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Legal Frameworks for Clean Hydrogen Certification: A Comparative Study with Recommendations for Thailand

กรอบกฎหมายว่าด้วยการรับรองไฮโดรเจนสะอาด :
การศึกษาเชิงเปรียบเทียบพร้อมข้อเสนอแนะ
สำหรับประเทศไทย

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Abstract

Clean hydrogen is globally recognized as essential for decarbonization, yet its environmental value is not inherent; it is a legal status requiring robust certification. This article addresses Thailand's subsidy paradox, where ambitious climate goals and Board of Investment (BOI) incentives for clean hydrogen are rendered functionally inoperable. This paralysis stems from a critical legal gap: the absence of a national definition, standard, and verification system for clean hydrogen, which creates severe legal uncertainty

for investors. The research argues that certification is a foundational legal prerequisite for any subsidy regime. Employing a functional-structural comparative legal methodology, the study analyzes six key jurisdictions (the United States, Canada, the European Union, South Korea, Australia, and Japan) to identify international best practices. Findings reveal an alignment on technical criteria (e.g., Well-to-Gate greenhouse gas assessment scope, tiered thresholds up to 4.0 $\text{kgCO}_2\text{e/kgH}_2$), but finds Thailand's current legal framework (BOI, ERC, TISI) incompatible for implementation due to critical jurisdictional and institutional constraints. The article concludes that the enactment of a new law is essential, recommending the enactment of a *sui generis* Hydrogen Certification Act. This new legal framework should adopt a pragmatic hybrid model, blending South Korea's tiered, technology-neutral, Well-to-Gate criteria with Australia's flexible, unbundled certificate (PGO/REGO) structure. This approach provides legal certainty while avoiding the prohibitive complexity of the EU model.

Keywords: clean hydrogen certification, subsidy, legal certainty, comparative Law, legal gap

บทคัดย่อ

ไฮโดรเจนสะอาดได้รับการยอมรับในระดับสากลว่าเป็นองค์ประกอบสำคัญในการลดการปล่อยคาร์บอน อย่างไรก็ตาม คุณค่าด้านสิ่งแวดล้อมของไฮโดรเจนไม่ได้เกิดขึ้นโดยธรรมชาติ หากแต่เป็นสถานะทางกฎหมายที่ต้องอาศัยระบบการรับรองที่เข้มแข็ง บทความนี้มุ่งวิเคราะห์ความย้อนแย้งของมาตรการอุดหนุนของประเทศไทย ซึ่งเป้าหมายด้านสภาพภูมิอากาศที่ทะเยอทะยาน และมาตรการส่งเสริมการลงทุนของสำนักงานคณะกรรมการส่งเสริมการลงทุนสำหรับไฮโดรเจนสะอาดกลับไม่สามารถดำเนินการได้จริงในเชิงปฏิบัติ ภาวะชะงักงันดังกล่าวเกิดจากช่องว่างทางกฎหมายที่สำคัญ กล่าวคือ การขาดนิยาม มาตรฐาน และระบบการตรวจสอบของไฮโดรเจนสะอาดในระดับชาติ ซึ่งก่อให้เกิดความไม่แน่นอนทางกฎหมายอย่างร้ายแรงต่อผู้ลงทุน งานวิจัยนี้เสนอว่าระบบการรับรองถือเป็นเงื่อนไขทางกฎหมายขั้นพื้นฐานสำหรับการจัดตั้งระบบอุดหนุนใด ๆ โดยใช้ระเบียบวิธีวิจัยทางกฎหมายเชิงเปรียบเทียบแบบโครงสร้างและหน้าที่ การศึกษานี้วิเคราะห์กรอบกฎหมายของหกเขตอำนาจศาลหลัก ได้แก่ สหรัฐอเมริกา แคนาดา สหภาพยุโรป เกาหลีใต้ ออสเตรเลีย และญี่ปุ่น เพื่อระบุแนวปฏิบัติที่เป็นเลิศในระดับสากล ผลการศึกษาพบว่ามีแนวโน้มความสอดคล้องกันของเกณฑ์ทางเทคนิค เช่น ขอบเขตการประเมินการปล่อยก๊าซเรือนกระจกตั้งแต่การจัดหาวัตถุดิบจนถึงขั้นตอนการผลิต และระดับเกณฑ์การปล่อยคาร์บอนแบบขั้นบันได สูงสุดถึง 4.0 กิโลกรัมคาร์บอนไดออกไซด์เทียบเท่าต่อกิโลกรัมไฮโดรเจน อย่างไรก็ตาม พบว่ากรอบกฎหมายปัจจุบันของประเทศไทยภายใต้สำนักงานคณะกรรมการส่งเสริมการลงทุน คณะกรรมการกำกับกิจการพลังงาน และสถาบันมาตรฐาน

