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Hydrogen Regulation in Southeast Asia

Steam Reforming from Biofuels as an Alternative to Electrolysis?

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7.1 INTRODUCTION

The ASEAN Center for Energy (ACE) highlights the potential for hydrogen to serve as an energy storage medium for intermittent renewable generation, especially from solar and wind energy.[1] It acknowledges the potential role of hydrogen, especially the contribution of hydrogen produced from biofuels from food crops, as an alternative to fossil fuel imports.[2] This chapter explains that, in spite of an absence of special legislation and regulations on hydrogen production, Association of Southeast Asian Nations (ASEAN) countries can rely on existing regulatory frameworks, especially manufacturing or industrial works and environmental protection regulatory regimes, for the regulation of the establishment and operation of hydrogen production plants. It uses Thailand as a case study to make a bigger point about regulatory techniques on hydrogen production in ASEAN countries, arguing that the current regulatory frameworks on energy production, for example, the one based on the Energy Industry Act BE 2550 (2007) (the Energy Industry Act), are too general in nature and incapable of sufficiently regulating production of green hydrogen.

This chapter starts by addressing the extent to which international climate policies have an impact on ASEAN countries' regulatory frameworks on energy production as well as manufacturing activities and environmental protection, followed by an overview of hydrogen utilisation plans in ASEAN countries. Section 7.3 analyses how the current Thai government is incorporating hydrogen production activities into the general energy production framework, due to a lack of comprehensive or special hydrogen legislation. Section 7.4 looks at how electricity procurement procedures under the Energy Industry Act can allow unintentional subsidisation of grey electricity that was formerly only thought to be available for the generation of green and blue hydrogen. The chapter concludes with some observations on the potential of hydrogen in ASEAN countries considering the current lack of regulation and an outlook on future activities.

[1] ASEAN Centre for Energy (ACE), 'Hydrogen in ASEAN: Economic Prospects, Development & Applications' (ASEAN Centre for Energy, 30 September 2021), 2 <https://aseanenergy.org/hydrogen-in-asean-economic-prospects-development-and-applications/> accessed 13 May 2022.

[2] Ibid.

7.2 THE TECHNICALITIES OF STEAM REFORMING FROM BIOFUELS AND ASEAN'S LAWS AND POLICIES ON HYDROGEN

Typically, green hydrogen is produced by water electrolysis,[3] but few people are aware that it is also possible to use chemical processes such as steam methane reforming (SMR) for the production of green hydrogen. This is a process involving the endothermic conversion of methane and water vapour into hydrogen and carbon monoxide.[4] SMR is a process by which natural gas or methane reacts with steam in the presence of a catalyst to produce hydrogen and carbon dioxide.[5] Technically speaking, a catalyser such as nickel is used to facilitate the thermochemical reaction of feedstocks such as natural gas and liquid petroleum gas to heat water to a temperature of around 850 °C and a pressure of 2.5 megapascal.[6] The methane found in natural gas reacts with steam to produce a syngas consisting of hydrogen and carbon monoxide.[7]

Depending on the fuels or energy carriers used for its generation, hydrogen produced via steam reforming itself can be categorised by colour. If it involves high greenhouse gas emissions, hydrogen produced by steam reforming of methane/natural gas is categorised as grey hydrogen.[8] Blue hydrogen is a more environmentally friendly choice – it is produced through steam methane reforming of natural gas or coal gasification, but with carbon dioxide capture and storage.[9] In any case, green and blue hydrogen are considered low-carbon hydrogen in Asia.[10] Alternatively, hydrogen may also be produced from biogas via steam reforming, and this chapter will now discuss if this can be considered green hydrogen.[11]

The exciting twist that ASEAN countries can bring to the table is to use biofuels to produce low-carbon hydrogen. Biofuels are defined by the Food and Agriculture Organization of the United Nations (FAO) as fuel produced directly or indirectly from biomass.[12] First-generation biofuels can be derived from agricultural crops grown for food and animal feed, including grains, starches, oil crops, sugarcane, sweet sorghum and non-food plants such as jatropha and pongamia pinnata.[13] Second-generation biofuels can also be produced from agricultural residue or from dedicated 'energy crops' such as grasses and fast-growing trees.[14] Organic waste, animal

[3] Martin Robinius et al., 'Economics of Hydrogen' in Manfred Hafner and Giacomo Luciani (eds.), *The Palgrave Handbook of International Energy Economic* (Palgrave Macmillan 2022) 83.

[4] Mahin Basha Syed, 'Technologies for Renewable Hydrogen Production' in Abul Azad and Mohammad Khan (eds.), *Bioenergy Resources and Technologies* (Academic Press 2021) 158.

[5] Sonal Singh et al., 'Hydrogen: A sustainable fuel for future of the transport sector' (2015) 51 Renewable and Sustainable Energy Reviews 623, 625.

[6] A. Velazquez Abad and P. E. Dodds, Production of Hydrogen in Martin Abraham (ed.), *Encyclopedia of Sustainable Technologies* (Elsevier 2017) 293–295.

[7] Ibid 295.

[8] Robert W. Howarth and Mark Z. Jacobson, 'How green is blue hydrogen?' (2021) 9 Energy Science & Engineering 1676, 1677.

[9] Ibid.

[10] Meng Yuan et al., 'Accelerating the Net-Zero Transition in Asia and the Pacific: Low-Carbon Hydrogen for Industrial Decarbonization' in Dina Azhgaliyeva, K. E. Seetha Ram and Haoran Zhang (eds.), *Decarbonization Strategies in Asia and the Pacific* (Asian Development Bank Institute 2023) 3.

[11] Hon Chung Lau, 'Decarbonization roadmaps for ASEAN and their implications' (2022) 8 Energy Reports 6000, 6019.

[12] Food and Agriculture Organization of the United Nations (FAO), 'Unified Bioenergy Terminology' (FAO, December 2004), 30 <https://fao.org/3/j4504e/j4504e00.pdf> accessed 26 January 2024.

