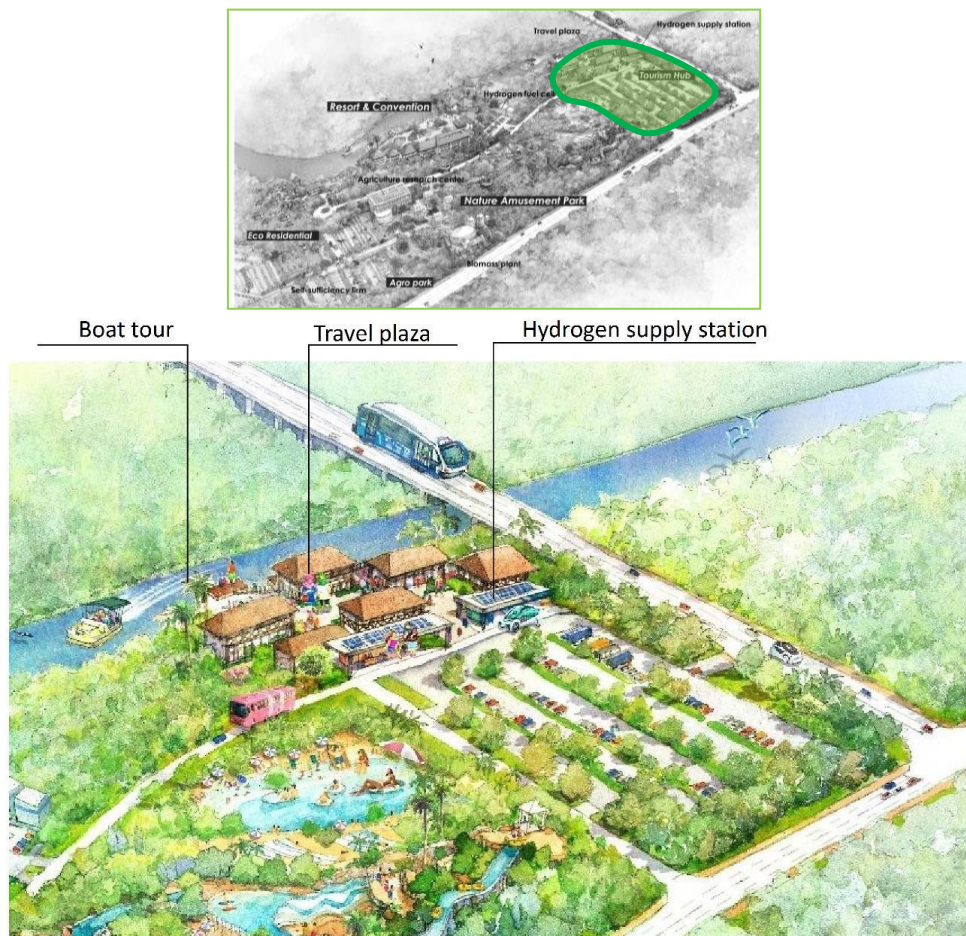
Source: Tokyo Gas (2020).

- **[TR-3] * Mobility Hub in the Gate Zone**

A mobility hub is a place where hydrogen-powered buses, electric cars, autonomous cars, electric boats, and bicycles are connected. Tourists arriving in Temburong from BSB via hydrogen-powered buses can transfer to other means of transport such as EVs, autonomous cars, electric boats, and bicycles to go to different tourist spots.

With the travel plaza here, tourists can enjoy many services such as accessing tourism information, booking tours and accommodations, and using the hydrogen supply station.

Figure 4.9: Image of Mobility Hub Zone



Source: ERIA and Nikken Sekkei Civil Engineering Ltd. (2018).

- **[TR-4] * Mass Transit Bus Services by Fuel Cell Buses between Empire Hotel, Airport, and Temburong Mobility Hub**

The energy supply system's medium-term target (by 2023) in the master plan considers the effective use of PV and pilot renewable energy-based hydrogen as existing technologies and use of EVs and FC vehicles. The Lalan Bas BSB–Bangar Route is proposed in the Temburong District Plan 2006–2025, which can be served by FC buses.

Such FC bus needs approximately 3,850 kg of hydrogen per year if operating for 365 days.

A black and white photograph of a Toyota SORA fuel cell bus. The bus is shown from a front-three-quarter view, facing left. It has a sleek, modern design with a black upper body and a white lower body. The words "FUEL CELL BUS" are written in blue on the side of the bus. The front of the bus features the Toyota logo and the text "FUEL CELL BUS" and "SORA". The bus has large windows and a prominent front grille. The background is a plain, light-colored surface.

- **[TR-5] * Community Bus Services by Fuel Cell Buses within Temburong Ecotown**
The FC buses will provide community bus services in Temburong. The proposed bus network, including the two routes, is shown in Figure 4.11.