ผลิตภัณฑ์อุตสาหกรรม ยังไม่สอดคล้องและไม่สามารถรองรับการดำเนินการได้ เนื่องจากข้อจำกัดด้านอำนาจหน้าที่และโครงสร้างสถาบันที่สำคัญ บทความนี้สรุปว่า การตรากฎหมายใหม่เป็นสิ่งจำเป็น โดยเสนอให้ตรากฎหมายเฉพาะ ได้แก่ พระราชบัญญัติการรับรองไฮโดรเจน กฎหมายใหม่นี้ควรใช้รูปแบบผสมผสานที่เน้นการนำไปใช้จริง โดยผสมผสานเกณฑ์การประเมินจากต้นน้ำถึงประตูโรงงานแบบเทคโนโลยีเป็นกลางและระบบชั้นบันไดของเกาหลีใต้ เข้ากับโครงสร้างใบรับรองแบบยืดหยุ่นและแยกส่วนของออสเตรเลีย แนวทางนี้จะช่วยสร้างความมั่นคงทางกฎหมาย พร้อมหลีกเลี่ยงความซับซ้อนที่มากเกินไปของระบบสหภาพยุโรป

คำสำคัญ : การรับรองไฮโดรเจนสะอาด เงินอุดหนุน ความแน่นอนทางกฎหมาย กฎหมายเปรียบเทียบ ช่องว่างทางกฎหมาย

1. Introduction: The Legal Nexus of Subsidy and Certification

1.1 The Decarbonization Imperative and the Hydrogen Challenge

Hydrogen, particularly when produced via low-carbon or renewable pathways, is globally recognized as a pivotal energy carrier in the transition towards decarbonization.¹ It offers critical solutions for hard-to-abate sectors and energy storage, aligning with ambitious climate goals worldwide.² However, the environmental value of hydrogen is not inherent; it is entirely dependent on its production pathway. Consequently, the concepts of ‘clean’ or ‘green’ hydrogen are not natural categories but are, in fact, legal statuses that must be meticulously constructed, defined, and verified by robust regulatory frameworks.³ This act of legal construction, certification, is the essential mechanism that translates a molecule’s physical attributes (or lack of emissions) into a verifiable, tradable, and legally cognizable commodity.⁴

1.2 Thailand’s Subsidy Paradox: The Inoperable Legal Gap

Thailand has significantly elevated its climate ambition through its Third Nationally Determined Contribution (NDC 3.0), establishing a definitive target to achieve net-zero greenhouse gas (GHG) emissions by 2050. In support of these goals, supportive mechanisms, such as high-level investment privileges from the Board of Investment (BOI), have been established to encourage clean energy projects, including green hydrogen production.

¹ Shahrouz Nayebossadri, Michael Walsh and Michael Smailes, ‘An Overview of the Green Hydrogen Value Chain Technologies and Their Challenges for a Net-Zero Future’ (2025) 6 Hydrogen 26, 26 <<https://doi.org/10.3390/hydrogen6020026>> accessed 30 October 2025; Francisca Gallegos, ‘Bridging the Gap: Certification Schemes for Sustainable Hydrogen in Global Trade’ (2024) 21 Journal for European Environmental & Planning Law 239, 239 <<https://doi.org/10.1163/18760104-21030005>> accessed 30 October 2025.

² Wenting Cheng and Sora Lee, ‘How Green Are the National Hydrogen Strategies?’ (2022) 14 Sustainability 1930, 1930. <<https://doi.org/10.3390/su14031930>> accessed 30 October 2025.

³ Francisca Gallegos, ‘The Art of Certifying Hydrogen: A New Era in International Trade’ (2024) 22 Oil, gas and energy law 1, 1 <<https://erepo.uef.fi/handle/123456789/33286>> accessed 30 October 2025; Lee V White and others, ‘Towards emissions certification systems for international trade in hydrogen: The policy challenge of defining boundaries for emissions accounting’ (2021) 215 Energy 119139, 119139 <<https://doi.org/10.1016/j.energy.2020.119139>> accessed 30 October 2025.