[13] United States Agency for International Development (USAID), 'Biofuels in Asia: An Analysis of Sustainability Options' (USAID, March 2009), 9 <https://cbd.int/doc/biofuel/USAID-biofuels-asia-2009-03.pdf> accessed 26 January 2024.

[14] Ibid 12.

manure and sewage sludge can be used in anaerobic digestion to produce what is considered in ASEAN countries to be gaseous biofuels.[15] Third-generation biofuels are produced from feedstock with better sustainability properties than second-generation biofuels, especially biodiesel produced from microalgae.[16]

Given the current and potential availability of biofuels, hydrogen produced from biofuels can serve as reliable inputs for the ASEAN countries' need for low-carbon hydrogen. ACE and the International Renewable Energy Agency (IRENA) emphasised the potential roles of low-carbon hydrogen in industry sectors such as iron and steel, aluminium, chemicals and international bunkering for shipping.[17] Later, ACE published the ASEAN Biofuel Research and Development Roadmap, highlighting that ASEAN countries boast immense agricultural goods that offer promising feedstock sources for biofuel production, such as sugar cane, crude palm oil and cassava.[18]

Biomass is defined by the FAO as material of biological origin excluding material embedded in geological formations and transformed into fossil form, for example, herbaceous biomass, fruit biomass and woody biomass.[19] Biomass can be converted into biofuels, as discussed earlier. Classification of biofuels is based on their state (at room temperature) and includes the following: (a) gaseous biofuels, like biogas from different sources and syngas (coal gas); (b) liquid biofuels, including biodiesel, bioethanol, vegetable oil and bio-oil; and (c) solid biofuels such as wood, biomass briquettes, sawdust and charcoal.[20]

Examples of different applications of hydrogen production are present in ASEAN countries. These countries recognised biomass as a renewable source of energy and its potential use as feedstock for hydrogen production in the ASEAN Strategy on Sustainable Biomass Energy for Agriculture Communities and Rural Development in 2020–2030.[21] With the exception of Singapore, most ASEAN countries are strong agricultural countries.[22] Agricultural products such as rubber, acacia and eucalyptus as well as waste products from production such as palm oil mill effluent (POME), cassava pulp, sugarcane molasses, cassava roots and starch are highlighted as potential feedstocks and as biomass energy resources in Indonesia, Thailand, Vietnam, Malaysia and Myanmar.[23] With the widespread presence of available biomass resources, ASEAN countries can rely in particular on the gasification process to produce hydrogen.

By extracting oil from oil palms, biodiesel and glycerol can be produced.[24] The produced glycerol can undergo a steam reforming process to produce hydrogen.[25] Biomass residue from

[15] ASEAN Centre for Energy and International Renewable Energy Agency, 'Renewable Energy Outlook for ASEAN: Towards a Regional Energy Transition' (2nd ed.) (International Renewable, Energy Agency, Abu Dhabi; and ASEAN Centre for Energy Jakarta, 2022), 6.

[16] Ibid 14.

[17] ASEAN Centre for Energy and International Renewable Energy Agency (n15) 21.

[18] ASEAN Centre for Energy, 'ASEAN Biofuel Research and Development Roadmap' (ACE, September 2023), 2 <https://aseanenergy.org/publications/asean-biofuel-research-and-development-roadmap/> accessed 6 February 2024.

[19] Food and Agriculture Organization of the United Nations (FAO) (n12), 31.

[20] Silvia Daniela Romano and Patricio An Anibal Sorichetti, *Dielectric Spectroscopy in Biodiesel Production and Characterization* (Springer London 2011) 2.

[21] ASEAN, 'ASEAN Strategy on Sustainable Biomass Energy for Agriculture Communities and Rural Development in 2020–2030' (ASEAN, August 2020), 2 <https://asean.org/wp-content/uploads/2021/12/FAFD-53.-Biomass-Energy-Strategy-ASEAN-2020-2030-Final-Draft-210820.pdf> accessed 26 January 2024.

[22] Ibid 3.

[23] IRENA, *Scaling Up Biomass for the Energy Transition: Untapped Opportunities in Southeast Asia* (International Renewable Energy Agency 2022) 14.

[24] Ibid.

[25] Ibid.

rice paddies and the rice itself can undergo a gasification process to be converted into a combustible gas that consists of carbon monoxide, carbon dioxide, hydrogen and methane.[26] Biomass can also be used in the metabolic processes of microorganisms to produce green hydrogen, which is of particular relevance in Malaysia, for instance, as will be discussed further below.[27]

Given the technical nature of hydrogen production processes, this gives rise to a legal question: how effective is a given regulatory framework in regulating the establishment and operation of such hydrogen production activities? This will now be answered by describing the main colours of hydrogen and the respective regulations thereof in selected ASEAN countries.

7.2.1 *Grey Hydrogen: Abundant Fossil Fuels*

ASEAN countries are blessed with fossil fuel resources and, at the current production rate, can continue producing coal for another half a century.[28] To give an example: coal is defined as an 'industrial mineral' by the Myanmar Mines Law (1994).[29] A person desiring to commercially produce coal must obtain a permit from the Ministry of Mines.[30] A coal production permit holder is obligated to, inter alia, comply with conditions specified in the permit, pay the royalty[31] and other fees to the Myanmar government,[32] and make provisions for safety and the prevention of accidents in the mine.[33]