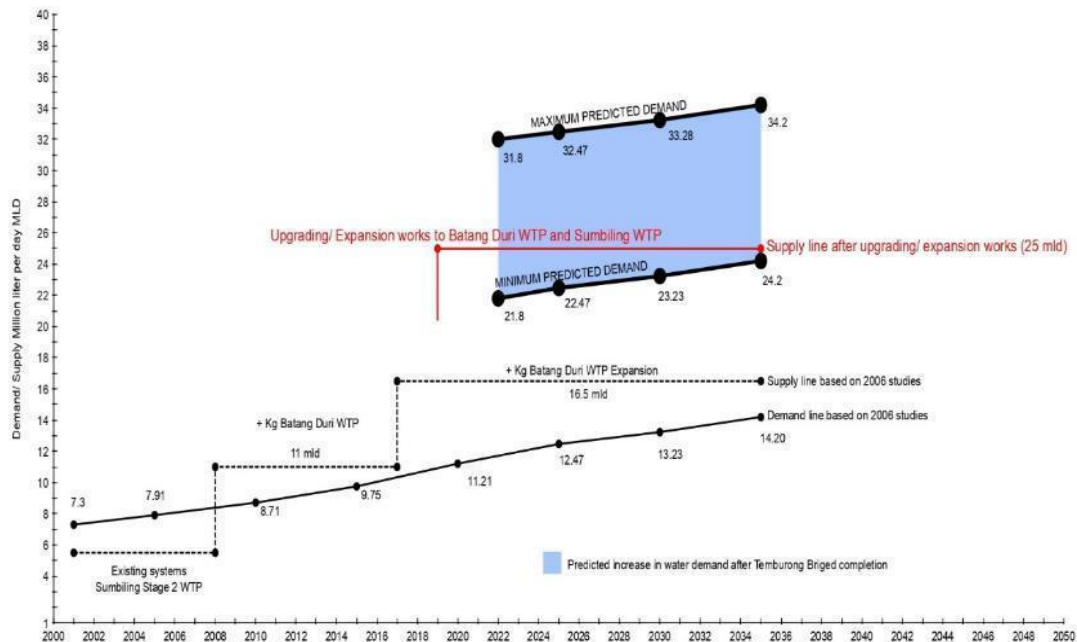
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5.3. Water supply sector

5.3.1. Direction for the Development of the Water Supply Sector

Water resources must be developed to supply enough water to the increasing residential population and tourism infrastructures (hotels, resorts, and convention facilities), as well as university facilities and industries in Temburong ecotown. Since there are existing water resources and water treatment plants, the selected strategy for additional water supply in the short and medium terms is to upgrade the existing water intake facilities and water treatment plants. Then in the long term, by monitoring the increasing volume of water demand, it would become necessary to develop new water resources and new water treatment plants. See the analysis of potable water supply system and demand in Temburong district.

Figure 4.12: Potable Water Supply in Temburong District



Source: Town and Country Planning Department, Ministry of Development (2010).

5.3.2. Projects for the Development of the Water Supply Sector

a) Outline of key projects of the water supply sector

Table 4.6 lists the priority projects for the development of the water supply sector in Temburong district. The priority projects with * are key projects to initiate and drive the development of the water supply sector towards a carbon-neutral society.

Table 4.6: Priority and Key Projects of the Water Supply Sector for Temburong Ecotown

Name of Project	Implementation Period
[WA-1] * Upgrading of Existing Batang Duri Water Treatment Plant	2022–2023
[WA-2] Upgrading of Existing Sumbiling Water Treatment Plant	2024–2030
[WA-3] New Water Treatment Plant at Batu Apoi of Capacity 30 mld	2031–2040

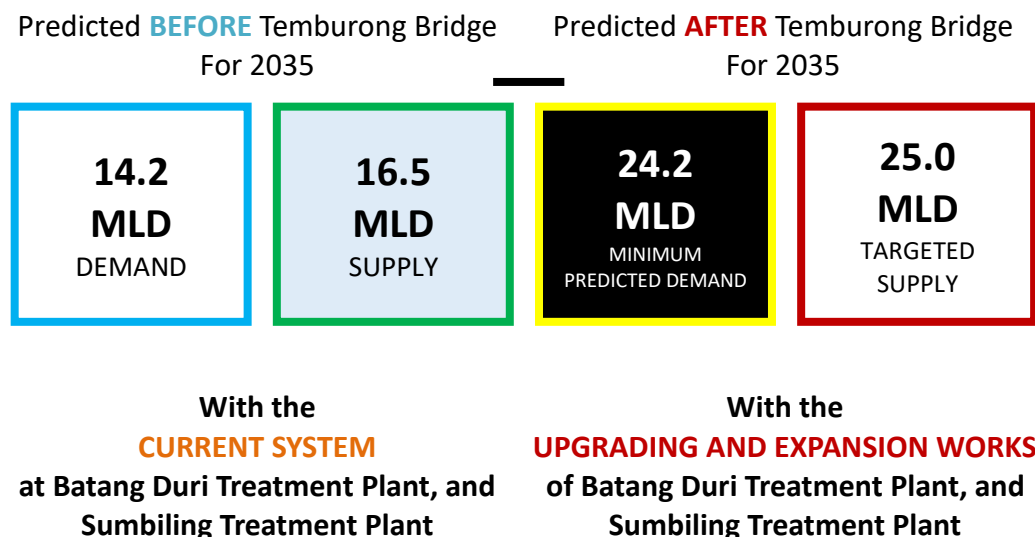
Source: Authors' analysis based on ERIA and Nikken Sekkei Civil Engineering Ltd (2018).

b) Outline of key projects of the water supply sector

• **[WA-1] * Upgrading of Existing Batang Duri Water Treatment Plant**

The existing Batang Duri Water Treatment Plant, as well as necessary water intake facilities, will be upgraded and expanded to supply the increasing amount of potable water under the Temburong ecotown development. Moreover, water pipelines should be expanded to cover the Labu Estate.

Figure 4.13: Potable Water Supply for Temburong District



Source: Town and Country Planning Department, Ministry of Development (2010).

5.4. Tourism sector

5.4.1. Direction for the Development of the Tourism Sector

The Temburong District Plan 2006–2025 acknowledges ecotourism as an opportunity for the Temburong district. The district plan identifies three focus areas of ecotourism: (i) Labu, (ii) Bangar, and (iii) Batang Duri and Ulu Temburong (Figure 4.14). The district plan also projects the number of international tourists to arrive in Temburong in 2025 to be 478,000.

