Chapter 5

Hydrogen Supply and Demand Balance and Proposed Models

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CHAPTER 5

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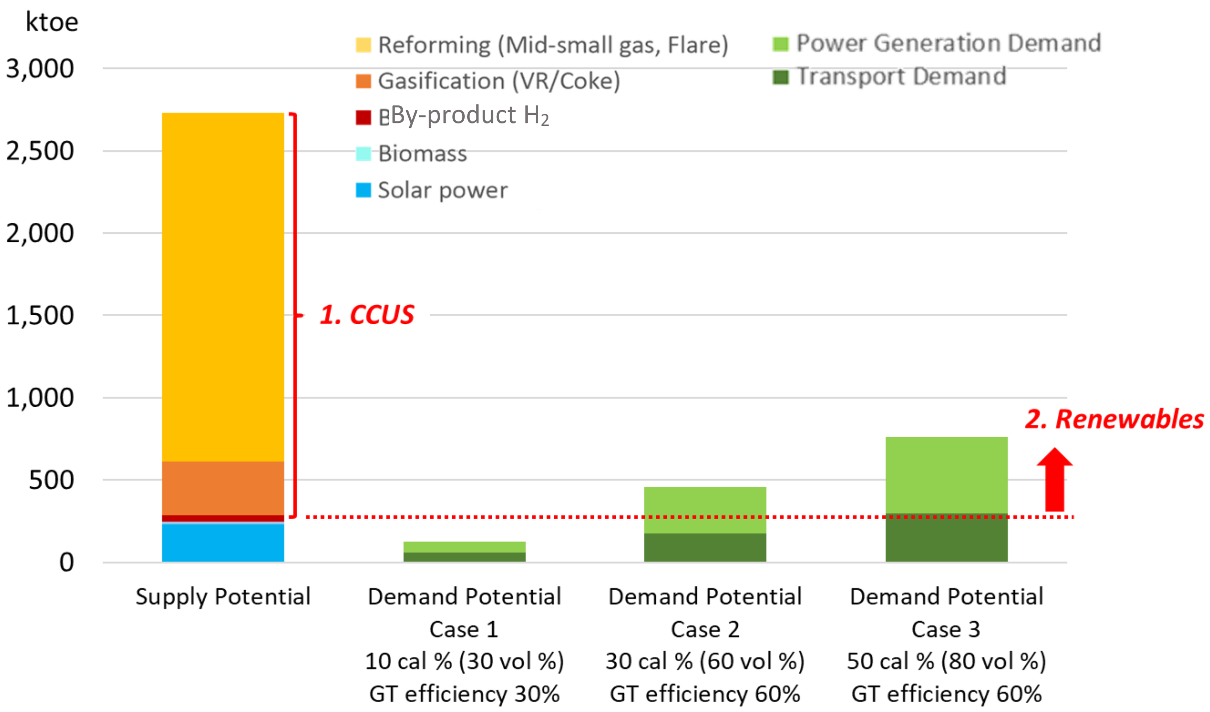
5.1. Hydrogen Balance in 2040

Figure 5.1 shows the hydrogen supply and demand balance of Brunei in 2040. We set the three scenarios (cases 1, 2, and 3) with 10, 30, and 50 calorific percentage of hydrogen penetration into the country's energy market to see the hydrogen supply and demand balances (Table 5.1).

The graph shows that there is enough potential in hydrogen production to fulfil the expected hydrogen demand in 2040 in Brunei Darussalam.

The large portion of the hydrogen supply potential will come from fossil fuels which require carbon capture and storage (CCS)/carbon capture and utilisation (CCU) technologies to make the hydrogen blue. However, with the expansion of renewable energies in the future, Brunei can potentially increase the volume and sustainability of hydrogen supply.

Figure 5.1: Hydrogen Supply and Demand Balance in 2040



GT = gas turbine, VR = vacuum residue.
Source: Author (2020).

Table 5.1: Hydrogen Penetration Scenario

	Power Generation (Calorie %) -> kWh			FCVs (Calorie %) -> km	
		NG	H_2	Gasoline /Diesel	H_2
Base	GT Efficiency 30%	100%	0%	100%	0%
Case 1	**Existing GT** 30 vol % co-fire, Efficiency 30%	90 cal %	10 cal % (30 vol %)	90%	10%
Case 2	**New Construction GT** 60 vol % co-fire, Efficiency 60%	70 cal %	30 cal % (60 vol %)	70%	30%
Case 3	**New Construction GT** 80 vol % co-fire, Efficiency 60%	50 cal %	50 cal % (80 vol %)	50%	50%

Source: Author (2020).