However, the Myanmar legal system lacks legislation to regulate the production of hydrogen from the extracted coal. The absence of hydrogen-specific regulations, however, does not mean that a hydrogen producer can freely produce hydrogen. A person desiring to use electricity generated from coal to produce grey hydrogen in Myanmar via a manufacturing process is subject to the Factories Act 1951. A manufacturing process in Myanmar is broadly defined as the creation of an article or substance with a view to its use, sale, transport, delivery or disposal.[34] In addition, this process also includes 'generating power'.[35] The term 'power' refers to 'electrical energy or any other form of energy which is mechanically generated and transmitted and is not generated by human or animal agency'.[36] Grey hydrogen produced from steam reforming of methane in natural gas is not considered a type of power under the Factories Act 1951 as it is not energy created by machines but thermochemical reaction of natural gas. However, the production of hydrogen from such a process can still be deemed to create an 'article or substance with a view to its use or sale'. Consequently, a person wishing to use any premises to produce hydrogen through natural gas via SMR in Myanmar is required by the Factories Act 1951 to obtain a factory licence by submitting a written notice to the Chief Inspector.[37] Therefore, hydrogen production is indirectly regulated via the Factories Act 1951. Requirements include, for

[26] Jitti Mungkalasiri and Woranee Paengjuntuek, 'Energy analysis of hydrogen production from biomass in Thailand' (2016) 21 Thammasat International Journal of Science and Technology 26, 27.
[27] Rafal Lukijtis et al., 'Hydrogen production from biomass using dark fermentation' (2018) 91 Renewable and Sustainable Energy Reviews 665, 666.
[28] ASEAN Centre for Energy (ACE) (n1) 3.
[29] Myanmar Mines Law (1994), Section 2(e).
[30] Ibid Section 4(c).
[31] Ibid Section 12(b).
[32] Ibid Section 12(f).
[33] Ibid Section 13(c).
[34] Myanmar Factories Act 1951, Section 2(k)(i).
[35] Ibid Section 2(k)(iii).
[36] Ibid Section 2(g).
[37] Ibid Section 6(1).

example, that a hydrogen production factory must be kept clean,[38] have adequate ventilation and be maintained at a steady temperature.[39]

In Singapore, grey hydrogen is produced from the gasification of coal. There is also currently an absence of special hydrogen production regulation in Singapore, but this does not mean that hydrogen production is unregulated in Singapore. According to the Factories Act 1987, a factory means any premises in which, close to or within the precincts of, persons are employed in manual labour in any process for or incidental to the making of any article or part of any article.[40] Since the air separation plant, gas processing units and sulphur recovery plants can be used to produce hydrogen, these plants shall be deemed to be factories. Consequently, operators of these plants are required by the Factories Act 1987 to register them as factories.[41] Regulatory requirements concerning cleanliness, overcrowding, ventilation, lighting, drainage of floors and sanitary conveniences apply.[42]

7.2.2 *Blue Hydrogen: Deployment of Carbon Capture Storage Technologies*

In other parts of Southeast Asia, slightly different priorities are set with regard to hydrogen production. The example of Vietnam will be examined more closely here. According to the National Green Growth Strategy for 2021–2030, the Ministry of Industry and Trade of Vietnam, for example, shall formulate mechanisms to encourage the development of hydrogen as a fuel, in particular blue hydrogen.[43]

Some words on the general regulatory climate in Vietnam are required before the next paragraph turns to blue hydrogen in Vietnam specifically. Similar to Myanmar, a regulatory framework on hydrogen production is absent in Vietnam. However, hydrogen production activities are governed by general regulatory rules concerning factory construction and fire prevention. A person wishing to construct a hydrogen production plant must obtain a construction permit from a competent state agency.[44] If the plant will be in an urban area, a construction permit can only be granted if an applicant can demonstrate that construction safety and environmental protection are ensured.[45] At the operational stage, a hydrogen facility, which can be deemed as a plant for producing flammable liquid or a gas station with total gas storage of at least 150 kg, is classified as an Appendix III facility and, therefore, is subject to fire safety requirements.[46] Consequently, a producer is required to use electrical equipment, spark-generating equipment, heat-generating equipment and fire sources and heat sources that comply with regulations and standards on fire prevention and fighting or regulations of the Ministry of Public Security.[47] However, it must be noted that to produce blue hydrogen, a producer must capture the emissions and permanently store them. Therefore, when it comes to blue hydrogen, a question on the permitting of carbon capture storage arises.

[38] Ibid Section 13(1).
[39] Ibid Section 15(1).
[40] Factories Act 1987 (Singapore), Section 6(1)(a).
[41] Ibid Section 8(1).
[42] Ibid Part IV.
[43] The Prime Minister's Decision to Ratify the National Green Growth Strategy for the 2021–2030 Period, Vision towards 2050 (No. 1658/QD-TTg), Article 1 para. IV.
[44] Construction Law (No. 50/2014/QH13), Article 89.
[45] Ibid Article 91 para. 3.
[46] Ibid Appendix III.
[47] Ibid Article 5 (d).

In other words, does carbon capture and storage (CCS) for blue hydrogen purposes require a separate permit and is it subject to any specific regulations? Comparable to Myanmar's legal system, mineral exploration and mining activities in Vietnam require a permit that is handed out by a competent state agency.[48] Exploration and mining activities focus on exploration for and production of minerals from reservoirs,[49] and therefore no injection of captured carbon into pore space. The same finding can be applied to petroleum activities. A holder of a petroleum contract granted by competent agencies can lawfully explore for and produce petroleum from reservoirs.[50] It does not regulate activities relating to the injection of a captured carbon stream into empty petroleum reservoirs. Many environmental laws and regulations were enacted before carbon emissions became a concern.[51] There are no regulations for land use and monitoring of long-term projects such as CCS.[52] In a nutshell, the result is that the injection does not require a permit and can be used for blue hydrogen purposes (in principle) in Vietnam.