Figure 4.14: Location of Ecotourism Focus Areas in Temburong District

(A) LABU

Family Zone . General Audience . Short Trip

- Labu Pitstop Zone
With increasing transit travellers, to develop Labu into a light F&B zone for pit stops: gas station, good restrooms, food trucks, container stores, accessible car parks.
- Bukit Patoi Recreational Park
To upgrade with better facilities and more trails. Add easy access from Labu Pitstop Zone.
- Labu Exotic Fruits Garden
To add educational tours for families.

(B) BANGAR

Cultural Zone . General Audience . Day Trip

- Bangar Cultural Town
Bangar is at risk of being deserted. To revamp Bangar into a cultural town with: regular cultural performances, hip cafes, art cinema, great restaurants, and parking spaces.

(C) BATANG DURI & ULU TEMBURONG

Pristine Forest Zone . Mid to High-End . Overnight Trip

- High-end Ecotourism Resort(s)
Working with investors to develop high-end ecotourism resorts (to include potentially mid-end ecotourism resort).



Source: Town and Country Planning Department, Ministry of Development (2010).

For Temburong district to develop its ecotourism potential, it is crucial to attract various types of visitors, including researchers and families, and provide sites for low-budget travellers to high-end travellers.

5.4.2. Projects for the Development of the Tourism Sector

a) Outline of key projects of the tourism sector

Table 4.7 lists the priority projects for the development of the tourism sector in Temburong district. The priority projects with * are key projects to initiate and drive the development of the tourism sector towards a carbon-neutral society.

Table 4.7: Priority and Key Projects of the Tourism Sector for Temburong Ecotown

Name of Project	Implementation Period
[TO-1] * Resort & Convention in Gate Zone	2020–2021
[TO-2] * Tourism Hub (Information and Learning Centre for Ecotourism)	2020–2021
[TO-3] * Nature Amusement Park in Gate Zone	2022–2023
[TO-4] * Agro Park in Gate Zone	2022–2023
[TO-5] Hotel and Convention in Labu Estate Phase 1	2024–2030
[TO-6] Hotel and Convention in Labu Estate Phase 2	2031–2040

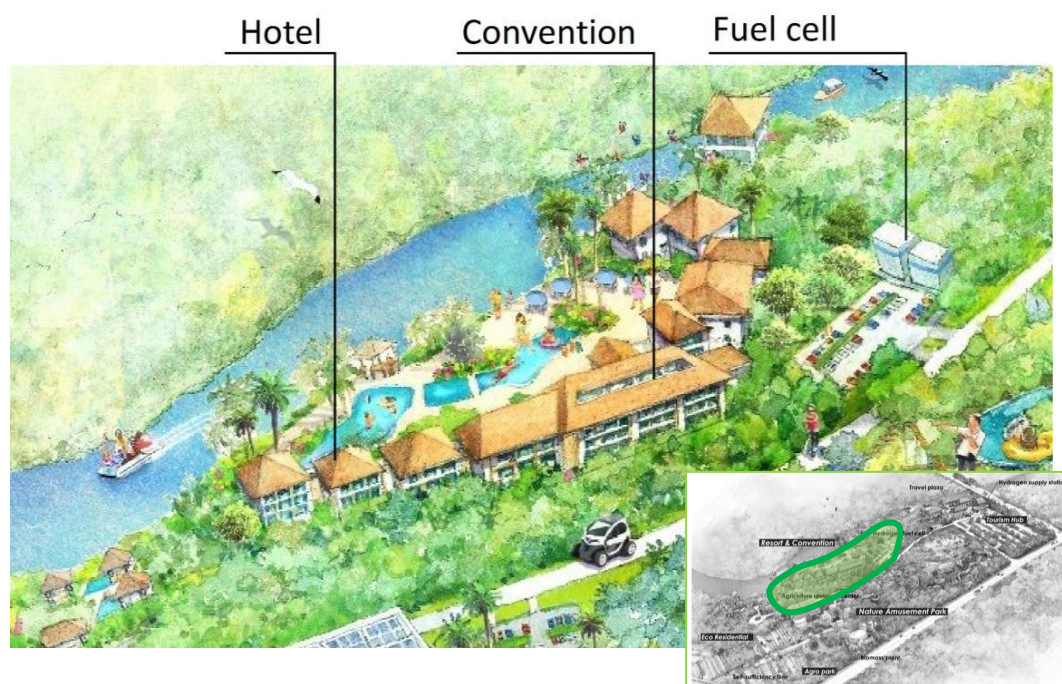
Source: Authors' analysis based on ERIA and Nikken Sekkei Civil Engineering Ltd (2018).

b) Outline of key projects of the tourism sector

• **[TO-1] * Resort and Convention in Gate Zone**

The zone facing the river is the Resort and Convention Zone. This zone is expected to be a tourist hub between the Labu area's sightseeing and Perdayan Forest Recreation Park. This resort has hotel and convention facilities. The convention centre should be one of the venues of the APEC meeting to be held in Brunei in 2024. As the APEC venue, this hotel's power source will be hydrogen fuel cells to help promote the potential of hydrogen in each APEC country.

Figure 4.15: Image of Resort and Convention Zone in Gate Zone



Source: Nikken Sekkei Civil Engineering Ltd. (2018).

- [TO-2] * Tourism Hub (Information and Learning Centre for Ecotourism)**
 The Tourism Hub will provide information and learning centre for ecotourism. It will be located in the Mobility Hub of Gate Zone, which is the gateway of Temburong district.