As a whole, Brunei Darussalam has a hydrogen supply potential of 2.7 Mtoe, with fossil fuel–derived hydrogen accounting for 90% of the total. On the other hand, in demand scenario case 1 (10% calorie of hydrogen), the hydrogen demand is estimated at 0.12 Mtoe; in case 2 (30% calorie), it is 0.46 Mtoe; and in case 3 (50% calorie), 0.76 Mtoe.

Considering the above circumstances, the feasibility of CCS, CO_2-enhanced oil recovery (EOR), and CCU applications for fossil fuel–derived hydrogen production and the significant increase of renewable energy production will play a central role in fulfilling the country's hydrogen demand in the future.

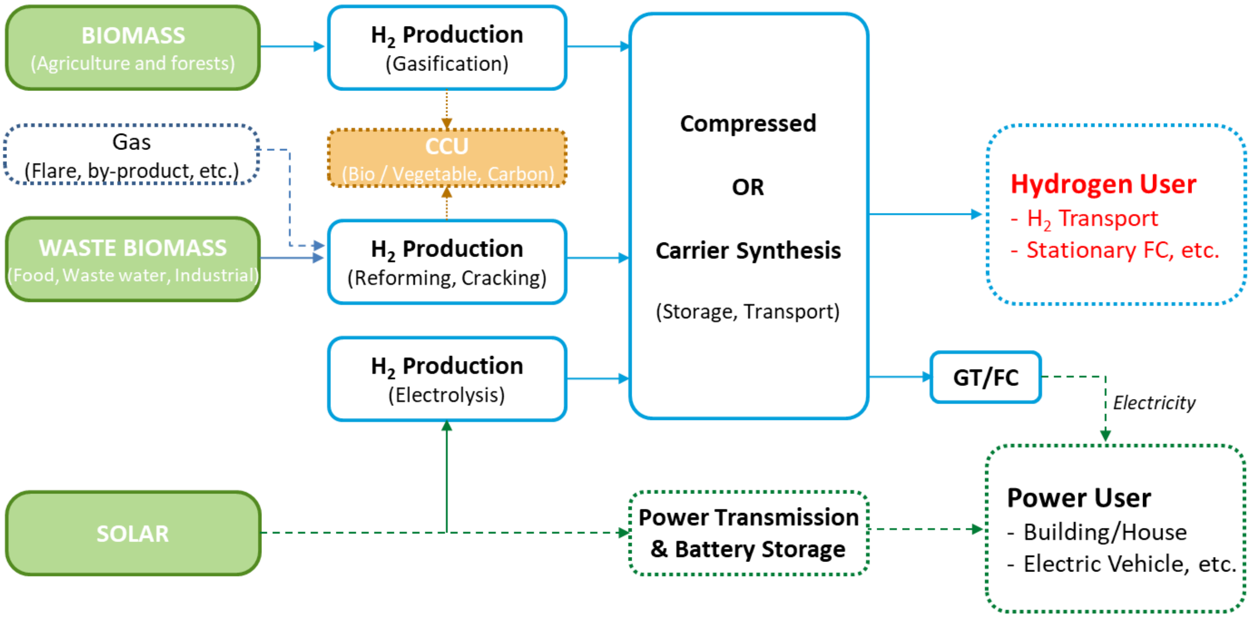
5.2. Proposed Hydrogen Penetration Models

To enhance the smooth penetration of hydrogen into Brunei's energy market, various models could be envisaged as hydrogen supply and demand models.

- ***Hydrogen Supply Model: Domestic Hydrogen Supply Chain in Brunei Darussalam***

To establish the domestic hydrogen supply chain, the key points will be to maximise the use of domestic renewable resources (green hydrogen) for both the power and transport sectors, and minimise the use of fossil fuel–based energy (blue hydrogen) for decarbonisation and maximise the benefits and sustainability of fossil fuel resources.