7.2.3 *Green Hydrogen: Potential Roles of Biomass and Biogas*

Among ASEAN countries, Thailand, Indonesia, Malaysia and the Philippines have the highest bioenergy potential.[53] The two major biofuels produced in ASEAN countries are biodiesel and bioethanol.[54] Indonesia's biofuel industry mostly produces biodiesel made from palm oil.[55] In Malaysia, biodiesel products are also mainly produced from palm oil.[56] Biodiesel products in the Philippines are mostly produced from coconut oil and bioethanol from sugarcane.[57] In Malaysia, a hydrogen producer desiring to produce green hydrogen through metabolic processes of microorganisms or biogas reforming techniques is deemed to be a manufacturer under the Industrial Co-ordination Act 1975. Under this law, a manufacturer is a person who engages in making, altering, blending, ornamenting, finishing or treating any article or substance with a view to its use, sale, transport or delivery.[58] Since metabolic processes of microorganisms or biogas reforming techniques can be applied to produce hydrogen which will be used, commercially sold or transported, production of hydrogen from biomass or biogas shall be deemed to be manufacturing activities. Consequently, to lawfully produce hydrogen from biomass or biogas in Malaysia, a manufacturing licence must be obtained.[59] With a view to the occupational safety and health of workers in hydrogen production plants, a producer, as an employer, owes a duty under the Occupational Safety and Health Act 1994 to ensure the safety of a hydrogen production plant and operate it without risks to health.[60]

A hydrogen producer in Indonesia is subject to the Law on Energy (Law of the Republic of Indonesia No. 30/2007 dated 10 August 2007) and the Industrial Affairs Law (Law of the

[48] Mineral Law (Resolution No. 51/2001/QH10), Article 4 para. 2.
[49] Ibid Article 2 paras. 5–7.
[50] Law on Petroleum 1993, Article 15.
[51] Minh Ha-Duong and Hoang Anh Nguyen Trinh, 'Two scenarios for carbon capture and storage in Vietnam' (2017) 110 Energy Policy 559, 564.
[52] Ibid.
[53] Hon Chung Lau et al., 'A review of the status of fossil and renewable energies in Southeast Asia and its implications on the decarbonization of ASEAN' (2022) 15 Energies 2152, 2159.
[54] Ibid.
[55] Ibid.
[56] Ibid.
[57] Ibid.
[58] Industrial Co-ordination Act 1975, Section 2.
[59] Ibid Section 3(1).
[60] Occupational Safety and Health Act 1994, Section 15(2)

Republic of Indonesia No. 5/1984). The Law on Energy allows business entities to exploit energy resources.[61] Energy resources are defined as natural resources that can be utilised, both as energy sources and as energy directly.[62] Energy resources can be used to produce energy, both directly and indirectly, through conversion or transformation processes.[63] A process converting or transforming biomass or biogas into hydrogen through a conveyor of energy shall be deemed energy resource exploitation. Therefore, the state can regulate hydrogen production, which is a kind of exploitation of energy resources, through the Law on Energy. For example, a hydrogen producer will become an energy business operator and is obliged to preserve and maintain the environmental sustainability function.[64]

In addition, the conversion or transformation processes of biomass or biogas into hydrogen can be deemed industrial affairs under the Industrial Affairs Law. Industrial affairs refers to settings and all activities relating to industrial activities.[65] The term 'industry' is defined as an economic activity that involves the processing of raw materials, basic materials, semi-finished goods and/or finished goods into goods of higher value, and includes design activity and industrial engineering.[66] Biomass and biogas can serve as inputs for the SMR to produce hydrogen, which is a new product of higher value. Both biogas and hydrogen are gaseous substances and can be directly utilised as fuels for electricity generation and vehicles.[67] A question therefore arises as to why producing hydrogen from biogas can be deemed converting raw materials into goods of higher value.

Firstly, it has to be determined whether hydrogen is another kind of gaseous substance which is a byproduct of industrial processes. Like natural gas, biogas primarily consists of methane along with small amounts of carbon dioxide, hydrogen and hydrogen disulfide.[68] Biomass gasification and biogas reforming can serve as methods to produce syngas.[69] By manipulating the reforming process, the ratio of hydrogen and carbon monoxide in syngas can be optimised, and high-purity hydrogen gas can be produced.[70] Hydrogen produced from biogas is a cleaner fuel for vehicles[71] and the gas turbine and fuel cell system for power generation.[72] It can be said that the steam reforming process is a means of converting one gaseous substance into another more environmentally friendly gaseous substance.[73]

Secondly, hydrogen will be the outcome of economic activity and can be deemed to be an industrial affair if hydrogen is a gaseous substance that has a higher value compared with biogas

[61] Law of the Republic of Indonesia No. 30/2007, Article 23(1).
[62] Ibid Article 1 para. 3.
[63] Ibid Article 1 para. 2.
[64] Ibid Article 24(1) b.
[65] Law of the Republic of Indonesia No. 5/1984, Article 1 para. 1.
[66] Ibid Article 1 para. 2.
[67] Joonsik Hwang, Krisha Maharjan and HeeJin Cho, 'A review of hydrogen utilization in power generation and transportation sectors: Achievements and future challenges' (2023) 48 International Journal of Hydrogen Energy 28629, 28636.
[68] Jai M. Mehta and Kenneth Brezinsky, 'Natural Gas for Combustion Systems' in Kenneth Brezinsky (ed.), *Combustion Chemistry and the Carbon Neutral Future: What Will the Next 25 Years of Research Require?* (Elsevier 2023) 65.
[69] L. Yang and X. Ge, 'Biogas and Syngas Upgrading in Advances in Bioenergy' in *Advances in Bioenergy* (Vol. 1) (Elsevier 2016) 161
[70] Ibid.
[71] Ibid.
[72] Md Abdus Salam, Md Aftab Ali Shaikh and Kawsar Ahmed, 'Green hydrogen based power generation prospect for sustainable development of Bangladesh using PEMFC and hydrogen gas turbine' (2023) 9 Energy Reports 3406, 3406.
[73] Fernando Vidal-Barrero et al., Hydrogen production from landfill biogas: Profitability analysis of a real case study' (2022) 324 Fuel 124438.

and biomass. Hydrogen has a higher value because of its usability and environmentally friendly qualities. Burning biogas, which primarily consists of methane, for electricity generation and combusting biogas for use in vehicles can produce carbon dioxide, thus contributing to climate change. However, biogas can be utilised to produce high-value products.[74] It can be upgraded through purification processes by removing some components such as carbon dioxide to increase its heating value or to standardise its quality to meet the requirements of gas appliances, for example, engines, boilers, fuel cells and vehicles.[75] Low-carbon hydrogen, which results from processing biogas and biomass, can be used to produce electricity that causes less environmental impact than the electricity from directly burning biogas. Given its enhanced usability and more environmentally friendly nature, hydrogen shall be deemed to have a higher value when compared with biomass and biogas that are used as inputs for hydrogen production.