Figure 4.16: Location of Tourism Hub in Gate Zone



Source: ERIA and Nikken Sekkei Civil Engineering Ltd (2018).

- [TO-3] * Nature Amusement Park in Gate Zone**
 The restored forest will become the Nature Amusement Park. An adventure land and water park will be planned here. The construction of the Nature Amusement Park aims to create a new tourist destination in Temburong to encourage extended visits, such as staying more than two nights.

Figure 4.17: Image of Nature Amusement Park in Gate Zone

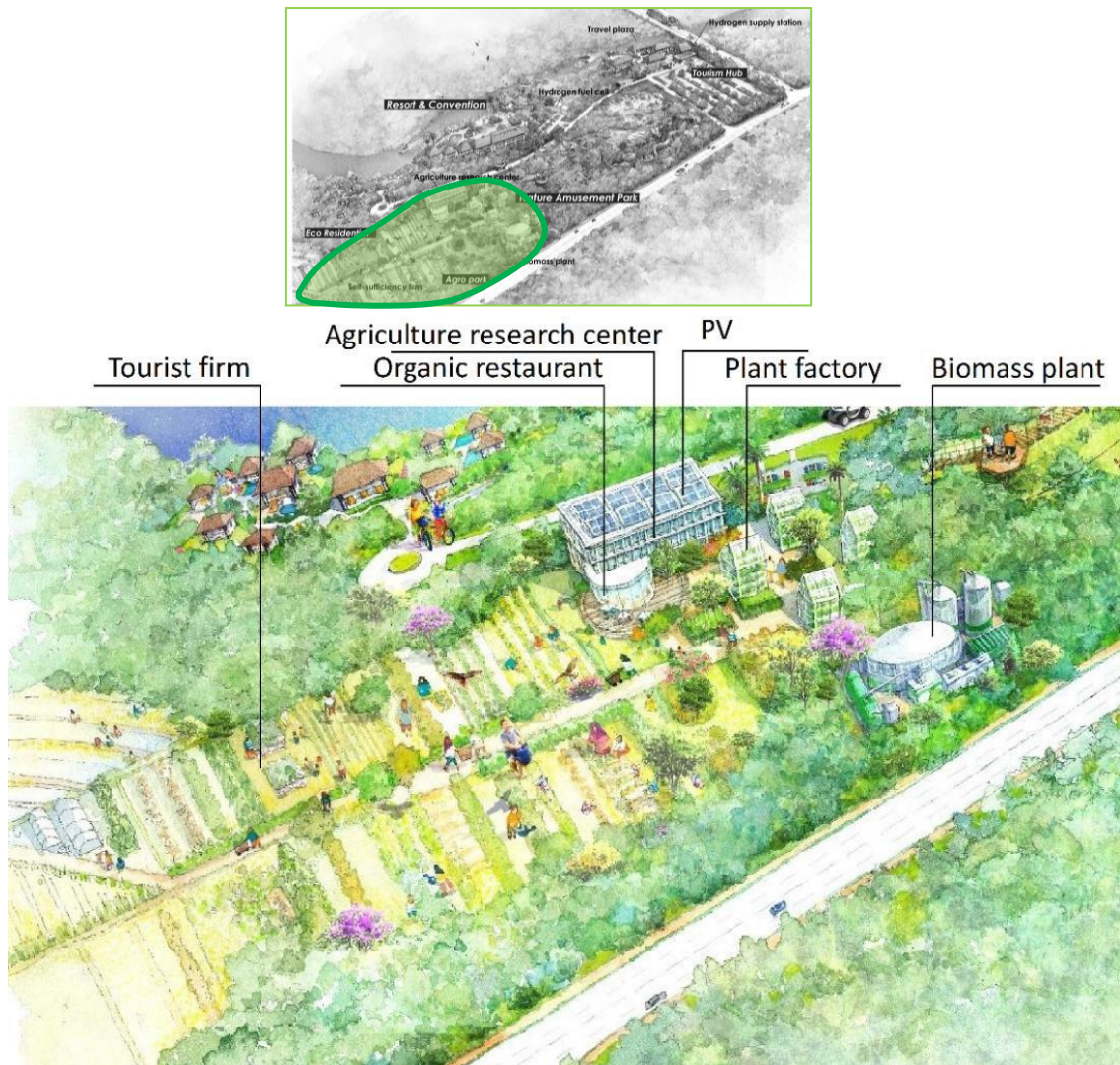


Source: ERIA and Nikken Sekkei Civil Engineering Ltd. (2018).

- **[TO-4] * Agro Park in Gate Zone**

Agro Park will be constructed to promote food self-sufficiency. This facility is planned to include an agricultural research institute, plant factory, and agricultural test site, and introduce PV and biomass plants as energy facilities. The park aims to improve agricultural productivity by linking surrounding agricultural lands like the existing one in the west. The park is also planned to attract tourists through a tourist farm and organic restaurant as part of the learning tourism ecosystem.

Figure 4.18: Image of Agro Park in Gate Zone



Source: ERIA and Nikken Sekkei Civil Engineering Ltd. (2018).

5.5. Education sector

5.5.1. Direction for the Development of the Education Sector

With the improved accessibility to Temburong district and its prospective ecotown environment, the development of new university campuses is envisioned to be part of the Temburong Ecotown Master Plan. Currently, the development of a new campus for the Universiti Islam Sultan Sharif Ali (Islamic University) is planned.