Figure 5.2: Hydrogen Supply Model: Domestic Hydrogen Supply Chain in Brunei Darussalam

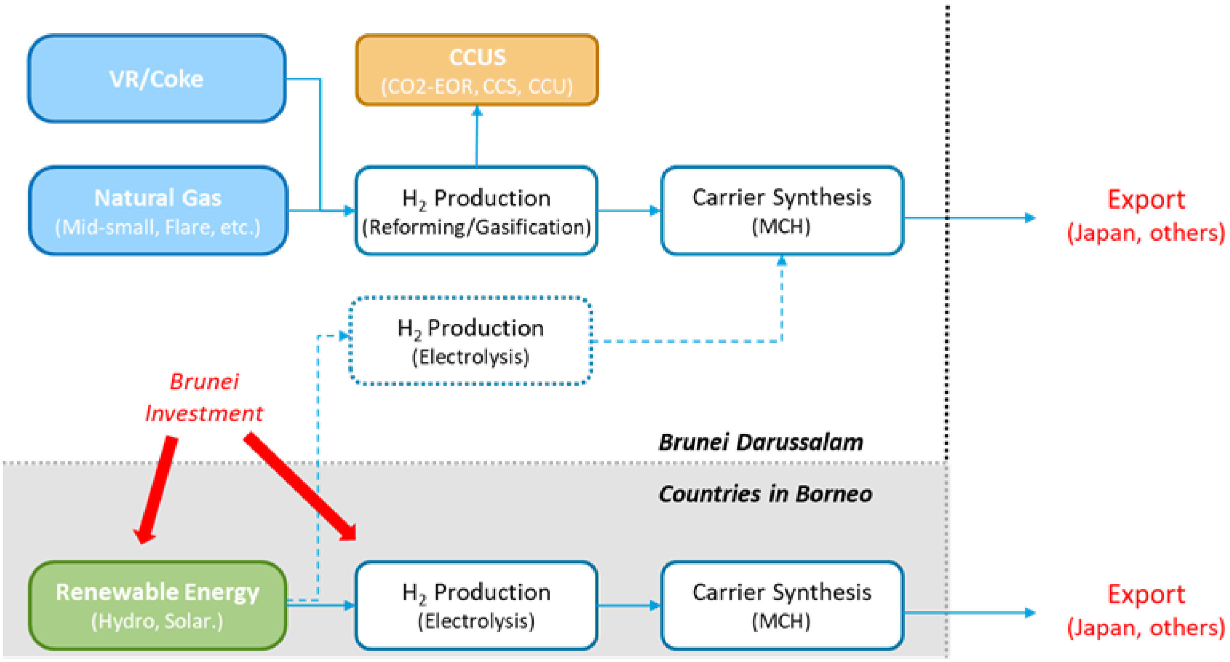


CCU = carbon capture and utilisation.
Source: Author (2020).

- ***Hydrogen Supply Model: Global Hydrogen Supply Chain from Brunei Darussalam***

Key points to establish a global hydrogen supply chain is the use of CCU technologies for fossil fuel–based hydrogen. Another option is the use of abundant renewable energy outside of Brunei Darussalam, with strategic investment for cross-bordering import of renewable energy in some cases, in collaboration with neighbour countries of Borneo.

Figure 5.3: Hydrogen Supply Model: Global Hydrogen Supply Chain from Brunei Darussalam



CCS = carbon capture and storage, CCU = carbon capture and utilisation, CCUS = carbon capture utilisation and storage, MCH = methylcyclohexane, VR = vacuum residue.
Source: Author (2020).

- ***Hydrogen Demand Model: Hydrogen Transportation***

There are also opportunities to introduce hydrogen-based buses, trucks, hydrogen fuel cell electric vehicles (FCEVs) and/or public transport systems such as bus rapid transportation (BRT)/light rail transit (LRT), to reduce fossil fuel consumption and CO_2 emissions from the transport sector of Brunei.

Figure 5.4: Hydrogen Demand Model: Hydrogen Transportation

Fuel Cell BRT system

(e.g. France: The world's first hydrogen-powered BRT)

Eight 18 meter long Van Hool fuel cell buses operate 6 km express route.

Fuel Cell LRT system

(e.g. Sarawak: Kuching LRT ready by 2024)

BRT = bus rapid transit, LRT = light rail transit.
Source: Smart Cities World (2019) (left); KUCHINGBORNEO (2018) (right).