⁴ Wenting Cheng and Sora Lee (n 2) 1947.

Despite this clear policy intent, these support mechanisms face a subsidy paradox stemming from a critical legal gap: the incentives are functionally inoperable. Government subsidies, by their legal nature, cannot be deployed without a clearly defined and verifiable object of subsidy.⁵ As of now, Thai law lacks a formal legal definition, a unified national standard, and an established, credible system for verifying what constitutes clean or green hydrogen. This regulatory vacuum creates a state of legal paralysis, rendering the BOI incentives difficult to target and deploy, which in turn fosters significant uncertainty for investors and project developers.

1.3 Research Questions and Analytical Focus

The research is guided by two primary legal research questions:

1. Primary Legal Research Question (RQ1): What are the essential legal design elements of a credible hydrogen certification system that successfully balance (1) environmental integrity, (2) market operability and (3) legal certainty for subsidy mechanisms?

2. Secondary Legal Research Question (RQ2): Drawing from a functional comparison of leading international models, how can these essential legal elements be functionally adapted to Thailand's specific legal and institutional context (e.g., BOI frameworks, Thai Industrial Standards Institute (TISI) standards) to operationalize its national climate objectives?

1.4 Hypothesis and Core Argument

This article argues that a functional certification system is not merely a beneficial policy tool but a foundational legal prerequisite for the operability of any effective subsidy regime. The optimal legal framework for Thailand is not a wholesale adoption of any single international model, but rather a pragmatic hybrid framework. The adoption of such a framework is the only pathway to provide the legal certainty and verifiable object of subsidy currently missing due to the institutional and jurisdictional constraints inherent in the Investment Promotion Act, B.E. 2520 (1977), the Energy Industry Act, B.E. 2550 (2007), the Industrial Product Standards Act, B.E. 2511 (1968), and the Fuel Oils Control Act, B.E. 2542 (1999).

⁵ Erlend Hordvei and others, 'From Policy to Practice: The Cost of Europe's Green Hydrogen Ambitions.' (2025) 12 Cleaner Energy Systems 100206 <<https://doi.org/10.1016/j.cles.2025.100206>> accessed 30 October 2025.

1.5 Structure of the Article

To substantiate this argument, this research employs a functional-structural comparative legal methodology. It analyzes the divergent legal frameworks of six key international jurisdictions: the United States, Canada, the European Union, South Korea, Australia, and Japan. Section 2 establishes the conceptual framework, identifying the inherent legal link between subsidy and certification and critically synthesizing existing literature to identify the knowledge gaps this article fills. Section 3 details the comparative methodology, providing a clear rationale for the selection of the six jurisdictions and establishing the analytical framework for the comparison. Section 4 presents the comparative analysis, which is then synthesized in Section 5 to provide concrete legal and policy recommendations for Thailand.

2. Conceptual Framework and Critical Synthesis of the Literature

2.1 The Inherent Legal Linkage: Certification as a Prerequisite for Subsidy

A robust conceptual framework for this topic must begin with the recognition of the inherent legal linkage between subsidy mechanisms and certification systems. Government support schemes, which typically encompass fiscal incentives such as Investment Tax Credits (ITC) and Production Tax Credits (PTC), price-support mechanisms like Contracts for Difference (CFDs), and regulatory mandates such as clean energy quotas, are critical for nascent technologies. Among these, production-based price supports (OPEX subsidies) are particularly vital for the clean hydrogen sector to bridge the substantial cost gap between low-carbon hydrogen and conventional fossil fuels. However, their efficacy is fundamentally contingent upon a legally recognized object of subsidy.⁶ Certification serves as the indispensable legal bridge in this context; it provides the objective technical criteria and verification required to distinguish hydrogen based on its carbon intensity rather than its chemical composition. Without a credible certification system, high-value support mechanisms cannot be precisely targeted. This

⁶ Ibrar Ahmad, Jamil Afzal, and Siraj Ahmad, 'Regulatory Analysis of Energy Law and Hydrogen Economy' in Ibrar Ahmad, Jamil Afzal, and Siraj Ahmad (eds) *Legal Framework of Green Hydrogen Production and Hydrogen Economy for Sustainable Development* (SCOPIA Books 2025) 94 <<https://doi.org/10.64060/978-627-7898-00-7-4>> accessed 30 October 2025.