Besides the new campus for the Islamic University, this road map study proposes to develop an additional new campus for a science and technology university or natural science and engineering faculties of the existing university in Labu Estate. Such a proposal aims to collaborate with experimental projects for renewable energy utilisation and ecotourism projects for learning forest ecology.

5.5.2. Projects for the Development of the Education Sector

a) Outline of key projects of the education sector

The priority projects for the development of the education sector in Temburong district are listed in Table 4.8. The priority projects with * are key projects to initiate and drive the development of the education sector towards a carbon-neutral society.

Table 4.8: Priority and Key Projects of the Education Sector for Temburong Ecotown

Name of Project	Implementation Period
[ED-1] * Construction of New Campus for Islamic University in Labu Estate	2020–2021
[ED-2] * Continuation of Construction of New Campus for Islamic University in Labu Estate	2021–2022
[ED-3] * Construction of New Campus for a University for Science and Engineering University or Science and Engineering Faculties in Labu Estate	2023–2030

Source: Authors' analysis based on ERIA and Nikken Sekkei Civil Engineering Ltd (2018).

b) Outline of key projects of the education sector

- **[ED-1] * Construction of New Campus for UNISSA Phase 1 in Labu Estate and [ED-2] * Continuation of Construction of New Campus for UNISSA Phase 1 in Labu Estate**

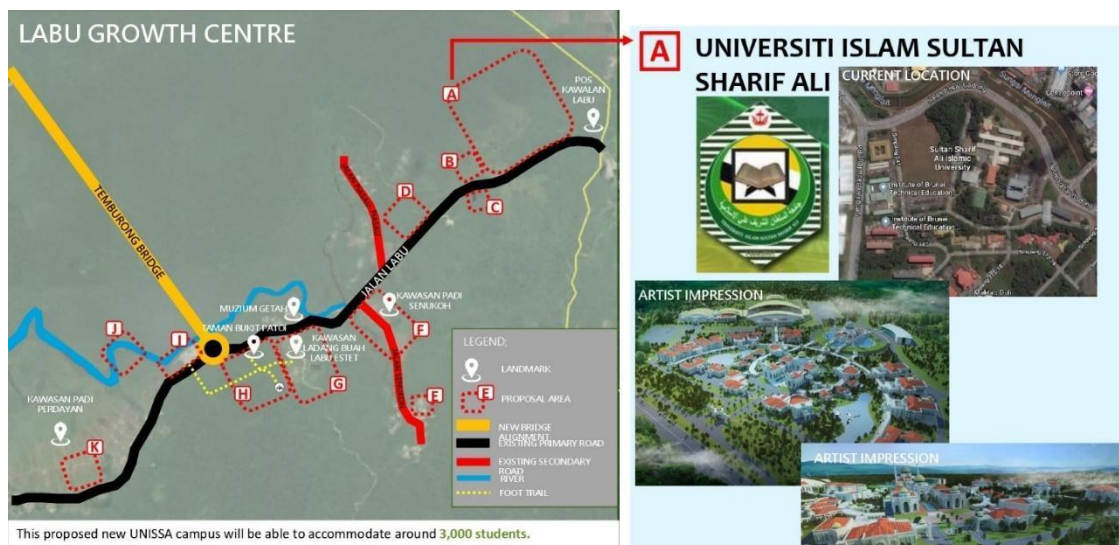
The development of a new campus for UNISSA is an important part of Temburong ecotown development. A new campus for UNISSA is planned to be located in Labu Estate.

Table 4.9: Land Necessary for the New Campus of Universiti Islam Sultan Sharif Ali (2030)

Item	Amount
Area (ha)	310
Students (number of people)	3,000

Source: Town and Country Planning Department, Ministry of Development (2010).

Figure 4.19: Location of New Campus for Universiti Islam Sultan Sharif Ali



Source: Town and Country Planning Department, Ministry of Development (2010).

- **[ED-3] * Construction of New Campus for a University for Science and Engineering University or Science and Engineering Faculties in Labu Estate**

To promote collaboration between experimental projects for the use of hydrogen and FC systems and science/engineering education/research, it is good to develop a new campus for a science and engineering university or science and engineering faculties of the existing university. Its location could be found in the Labu Estate adjacent to the R&D Centre.

Another possible field for science for the new university campus is forest ecology, which could be the basis for ecotourism. The university or faculty located in Temburong district could provide advantageous education and research opportunities for forest ecology.

5.6. Industry sector

5.6.1. Direction for the Development of the Industry Sector

Diversification of economies and industries is one of the important directions for Brunei Vision 2035. Temburong district could provide a very ideal location for advanced technological industries. This is by utilising natural forest resources and hydrogen made from associated gas in the short to middle term and hydrogen made from solar power in the medium and long term. The BSB–Temburong Bridge is a real bridge to such a potential land of Temburong.

5.6.2. Projects for the Development of the Industry Sector

a) Outline of key projects of the industry sector

Table 4.10 lists the priority projects for developing the industry sector in Temburong district. The priority projects with * are key projects to initiate and drive the industry sector's development towards a carbon-neutral society.