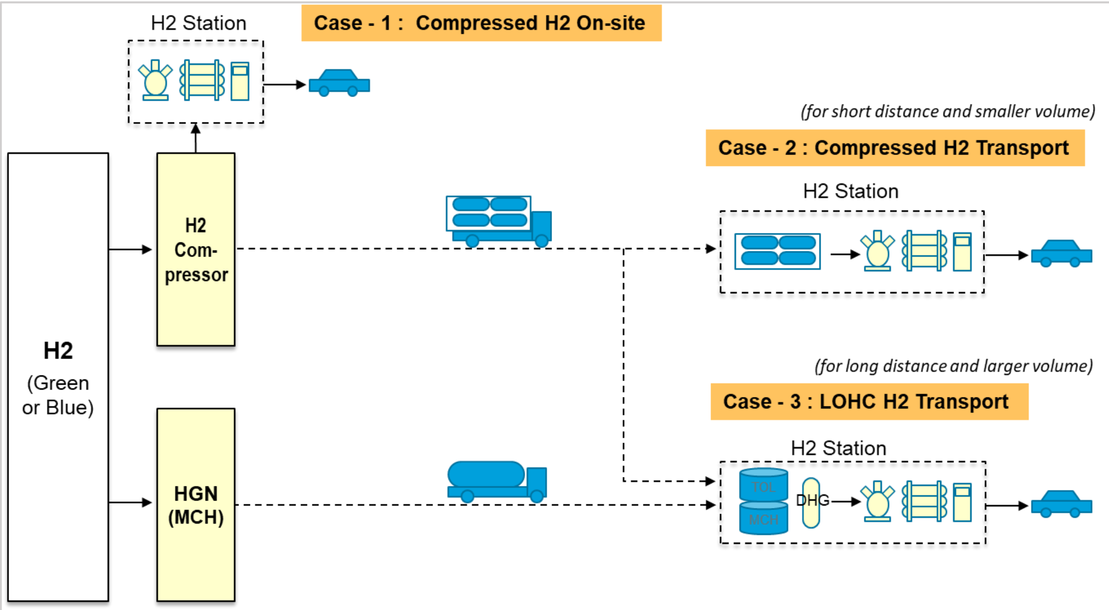
FCEVs will play an important role in decarbonising the transport sector. Gasoline and diesel are reported to account for 21% of global carbon emission (Hydrogen Council, 2017). The introduction of hydrogen into the mobility sector will significantly reduce CO_2 emissions in the transport sector.

FCEVs demonstrate their strength especially in the use of heavier duty vehicles (over 100 km per day, 10 tonnes) such as medium-to-large cars, trucks, buses, and BRT and LRT systems. FCEVs will potentially contribute to reducing the government's fuel subsidy of B$180 million–B$400 million annually. Decreasing domestic gasoline and diesel consumption can also increase the country's oil and gas export.

- ***Hydrogen Demand Model: Hydrogen Transportation (H_2 Refuelling Station)***

There are several options for hydrogen refuelling stations, such as onsite hydrogen generation and refuelling system, compressed hydrogen refuelling station, and liquid organic hydrogen carrier methylcyclohexane (MCH) refuelling station, with hydrogen transport and larger hydrogen production and to be selected depending on the location, volume of hydrogen sources, grid infrastructure, etc.

Figure 5.5: Hydrogen Demand Model: Hydrogen Transportation Model (H_2 Refuelling Station)



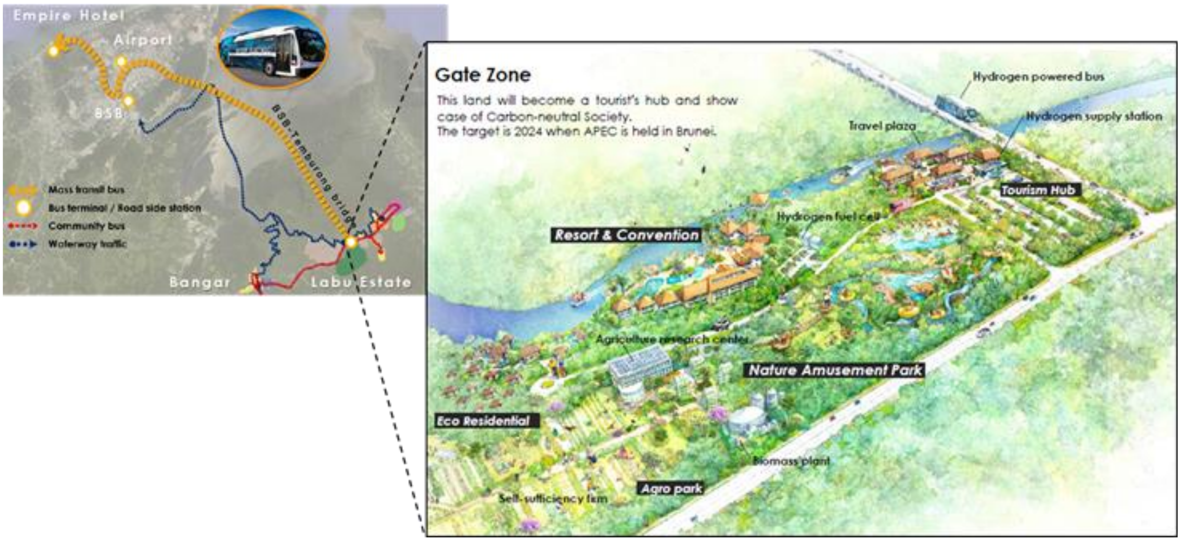
LOHC = liquid organic hydrogen carrier, MCH = methylcyclohexane.
Source: Author (2020).