When hydrogen production can be deemed an industrial affair under the Industrial Affairs Law, the state can regulate this economic activity through a licensing system. Under the Industrial Affairs Law, a person producing hydrogen from biomass or biogas must obtain an industrial business licence.[76] A hydrogen producer, being an industrial company, owes a statutory duty to prevent damage and pollution to the living environment resulting from the production processes.[77]

7.2.4 *Summary of Manufacturing and Environmental Permit Requirements in ASEAN Countries*

To sum up, environmental protection plays an important role with regard to whether permission is given for the operation of a hydrogen production facility. However, the environmentally friendly nature of green hydrogen does not mean that its production is free from safety and environmental risks. Hydrogen is still a hazardous chemical and flammable substance.[78] This means that safety requirements are necessary for grey (and blue) hydrogen production, which can also apply for green hydrogen production. If the regulatory regime only regulates hydrogen production through gas separation operations, it will be unable to mitigate safety risks inherently associated with other hydrogen production procedures.

Thermal processes for hydrogen production typically involve steam – for example, steam reforming. If the fuel used for steam reforming is of hydrocarbon origin, such as natural gas or diesel, the hydrogen production facility will emit carbon dioxide, having a negative impact on the environment. In addition to the discussed manufacturing licence, the state can require a person who wishes to conduct activities potentially causing adverse impacts on the environment to conduct an environmental impact assessment (EIA) and submit a report thereon in ASEAN countries.[79] The requirements of the EIA report are subject to the discretion of the relevant competent national authority.[80] Environmental legislation or regulations can require a person seeking to produce hydrogen to conduct an EIA.

[74] Tomy Hos and Moti Herskowitz, 'Techno-economic analysis of biogas conversion to liquid hydrocarbon fuels through production of lean-hydrogen syngas' (2022) 2 ACS Engineering Au 450, 451.
[75] R. Borja and B. Rincón, 'Biogas Production' in Murray Moo-Young (ed.), *Comprehensive Biotechnology* (2nd ed.) (Elsevier 2011) 785.
[76] Law of the Republic of Indonesia No. 30/2007, Article 13(1).
[77] Ibid Article 21(1).
[78] Itsuki Uehara, 'Handline and Safety of Hydrogen' in Tokio Ohta (ed.), *Energy Carriers and Conversion Systems* (Vol. 1) (Encyclopedia of Life Support Systems 2009) 253.
[79] Rio Declaration on Environment and Development, Principle 17.
[80] Ibid.

The particular requirements of the individual EIAs depend on the individual country. In Malaysia, a person intending to carry out any of the prescribed activities under the Environmental Quality Act 1974 shall, before any approval for the carrying out of such activity is granted by the relevant approving authority, submit a report to the Director General of Environmental Quality.[81] The EIA regime in Malaysia makes no specific reference to hydrogen production; however, it categorises a 'chemical' factory with a total production capacity of each product or of a combined product that is equal to or greater than 100 tons per day as an activity that requires the submission of an EIA Report.[82]

Taking these findings into account, it seems necessary to look more closely into a specific case from one of the ASEAN countries to understand the interplay of norms. The following section therefore provides a case study on how Thailand and its existing, relatively advanced, natural resources regulatory regime tackle hydrogen production.

7.3 THAILAND AS A CASE STUDY

In Thailand, hydrogen is recognised as an alternative transport fuel.[83] In addition, the state mentions in the Power Development Plan (PDP) 2018–2037 that it will promote the establishment of biomass and biogas power plants having a combined capacity of 3,180 megawatts (MW) by 2037.[84] These goals trigger a question concerning how and to what extent Thai regulatory regimes can regulate the production of hydrogen. Regulatory requirements for hydrogen production cover at least operational safety, occupational safety and environmental safety. However, activities relating to hydrogen production in Thailand are not considered energy production under the Energy Industry Act or the Petroleum Act BE 2514 (1971) (the Petroleum Act). In the absence of specific hydrogen legislation, a hydrogen producer relying on machinery to produce hydrogen, including gasification and fermentation of biomass and the reformation of biogas, is subject to the factory licensing regime under the Factory Act BE 2535 (1992) (the Factory Act).

7.3.1 *Hydrogen Production under Thai Energy Law*

Unlike the Indonesian energy regulatory regime as discussed in Section 7.2.3 above, the Thai energy licensing regime does not recognise hydrogen as energy or an energy resource. The Energy Industry Act of Thailand only regulates the production of electricity.[85] Production of electricity as well as establishment of an electricity production facility are subject to a licensing requirement under the Energy Industry Act.[86] The law only limitedly applies to the production of electricity and not to the production of energy from other resources, including the conversion of biomass or biogas into green hydrogen.