Table 4.10: Priority and Key Projects of the Industry Sector in Temburong Ecotown

Name of Project	Implementation Period
[IN-1]* Development of Industrial Park in Labu Estate	2022–2023
[IN-2]* Establishment of R&D Centre Phase 1	2024–2030
[IN-3] Establishment of R&D Centre Phase 2	2031–2040

Source: Authors' analysis based on ERIA and Nikken Sekkei Civil Engineering Ltd (2018).

b) Outline of key projects of the industry sector

- **[IN-1] * Development of Industrial Park in Labu Estate**
An industrial estate to accommodate non-polluting industries hopefully utilising existing forest resources will be developed in Labu Estate. The BSB–Temburong Bridge could greatly improve the connectivity between the International Airport and Labu Estate in Temburong district.
- **[IN-2] * Establishment of R&D Centre Phase 1**
The location of Temburong district could provide two types of advantages: (i) closeness to natural forest resources in the Heart of Borneo, and (ii) closeness to experimental projects for hydrogen utilisation for FC systems for motor vehicles and buildings. These two different kinds of ecotechnologies would be the basis for an R&D centre in Temburong district.

5.7. Housing sector

5.7.1. Direction for the Development of the Housing Sector

Based on the population framework, housing demand is estimated to reach 1,715. Some of these houses will be constructed in eco-residential areas and new residential areas in Labu Estate.

5.7.2. Projects for the Development of the Housing Sector

a) Outline of key projects of the education sector

The priority projects for the development of the housing sector in Temburong district are listed in Table 4.11. Those with * are vital projects to initiate and drive the housing sector's development towards a carbon-neutral society.

Table 4.11: Priority and Key Projects of the Housing Sector in Temburong Eco Town

Name of Project	Implementation Period
[HO-1] * Eco Residential Area in Gate Zone	2020–2021
[HO-2] * Residential Areas Phase 1 in Labu Estate	2021–2022
[HO-3] Continuation of Residential Areas Phase 1 in Labu Estate	2023–2030
[HO-4] Residential Area Phase 2 in Labu Estate	2031–2040

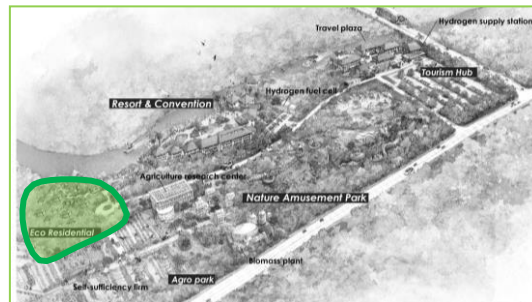
Source: Authors' analysis based on ERIA and Nikken Sekkei Civil Engineering Ltd (2018).

b) Outline of key projects of the housing sector

- **[HO-1] * Eco-residential Area in Gate Zone**

The Eco-residential Area is planned next to the Resort and Convention Zone. Eco residential is a diverse community that is home to people working at the Gate Zone, such as energy and transportation workers, agricultural researchers, and employees in the service industry. With the introduction of smart technology, such as renewable energy and sustainable architecture, this area will become a living lab.

Figure 4.20: Image of Eco-residential Area in the Gate Zone

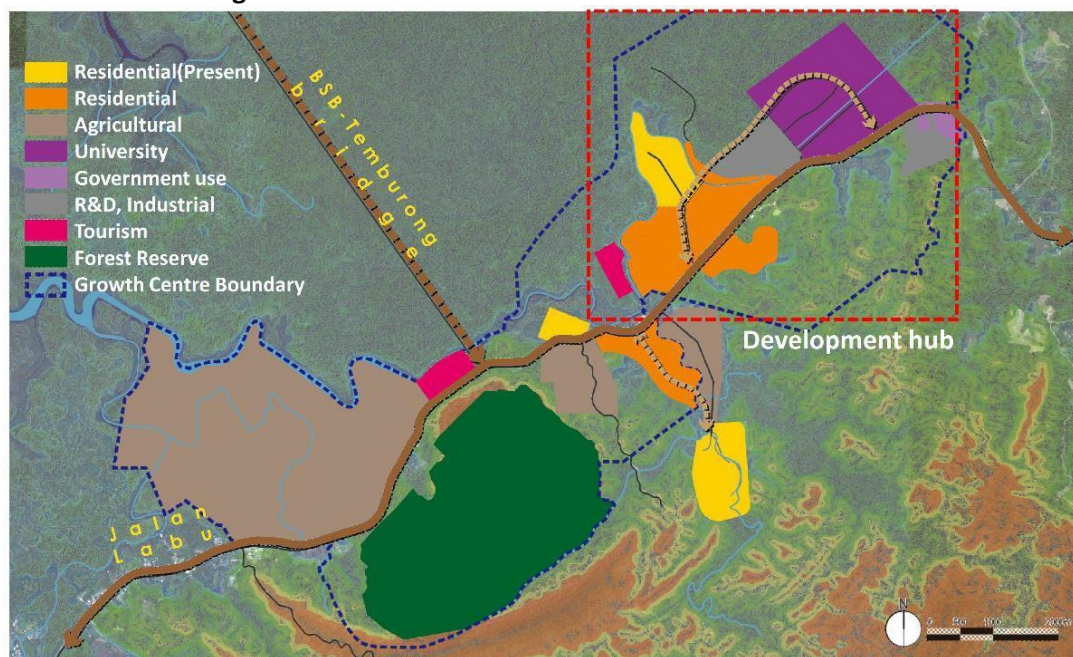


Source: ERIA and Nikken Sekkei Civil Engineering Ltd. (2018).

- **[HO-2] * Residential Areas Phase 1 in Labu Estate**

The existing residential areas divide the housing area into three villages. The master plan proposes housing development between the three villages to connect them, providing better service based on the optimisation of public services and the effect of scale.

Figure 4.21: Location of Residential Area in Labu Estate



Source: ERIA and Nikken Sekkei Civil Engineering Ltd. (2018).

5.8. Development of Bangar Urban Centre

5.8.1. Direction for the Development of Bangar Urban Centre

Bangar, as the capital of Temburong district, will continue to be the essential growth centre for the district. As the centre of public services, Bangar will house the district office, hospital, market, and residential communities.