- ***Hydrogen Demand Model: Ecotown (Renewable and Hydrogen Energy System)***

There is opportunity to build an eco-friendly and innovative town using hydrogen technology as one of the key alternatives for a sustainable town model in Southeast Asia.

Figure 5.6: Hydrogen Demand Model: Ecotown (Renewable and Hydrogen Energy System)

<u>**Temburong Ecotown and Smart Mobility Network**</u>



APEC = Asia-Pacific Economic Cooperation.

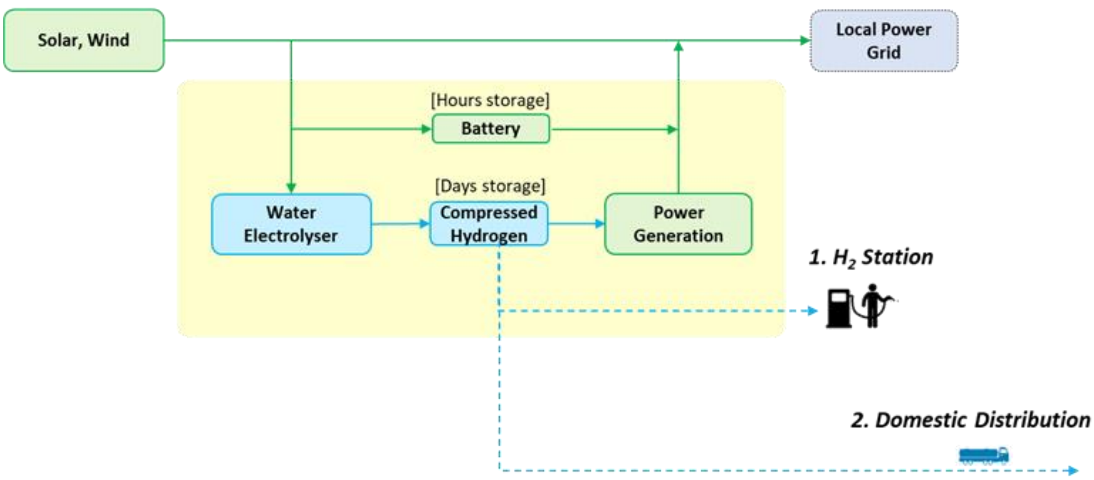
Source: ERIA and Nikken Sekkei Civil Engineering Ltd (2019).

- ***Hydrogen Demand Model: Ecotown (Area-based Green Storage System)***

To supply stable renewable energy in remote areas, like the Temburong district, it will be valuable to install the integrated battery and hydrogen storage and transport system that will become a part of the hydrogen network.

Figure 5.7: Hydrogen Demand Model: Ecotown (Area-based Green Storage System)