Apart from producing green hydrogen from biomass and biogas, the production of grey hydrogen from natural gas via the steam reforming process is also conducted in Thailand.[87]

[81] Environmental Quality Act 1974 (Malaysia), Section 34A(2).
[82] Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) Order, 1987 (Malaysia), para. 8 (a).
[83] Alternative Energy Development Plan (AEDP 2015), 14.
[84] Power Development Plan 2018–2037, 23.
[85] Energy Industry Act BE 2550 (2007) (Thailand), Section 5.
[86] Ibid Sections 47 and 48.
[87] For example, a hydrogen production project located in an industrial estate in Rayong Province relying on steam reformer to convert natural gas into hydrogen. Please see Air Liquide(Thailand), 'EIA Report: Hydrogen Production,

Comparable to the situation in Myanmar, Thai energy law does not regulate the production of hydrogen from fossil fuels either. Production of natural gas is not governed by the Energy Industry Act but by the Petroleum Act. Any person seeking to explore for and produce natural gas is required to obtain a concession, production-sharing contract or service contract from the Ministry of Energy.[88] However, the law defines natural gas as 'all kinds of gaseous hydrocarbons whether wet or dry, produced from oil or gas wells, and shall include the residue gas remaining after the extraction of liquid hydrocarbons or by-products from wet gas'.[89] Since hydrogen is not extracted from oil or natural gas wells and nor is it a by-product remaining after the extraction of liquid hydrocarbons, a hydrogen producer is not required to obtain a concession, production-sharing contract or service contract under the Petroleum Act.

7.3.2 *Hydrogen Production under the Current Thai Industrial Works Regulatory Regimes*

In line with Myanmar, Singapore, Vietnam, Malaysia and Indonesia, a person desiring to legally establish and operate a hydrogen production facility in Thailand, whether to produce grey, blue or green hydrogen, has the statutory duty to comply with general laws governing the establishment and operation of a factory, as well as environmental protection regulations.

Establishment of Hydrogen Production Factory

In the Factory Act, a 'factory' means buildings, premises or vehicles using machines with a total power output of 50 horsepower (hp) or more, or the equivalent, or which employ fifty workers or more with or without machinery to engage in the operation of a factory in accordance with the type or kind of factory as prescribed in the Ministerial Regulations.[90] These Ministerial Regulations do not specifically refer to hydrogen production but 'gas production'.[91] A plant with the capability of converting natural gas into gaseous hydrogen through the steam reforming process relying on a reactor with 50 or more hp, or the equivalent, is, therefore, deemed to be a factory. If these machines together with others that are used in a plant have 50 or more hp, or the equivalent, this plant will be deemed a factory under the Factory Act. Likewise, if machines with 50 or more hp, or the equivalent, are used in a plant for biogas reforming, whether dry reforming (DR), steam reforming (SR), catalytic partial oxidation (CPOX) or auto-thermal reforming (ATR), this plant will become a factory under the Factory Act.

The Minister of Industry has powers to categorise hydrogen production plants as a 'group 3 factory', which are factories of the type, kind and size that require a permit to be granted prior to creation and operation.[92] The Minister of Industry is vested with regulatory power to enact a Ministerial Decree requiring a hydrogen producer to use particular types of machines and equipment for hydrogen production.[93] To ensure that a hydrogen producer, who holds a factory licence, will produce hydrogen from these second-generation biofuels, the Minister of Industry can exercise power under Section 8 para. 1(4) of the Factory Act to promulgate a Ministerial Decree requiring that hydrogen must be produced from agricultural residues.

Carbon Monoxide, and Infrastructure Project' (Office of Natural Resources and Environmental Policy and Planning, January 2012), 1–2 <https://eia.onep.go.th/eia/detail?id=10892> accessed 28 January 2023.

[88] Petroleum Act BE 2514 (1971) (Thailand), Section 23.

[89] Ibid Section 4.

[90] Ministerial Regulation Prescribing Types, Kinds, and Size of Factories BE 2563 (2020) (Thailand).

[91] Ibid Annex (No. 89).

[92] Factory Act BE 2535 (1992), Section 7 para. 1(3).

[93] Ibid Section 8 para. 1(2).

Once regulated under the Factory Act, a hydrogen producer must adhere to the ministerial rules on production processes and provisions concerning other equipment or tools to prevent or stop or mitigate dangers that may be caused to the persons or property in the factory or its vicinity.[94] Hence, biomass gasification and biofuel reforming plants can be listed as factories that are subject to by-laws prescribing criteria relating to production processes[95] as well as standards and methods of controlling the discharge of waste, pollutants or anything affecting the environment as a result of the factory operation.[96]

Occupational Safety and Health Management

A hydrogen production plant can be deemed as a working place under the Occupational Safety, Health, and Environment Act BE 2554 (2011) (the OSHE Act). The law primarily places statutory duties upon the employer to ensure the safety and hygiene of a working place for its employees.[97] In line with Malaysia, the OSHE can serve as a legal basis for the Minister of Labour to promulgate ministerial decrees imposing duties on hydrogen producers, as the employers, to manage and operate their hydrogen production plants in accordance with the prescribed occupational safety, health and environmental standards.[98]

Environmental Impact Assessment

Under the Enhancement of National Environmental Quality Act BE 2535 (1992) (the Enhancement of National Environmental Quality Act), the Minister of Natural Resources and Environment is vested with the power to promulgate a ministerial notification prescribing which projects, business operations or activities require an EIA report.[99] If the establishment and operation of a hydrogen production factory is prescribed as a project, business operation or activity that requires an EIA report, the Permanent Secretary of the Ministry of Energy or a delegated official cannot grant a factory licence to the applicant unless the EIA report for the hydrogen factory is approved by the Environmental Expert Committee.[100]

The Ministerial Notification concerning Projects, Operation or Activities that require an EIA Report and Criteria, Methods and Conditions on the EIA Report Preparation BE 2566 (2023) (the EIA Notification) does not specifically make any reference to hydrogen production. However, it imposes the EIA report requirement on industrial activities involving natural gas separation. Regardless of the size of the factory, a factory established for natural gas separation by conversion of natural gas from gaseous status into liquid status and natural gas separation by conversion of natural gas from liquid status by using seawater or water from natural water resources for heating the separation are subject to the EIA report requirement.[101] It appears that the current environmental protection regime in Thailand places its focus on inputs used for manufacturing processes. Therefore, a person seeking to use natural gas as an input to produce hydrogen through the natural gas separation process will be required to prepare an EIA report.