5.8.2. Projects for the Development of Bangar Urban Centre

a) Outline of key projects for the development of Bangar Urban Centre

Table 4.12 lists the priority projects for the development of Bangar Urban Centre are listed in Table 4.12. Those with * are key projects to initiate and drive the Bangar Urban Centre's development towards a carbon-neutral society.

Table 4.12: Priority and Key Projects of Development of Bangar Urban Centre

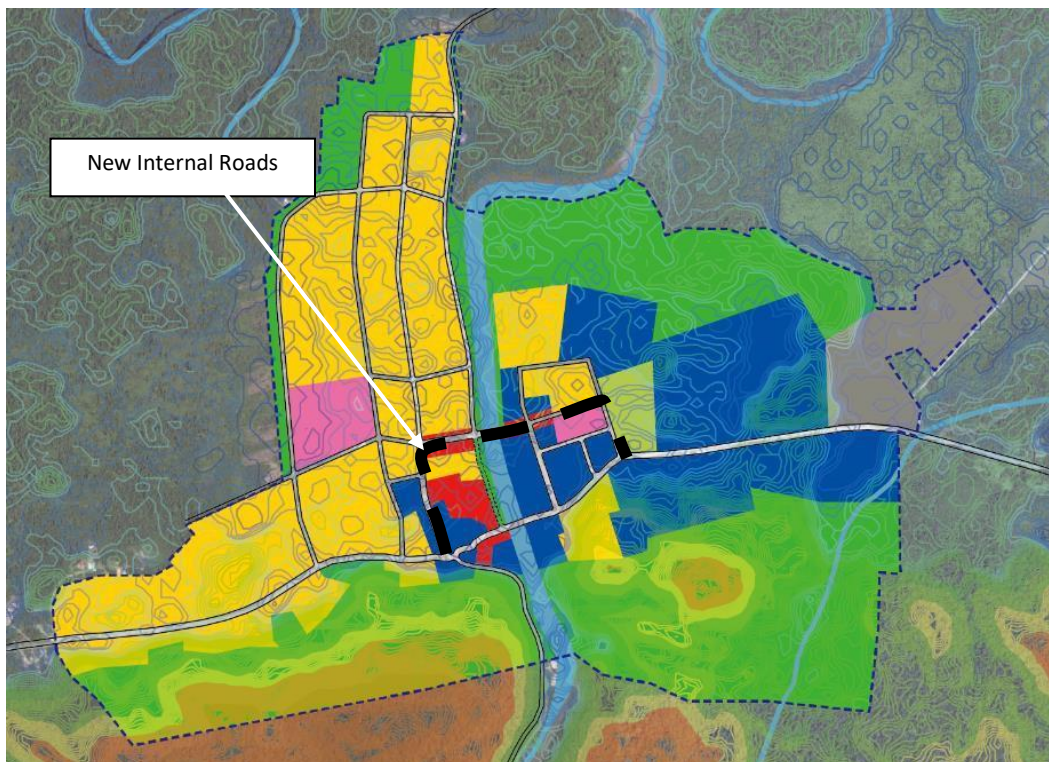
Name of Project	Implementation Period
[UC-1] * Improvement of Internal Road and Construction of Second Bridge of Bangar Phase 1	2020–2021
[UC-2] * Construction of Port Facility	2020–2021
[UC-3] * Improvement of Internal Road and Construction of Second Bridge of Bangar Phase 2	2022–2023
[UC-4] Riverside Park	2022–2023
[UC-5] New Hospital or Expansion of Hospital	2024–2030
[UC-6] Temburong Industrial Estate in Bangar	2024–2030

Source: Authors' analysis based on ERIA and Nikken Sekkei Civil Engineering Ltd (2018).

- b) Outline of key projects for the development of Bangar Urban Centre
 - **[UC-1] * Improvement of Internal Road and Construction of Second Bridge of Bangar Phase 1 and [UC-3] * Improvement of Internal Road and Construction of 2nd Bridge of Bangar Phase 2**

The Temburong River divides the Bangar area, and Jalan Labu is the only connection between the two areas. Considering the increase in population and expansion in the logistics sector, through-traffic should be separated from inner-city traffic through the construction of more inner roads and bridges. Figure 4.22 shows the new road and bridge for the inner-city traffic.

