Chapter 1

Introduction

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Chapter 1

Introduction

The strategic measures in the Association of Southeast Asian Nations (ASEAN) Plan of Action for Energy Cooperation 2016–2025 include increasing the share of renewable energy to a mutually agreed percentage in the ASEAN energy mix (total primary energy supply) by 2020. However, a critical barrier is the intermittency of renewables, especially solar and wind energy.

The energy system, including the power grid, needs significant energy storage capacity to fully absorb renewable energy. Otherwise, harvested renewable energy will be abandoned, resulting in the sheer waste of energy and money by countries that have already heavily invested in intermittent renewables.

Pumped hydropower is a low-cost energy storage solution, but its potential is limited by geological conditions. The other solution is large-scale battery storage, but batteries have high capital expenditure (CAPEX) and operational expenses (OPEX), a short lifetime (5–7 years), and fixed and limited storage capacity that degrades continuously (Khalili et al., 2019).

Hydrogen (H_2) does not typically occur in nature on Earth, but it could be produced using various physical and chemical processes, which consume energy in various forms. When high-purity hydrogen is consumed to acquire energy (especially by using fuel cell technologies), it is considered an energy carrier. As consumption of hydrogen as an energy carrier typically produces pure water (H_2O), hydrogen is considered clean energy, especially if it is produced from renewable energy–based pathways. Hydrogen thus has the potential to cure our dependence on fossil fuel and eliminate greenhouse gas (GHG) emissions.

Hydrogen as an energy carrier has many advantages:

(i) Its energy intensity is higher than that of gasoline; 5 kilograms (kg) of hydrogen can power a passenger vehicle for up to 500 kilometres (km).

(ii) Refuelling can be done as quickly as for gasoline and diesel. These first two advantages make hydrogen especially suitable for long-distance or heavy-duty trips, for example, by intercity buses and cargo delivery trucks.

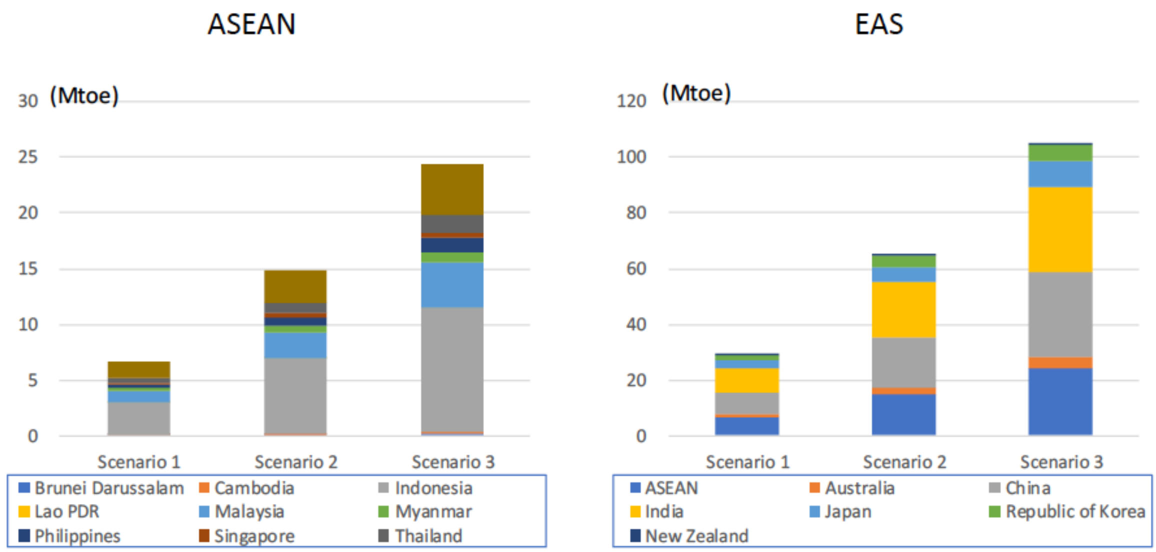
(iii) Hydrogen can be produced from clean and indigenous sources such as renewables, nuclear energy, biomass, and biofuel. This is critically important for the energy security of countries highly reliant on imports of fossil fuels to power transport.

(iv) The scale and location of hydrogen production are highly flexible, especially in the cases of onsite electrolysis and onsite transformation using pipeline natural gas. Hydrogen can be stored by many means, centralised or distributed, and then delivered using existing infrastructure such as road and rail. An electrified transport system, however, is vulnerable if fully reliant on the power grid; blackouts, cyberattacks, or physical attacks could paralyse road transport.

(v) When the share of intermittent renewables is high, using surplus or abandoned renewables to produce hydrogen can not only balance the power grid but also offer an option to store energy when the weather is sunny (solar), windy (wind), or rainy (hydropower) and release it back to the power grid when needed.

The potential of hydrogen as an energy carrier and a complementary development for large-scale expansion of renewable energy in ASEAN and East Asian countries should, therefore, be studied. An ERIA (2019) report estimated the following outlook for hydrogen demand in ASEAN and East Asia Summit countries (Figure 1).

Figure 1. Hydrogen Demand Potential by Country in 2040



ASEAN = Association of Southeast Asian Nations, EAS = East Asia Summit, Lao PDR = Lao People's Democratic Republic, Mtoe = million tonnes of oil equivalent.
Source: ERIA (2019).

This study investigates the economics of using hydrogen to store renewable energy and subsequently consumed by downstream applications in ASEAN and East Asian countries.

For the power sector, the cost of storing and then delivering each kilowatt-hour of renewable energy, which includes the cost of producing hydrogen, transporting and storing hydrogen, and then converting it into electricity, is compared with alternatives such as batteries and pumped hydropower.

For transport sector, a well-to-wheel model is used to compare the cost of fuel cell electric vehicles (FCEVs) powered by hydrogen sourced from renewable energy sources (RESs) with the cost of battery electric vehicles (BEVs), plug-in hybrid vehicles (PHEVs), and conventional internal combustion engine vehicles (ICEVs).

To substantiate the desktop research, the study interviewed experts and visited sites to investigate existing and potential demonstration projects that apply such energy storage concepts, to identify lessons, experience, and key barriers given technology levels and supply chain costs.

Chapter 2 reviews the literature on relevant topics. Chapter 3 discusses quantitative studies on the economics of using hydrogen to store renewable energy and the well-to-wheel model to assess the cost of FCEVs in ASEAN and East Asian countries. Chapter 4 summarises the findings from visits to demonstration projects in China and Japan. Chapter 5 concludes with policy implications.