[94] Ibid Section 8 para. 1(4).
[95] Ibid Section 8 para. 1(4).
[96] Ibid Section 8 para. 1(5).
[97] Occupational Safety, Health, and Environment Act BE 2554 (2011), Section 6 para. 1.
[98] Ibid Section 8.
[99] Enhancement of National Environmental Quality Act BE 2535 (1992), Section 48 para. 1.
[100] Ibid Section 50.
[101] Ministerial Notification concerning Projects, Operation, or Activities that require an Environmental Impact Assessment Report and Criteria, Methods, and Conditions on the Environmental Impact Assessment Report Preparation BE 2566 (2023), Annex 4 (No. 7).

The term 'natural gas' is not specially defined by the Enhancement of National Environmental Quality Act or its by-laws. However, natural gas is defined by the Petroleum Act as all kinds of gaseous hydrocarbons, whether wet or dry, produced from oil or gas wells; and also includes the residue gas remaining after the extraction of liquid hydrocarbons or by-products from wet gas.[102] Moreover, the Ministry of Energy Notification concerning Criteria and Safety Standard of a Place where Natural Gas Is Used and Regulated by Department of Energy Business BE 2550 (2007) defines natural gas as gaseous hydrocarbon mainly consisting of methane.[103] Therefore, a person using biogas, which is a kind of natural gas, as an input to produce hydrogen will be required to prepare an EIA report. In practice, hydrogen production from natural gas is deemed a project that is subject to the EIA requirements. The Environmental Expert Committee, in its meeting No. 3/2561 of 16 July 2018, opined that the utilisation of natural gas to produce hydrogen is considered a kind of natural gas separation and transformation project.[104]

However, the EIA Notification does not govern the utilisation of renewable sources as inputs for manufacturing or production. Production of green hydrogen does not use natural gas as an input for production, but electrolysis from renewable sources. In relation to energy projects, it only applies to a thermal power plant with an installed capacity of 10 MW and more.[105] Therefore, if a person is seeking to use natural gas to produce hydrogen, this is not a type of renewable source, so they are not required to submit an EIA Report.

7.4 (RE-)CONVERSION OF ELECTRICITY: UNINTENDED SUBSIDISATION OF ELECTRICITY GENERATED FROM GREY OR BLUE HYDROGEN

To support the energy transition, the state may create market demand for green hydrogen. In Thailand, demand for green hydrogen, such as hydrogen produced from biomass and biofuel, can be stimulated by the state through subsidisation of renewable electricity generated from green hydrogen. Hydrogen end users, such as renewable electricity producers, can be encouraged to purchase hydrogen from hydrogen producers or suppliers if the government is also allowing them to participate in subsidised electricity selling prices.[106] However, the Energy Industry Act of Thailand gives the Energy Regulatory Commission broad powers to procure renewable electricity generated from 'hydrogen' without specific reference to its colour.

7.4.1 *Electricity Procurement under the Energy Industry Act BE 2550 (2007)*

Thailand does not have a competitive wholesale electricity market, as the government gave a mandate to state-owned electricity enterprises to purchase electricity from producers based on the allocated quotas.[107] The Energy Policy Committee has the power to determine the amount

[102] The Petroleum Act BE 2514 (1971), Section 4.
[103] Ministry of Energy Notification concerning Criteria and Safety Standard of a Place Where Natural Gas Is Used and Regulated by Department of Energy Business BE 2550 (2007), Clause 4.
[104] Division of Environmental Impact Assessment Development, 'Hydrogen Production, Carbon Monoxide, and Infrastructure Factories' (Office of Natural Resources and Environmental Policy and Planning, June 2022) <https://eia.onep.go.th/eia/detail?id=10892> accessed 26 January 2024.
[105] Ministerial Notification BE 2566 (n101) Annex 4 (No. 18).
[106] Ministry of Energy, 'Power Development Plan 2018 Revision 1' (Energy Policy and Planning Office, October 2021), 11 <https://eppo.go.th/images/Infromation_service/public_relations/PDP2018/PDP2018Rev1.pdf> accessed 26 January 2024.
[107] Cabinet Resolution dated 9 December 2003.

of electricity that can be procured from the private sector as well as the purchase price, including the guaranteed price of electricity generated from hydrogen.

In practice, the Energy Policy Committee will instruct the Energy Regulatory Commission to take necessary steps for electricity procurement in accordance with its requests. This instruction will refer to the type of electricity to be procured, for example, electricity from renewable resources such as electricity from biomass and biogas.[108] This procurement announcement can invite electricity producers to sell electricity generated from renewable resources, including hydrogen, at a fixed subsidised price, thus stimulating demand for hydrogen consumption.

7.4.2 *Current Practice on Procurement of Hydrogen-Based Electricity*

Hydrogen that is used to fuel electricity generation can be grey, blue or green or have other colours. The current practice on electricity procurement is that the criteria that have been announced by the Energy Regulatory Commission feature hydrogen as a renewable resource that qualifies for subsidised electricity purchasing prices.[109] For example, in 2018 the Energy Regulatory Commission invited power producers with a generation capacity of not exceeding 10 MW to sell electricity generated from 'renewable resources' to the state-owned electricity enterprises.[110] This regulation explicitly included hydrogen as a renewable resource.[111] After the competitive bidding process, a selected power producer will sign a long-term power purchase agreement that recognises subsidised electricity prices, based on the type of renewable resource. The state-owned buying enterprises will be responsible for paying the seller a fixed and subsidised wholesale price as announced by the Energy Regulatory Commission. This subsidy scheme is called the Feed-in Tariff (FiT) scheme.[112]

Notwithstanding, electricity producers are not prohibited from using grey or blue hydrogen for the generation of electricity and can nonetheless apply for subsidies from the scheme. This loophole exists because the Energy Regulatory Commission does not recognise any differences between types of hydrogen. Its regulations in the past simply featured hydrogen as automatically qualifying for the bidding process.[113] Renewable electricity procurement announcements typically refer to 'hydrogen' as a kind of renewable resource which is qualified to gain benefits from the price guarantee scheme without making specific reference to green hydrogen, so all kinds of hydrogen can benefit equally.