Figure 4.22: Location of New Internal Roads and Bridge in Bangar Urban Centre

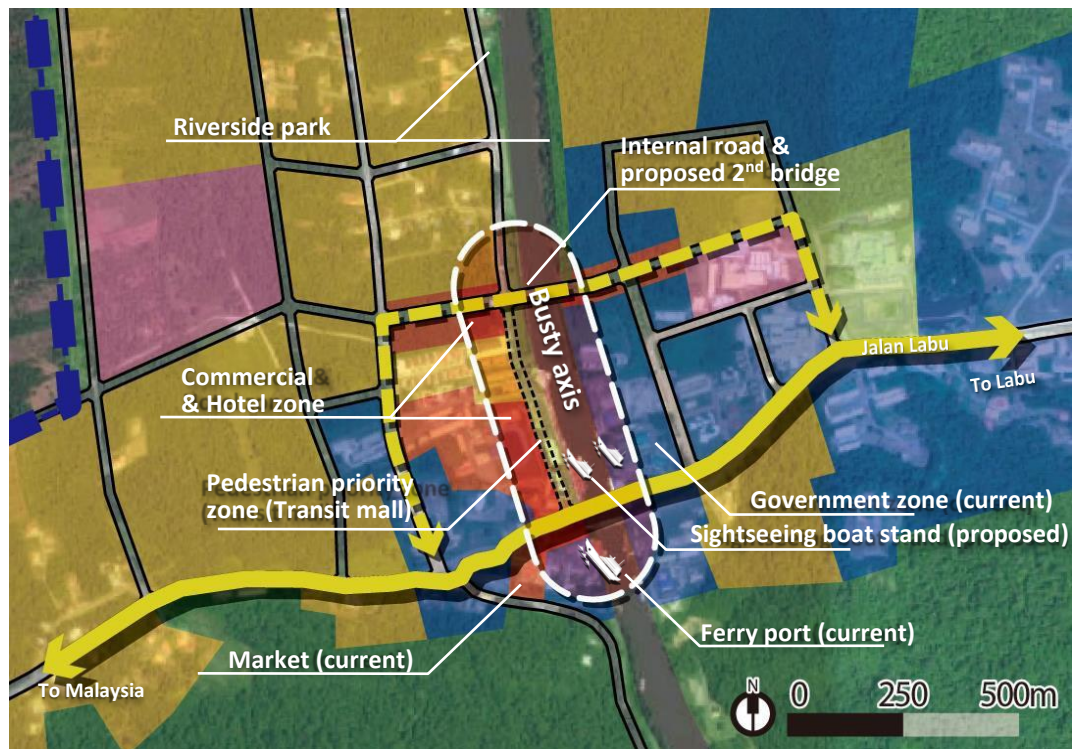


Source: ERIA and Nikken Sekkei Civil Engineering Ltd. (2018).

- **[UC-2] * Construction of Port Facility**

The main ferry port, downstream from Jalan Labu, is the terminal for high-speed, large vessels used to travel to the national capital and neighbouring countries. The study plans to introduce new river-related activities in Bangar and Labu, along with a sightseeing dock in the transit mall area in front of the commercial district on the left bank and the administrative area on the right bank. These new docks will avoid the complication of the high-speed, large vessel ferries and create a lively river space. The area around the new ferry port is also intended to be a bustling area with uninterrupted shopping space by pedestrianising part of the roads between the current commercial area and the Temburong River. This will create an urban space for the residents and tourists to enjoy.

**Figure 4.23: Location of New Port and the Riverside Development Area
in Bangar Urban Centre**



Source: ERIA and Nikken Sekkei Civil Engineering Ltd. (2018).

5.9. Summary of road map for Temburong ecotown development

Table 4.13 summarises the priority projects of the road map for the Temburong Ecotown development.

**Table 4.13: Summary of Priority and Key Projects in the Road Map
for Temburong Ecotown Development**

	Present	Present – 2021	2022–2023	2024–2030	2031–2040
Energy	[EN-1]*Hydrogenation Plant	[EN-2]*Exportation of SEPERA Hydrogen to Japan	[EN-3]*Photovoltaic Power Station Phase 1	[EN-4]*Photovoltaic Power Station Phase 2	[EN-5]*Photovoltaic Power Station Phase 3
Transportation	[TR-1]*BSB-Temburong Bridge	[TR-2]*Hydrogen Supply Stations for Fuel Cell (FC) Buses and Vehicles	[TR-4]*Mass Transit Bus Services by FC Buses between Empire Hotel Aiport, and Temburong Mobility Hub	[TR-6]*Expansion of Mass Transit Bus Services by FC Buses between Empire Hotel Airport and Temburong Mobility Hub	[TR-8]*Expnasion of Fuel Cell Bus and Passenger Car Operation both in Temburong District and Mainland
		[TR-3]*Mobility Hub'in the Gate Zone	[TR-5]*Community Bus Services by FC Buses within Temburong Ecotown	[TR-7]*Expnasion of Community Bus Services by FCI Buses within Temburong Ecotown	
Water			[WA-1]*Upgrading of Existing Batang Duri Water Treatment Plant	[WA-2]*Upgrading of Existing Sumbing Water Treatment Plant	[WA-1]*New Water Treatment Plant at Batu Apoi of Capacity 20 Mld
Tourism		[TO-1]*Resort & Convention in Gate Zone	[TO-3]*Nature Amusement Park in Gate Zone	[TO-5]*Hotel and Convention in Labu Estate Phase 1	[TO-6]*Hotel and Convention in Labu Estate Phase 2
		[TO-2]*Tourism Hub (Information and Learning Centre for Ecotourims)	[TO-4]*Agro Park in Gate Zone		
Education		[ED-1]*New Campus of	[ED-2]*Continuation	[ED-3]*Construction	

		Islamic University in Labu Estate	of New Campus of Islamic University in Labu Estate	of New Campus of Science & Engineering Faculties in Labu Estate	
Industry			[IN-1]*Industrial Park in Labu Estate	[IN-2]*R&D Centre Phase 1	[IN-3]*R&D Centre Phase 2
Housing		[HO-1]*Eco Residential Area in Gate Zone	[HO-2]*Residential Areas Phase 1 in Labu Estate	[HO-3]*Continuation of Residential Areas Phase 1 in Labu Estate	[HO-3]*Residential Areas Phase 2 in Labu Estate
Urban Centre Bangar		[UC-1]*Internal Road	[UC-3]*2nd Bridge of Bangar	[UC-5]*New Hospital or Expansion of Hospital	
		[UC-2]*Port Facility	[UC-4]*Riverside Park	[UC-6]*Temburong Industrial Estate in Bangar	

Source: Authors' analysis based on ERIA and Nikken Sekkei Civil Engineering Ltd (2018).