lack of precision leads to a subsidy failure, where the state risks misallocating public funds to fossil-based production or facilitating greenwashing, thereby undermining the very environmental objectives the support was intended to achieve.⁷

This legal linkage is not theoretical; it is empirically demonstrated in major international support mechanisms:

- **United States:** The Inflation Reduction Act (IRA) and its Section 45V Clean Hydrogen Production Tax Credit do not merely subsidize hydrogen; they subsidize verified levels of cleanliness. The law embeds certification directly into the tax code by defining four distinct tiers of ‘cleanliness’ based on lifecycle greenhouse gas (GHG) emissions ($\text{kgCO}_2\text{e/kgH}_2$), with corresponding tax credit values. Qualification demands rigorous measurement, reporting, and verification (MRV) of GHG emissions.⁸

- **Japan:** Similarly, Japan’s support mechanism, which includes Contracts for Difference (CFDs), establishes specific eligibility criteria based on a defined carbon intensity for low-carbon hydrogen that qualifies for governmental support.⁹

These examples demonstrate that certification functions as the legal mechanism to transform an intangible environmental attribute (e.g., ‘low-carbon’) into a tangible, verifiable, and, critically, subsidisable legal asset.

2.2 The Current Legal Vacuum in Thailand and its Operability Crisis

Thailand’s current regulatory landscape represents a critical legal vacuum, specifically in the context of clean hydrogen certification and environmental standardization.¹⁰ While the BOI has established its investment promotion regime, a discretionary framework of fiscal and non-fiscal incentives governed by the Investment Promotion Act, B.E. 2520

⁷ Gabriela Gonçalves Dias Ponzi and others, ‘The hydrogen life cycle assessment methodology: an overlooked puzzle piece in harmonizing hydrogen certification and trade’ (2024) 26 *Clean Technol Environ Policy* 2573, 2574 <<https://doi.org/10.1007/s10098-024-02752-y>> accessed 30 October 2025.

⁸ Donna M. Attanasio and Meghan Briggs, ‘Hydrogen Regulation in the United States Hydrogen Regulation in the United States: Will Government Financial Incentives Outweigh Regulatory Hurdles?’ in Ruven Fleming (ed) *The Cambridge Handbook of Hydrogen and the Law* (CUP 2024) 36–37 <<https://doi.org/10.1017/9781009459259>> accessed 30 October 2025.

⁹ Ibrar Ahmad, Jamil Afzal, and Siraj Ahmad, ‘Regulatory Analysis of Energy Law and Hydrogen Economy’ (n 6) 94

¹⁰ Piti Eiamchamroonlarp, ‘Hydrogen Regulation in Southeast Asia: Steam Reforming from Biofuels as an Alternative to Electrolysis?’ in Ruven Fleming (ed) *The Cambridge Handbook of Hydrogen and the Law* (CUP 2024) 97, 106, 110 <<https://doi.org/10.1017/9781009459259>> accessed 30 October 2025.

(1977) to attract strategic capital into prioritized sectors, for green hydrogen production activities, it lacks concrete technical specifications linked to a recognized certification standard to legally define and verify what constitutes eligible ‘green’ or ‘clean’ hydrogen.

This absence is not merely a policy ambiguity; it creates a crisis of legal operability. Legal operability, in this context, refers to the functional capacity of a legal framework to be executed and enforced through precise definitions, objective technical criteria, and established administrative procedures that allow state agencies to act. A crisis of operability occurs when a high-level policy objective exists in a statutory vacuum, devoid of the legal infrastructure necessary to identify and verify the object of that policy. Without a legally binding definition and a rigorous verification standard, the BOI’s incentives remain functionally inert. It hinders the targeted deployment of subsidies and, furthermore, creates a significant risk of arbitrary administrative discretion in the granting of fiscal incentives.¹¹ In the context of Thai administrative practice, while the BOI is legally empowered with broad discretionary authority under Section 16 of the Investment Promotion Act, exercising this discretion without an objective, scientifically verifiable benchmark is structurally problematic. Because the law currently lacks a quantifiable threshold (e.g., a specific $kgCO_2e/kgH_2$ limit) to legally define ‘clean’ hydrogen, administrative officers are forced to rely on subjective evaluations of project proposals. This absence of boundaries creates a structural vulnerability where decisions could be inconsistent, potentially allowing projects with marginal environmental benefits to receive the same level of public subsidy as truly zero-emission projects. This uncertainty violates the fundamental legal principle of Legal Certainty, a cornerstone of the Rule of Law necessary to secure large-scale, long-term capital investment.¹²

2.3 Critical Synthesis and the Knowledge Gaps

A review of existing literature reveals a field dominated by technical, engineering, and economic analyses.¹³ While valuable, this body of work contains significant knowledge gaps from a legal and regulatory perspective, which this article seeks to fill.