This is an undesirable and possibly unintended outcome because hydrogen produced from natural gas – grey hydrogen – relies on the fossil fuel natural gas. Its production process involves the conversion of fossil fuels into another form of energy. Therefore, hydrogen produced from fossil fuels should not be deemed a renewable energy resource and the loophole needs to be closed.

7.5 CONCLUSION

In Southeast Asia no common approach towards hydrogen regulation has evolved so far. ASEAN countries are mainly at the initial stages of hydrogen production and there is currently little

[108] For example, Regulations of the Energy Regulatory Commission on Procurement of Renewable Electricity in the Form of Feed-in-Tariff (FiT) in 2022–2030 for the Non-Fuel Group 2022.

[109] For example, the Energy Regulatory Commission's Regulation re: Procurement of Electricity from Renewable Electricity Projects of Very-Small Power Producers BE 2561 (2018).

[110] Ibid Clause 5.

[111] Ibid Clause 3.

[112] Piti Pita et al., 'Assessment of Feed-in Tariff Policy in Thailand: Impacts on National Electricity Prices' (2015) 79 Energy Procedia 584, 585.

[113] For example, Energy Regulatory Commission's Regulation BE 2561 (n109) Clause 3.

utilisation of hydrogen. However, in the absence of such legislation in Myanmar, Singapore, Vietnam, Malaysia and Indonesia, a hydrogen producer does not necessarily have full freedom to produce hydrogen without being subject to regulations. These ASEAN countries can rely on factory or industrial affairs legislation to impose a duty upon a hydrogen producer to obtain a factory or manufacturing activity licence before operating a hydrogen production plant. These regulations mainly focus on ensuring the safety of the factory establishment and operation and do not always specify how hydrogen is produced.

The existing environmental impact assessment requirements in Malaysia and Thailand can serve as regulatory bases to require certain types of hydrogen production plants, including biomass gasification and biogas steam reforming plants, to be activities that need to conduct an EIA prior to their operation. Like most other ASEAN countries, except Indonesia, activities relating to hydrogen production in Thailand are not deemed to be energy production under the Energy Industry Act or under the Petroleum Act.

However, a hydrogen producer relying on machines to produce hydrogen, including the gasification and fermentation of biomass and the reformation of biogas, can be considered an industrial operator who is required to obtain a factory licence. Production of blue and grey hydrogen from natural gas including biogas through the SMR process is considered natural gas separation activity and needs an EIA report. Once a hydrogen producer becomes a factory licensee, the Minister of Industry can regulate how hydrogen is produced through ministerial rules concerning machines, equipment or other things used for engagement in a factory business. On the grounds of avoidance of conflict between food security and energy security, the Factory Act can be utilised by the Minister of Industry to require a hydrogen producer, who is a holder of a factory licence, to produce hydrogen from these second-generation biofuels.

The Thai government could stimulate demand for electricity produced from biogas. The stimulated demand for biogas as inputs for electricity to be purchased by the state at a subsidised price could contribute to the formulation and development of hydrogen markets in Thailand. The problem arises of possible diversion of subsidies that are intended to promote green hydrogen and electricity produced from green sources. In spite of the ability to regulate safety and mitigate environmental impacts, the Thai legal system faces challenges arising from unintentionally subsidising grey or blue hydrogen through electricity procurement legislation. This is an issue because the Energy Industry Act of Thailand gives the Energy Regulatory Commission broad powers to procure renewable electricity generated from 'hydrogen' without specific reference to its colour. This loophole demonstrates a general issue with the current stage of hydrogen regulation in ASEAN countries: the existing regulations have not been created with hydrogen in mind and if they are amended there can be a lack of technical understanding that could lead to unintended side effects. It therefore remains a challenge for ASEAN countries in the coming years to improve their regulatory approaches towards hydrogen and to better incorporate it into their existing regulatory landscape.

FURTHER READING

ASEAN, 'ASEAN Strategy on Sustainable Biomass Energy for Agriculture Communities and Rural Development in 2020–2030' (ASEAN, August 2020) <https://asean.org/wp-content/uploads/2021/12/FAFD-53.-Biomass-Energy-Strategy-ASEAN-2020-2030-Final-Draft-210820.pdf> accessed 19 January 2023

ASEAN Centre for Energy, 'Hydrogen in ASEAN: Economic Prospects, Development & Applications' (ASEAN Centre for Energy, 30 September 2021) <https://aseanenergy.org/hydrogen-in-asean-economic-prospects-development-and-applications/> accessed 13 May 2022

Division of Environmental Impact Assessment Development, 'Hydrogen Production, Carbon Monoxide, and Infrastructure Factories' (Office of Natural Resources and Environmental Policy and Planning, 1 January 2022) <https://eia.onep.go.th/eia/detail?id=10892> accessed 11 September 2022

Minh Ha-Duong and Hoang Anh Nguyen Trinh, 'Two scenarios for carbon capture and storage in Vietnam' (2017) 110 Energy Policy 559

Jacob J. Lamb and Bruno G. Pollet, 'Future Prospects of Selected Hydrogen and Biomass Energy Technologies' in Jacob J. Lamb and Bruno G. Pollet (eds.), Hydrogen, Biomass and Bioenergy Integration Pathways for Renewable Energy Applications (Academic Press 2020)

Jitti Mungkalasiri and Woranee Paengjuntuek, 'Energy analysis of hydrogen production from biomass in Thailand' (2016) 21 Thammasat International Journal of Science and Technology 26

Hon Chung Lau, 'Decarbonization roadmaps for ASEAN and their implications' (2022) 8 Energy Reports 6000

L. Yang and X. Ge, 'Biogas and Syngas Upgrading in Advances in Bioenergy' in Advances in Bioenergy (Vol. 1) (Elsevier 2016) 161