<u>**Area-based Green Energy Storage**</u>

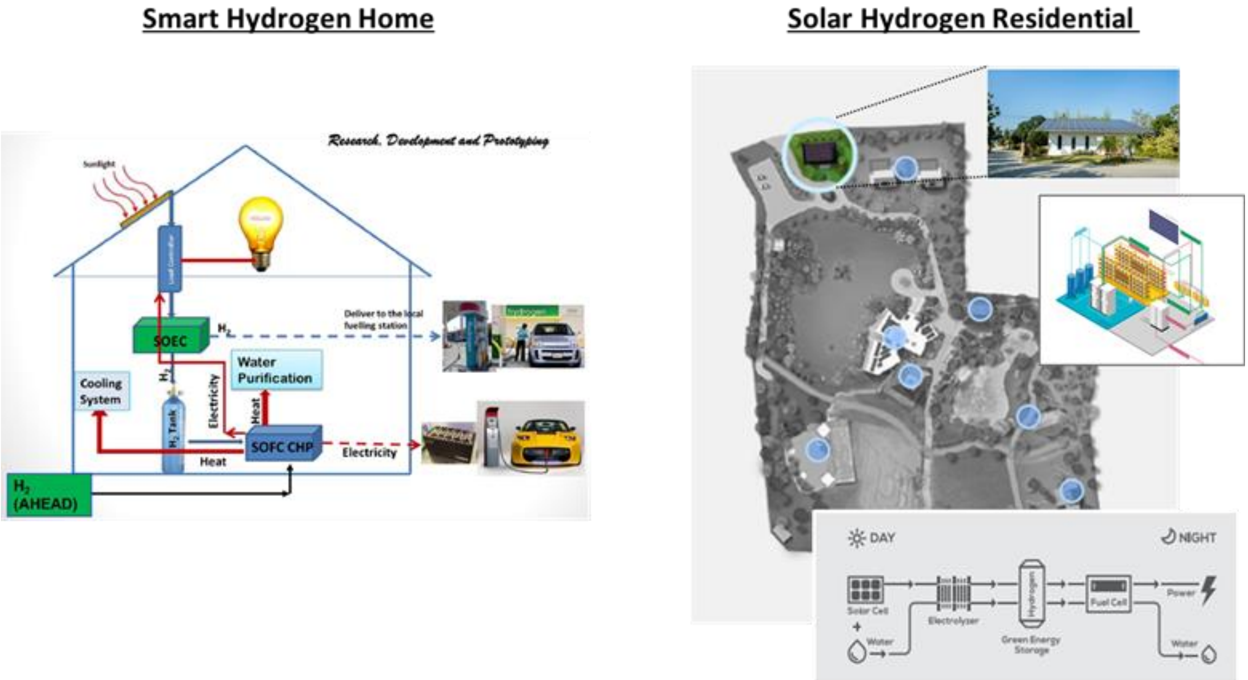


Source: Author (2020).

- ***Hydrogen Demand Model: Ecotown (Home Storage System)***

Another application is an integration system of solar, battery, and hydrogen storage for lower or zero CO_2 emissions and stable green energy supply to the residential zone.

Figure 5.8: Hydrogen Demand Model: Ecotown (Home Storage System)



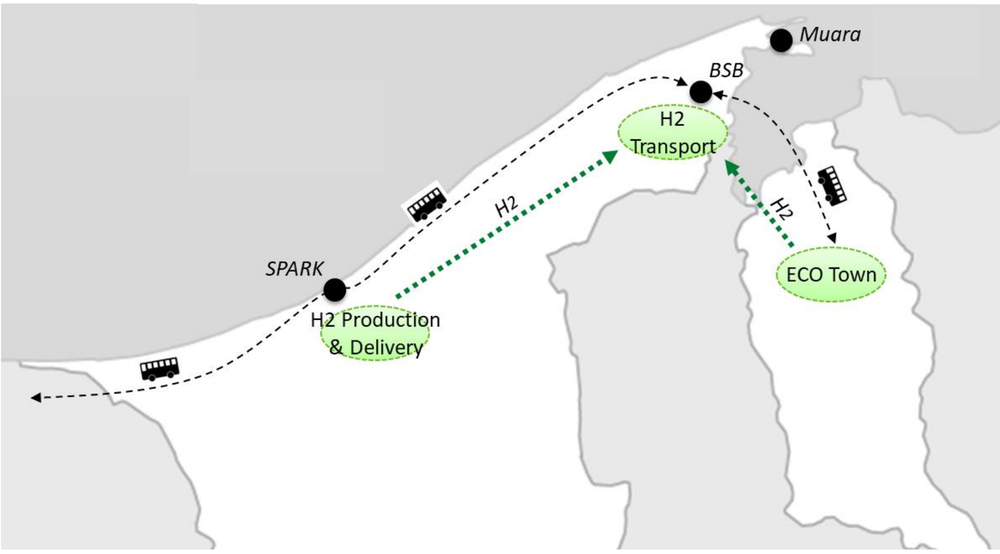
Source: Azad (2018) (left); Phi Suea House (2020) (right).

- ***Hydrogen Demand Model: Example Projects***

There are several opportunities to introduce hydrogen, and the following are examples of hydrogen projects in Brunei Darussalam:

- Hydrogen transportation in Bandar Seri Begawan, using the BRT system and FCEVs
- Temburong ecotown, utilising solar hydrogen storage
- Hydrogen production and delivery at Sungai Liang Industrial Park (SPARK), Belait district, utilising steam methane reforming and electrolysis, and compression of MCH.

Figure 5.9: Hydrogen Demand Model: Example Projects



Source: Author (2020).