¹¹ Daniel Goodwin and others, ‘Expert views on the legitimacy of renewable hydrogen certification schemes’ (2025) 121 Energy Research & Social Science 103970 <<https://doi.org/10.1016/j.erss.2025.103970>> accessed 30 October 2025.

¹² Ibrar Ahmad, Jamil Afzal, and Siraj Ahmad, ‘Regulatory Analysis of Energy Law and Hydrogen Economy’ (n 6) 99, 107

¹³ Ruven Fleming, ‘Introduction’ in Ruven Fleming (ed) *The Cambridge Handbook of Hydrogen and the Law* (CUP 2024) 1, 4 <<https://doi.org/10.1017/9781009459259>> accessed 30 October 2025.

- **Knowledge Gap 1 (The Subsidy Linkage):** There is a lack of scholarly legal analysis on the direct implications of certification design (or its absence) for the legal operability and efficacy of domestic subsidy regimes. Much of the literature treats certification as a technical issue of measurement and subsidy as a separate political issue of finance.¹⁴ This article connects them as a singular legal-administrative challenge.

- **Knowledge Gap 2 (The Comparative Law Gap):** Existing comparative studies on hydrogen are often descriptive policy inventories, cataloging different national targets or standards.¹⁵ There is a specific gap in systematic comparative legal analysis that connects the divergent legal frameworks (e.g., tax-embedded vs. stand-alone certificates) to their functional outcomes in terms of market operability and legal certainty.

2.4 Core Structural Elements: The Linkage between Promotion, Certification, and Operability

A hydrogen certification framework is more than a collection of technical standards; it is the essential legal bridge that connects the investment promotion regime to its intended outcomes. For a promotion regime (such as the BOI's fiscal incentives) to achieve legal operability, it must be anchored in a robust certification system that can precisely define and verify the object of subsidy. Without this linkage, the promotion regime remains functionally inert, as administrative agencies lack the objective criteria necessary to identify and reward the specific environmental performance they seek to promote. This research identifies seven core structural elements that constitute this legal framework, serving as the functional components that translate high-level policy intent into an operable regulatory system:

1. **Legal Basis:** The statutory authority that grants legitimacy to the certification process.
2. **GHG Calculation Scope (System Boundaries):** The defined lifecycle boundaries (e.g., Well-to-Gate) for measurement.
3. **GHG Emission Thresholds:** The specific tiered or single-value limits that define 'cleanliness'.
4. **Complexity and Additional Conditions:** Factors such as additionality that ensure environmental integrity.

¹⁴ Francisca Gallegos, 'The Art of Certifying Hydrogen: A New Era in International Trade' (n 3) 1.

¹⁵ Wenting Cheng and Sora Lee (n 2) 1932.

5. Tracking Method (Chain of Custody): The system (e.g., Mass Balance) used to track the ‘green’ attribute through the supply chain.

6. Technology Neutrality: The extent to which the framework focuses on carbon intensity rather than specific production methods.

7. Market Impact and Linkage to Subsidies: The definitive legal mechanism that triggers the deployment of incentives based on certified results.

Together, these seven elements form the conceptual framework for the comparative analysis, ensuring that the certification system provides the precision necessary for legal operability within the investment promotion regime.

3. Methodology: A Framework for Comparative Legal Analysis

3.1 Defining the Comparative Methodology: A Functional-Structural Approach

This research employs a qualitative, comparative legal methodology. While grounded in the broad comparative tradition, this study adopts a specific Functional-Structural Approach.¹⁶

- **Functionalism (The ‘Function’):** This approach begins with the presumption that all selected jurisdictions, despite their different legal traditions, are attempting to solve the same fundamental legal-economic problem (the function).¹⁷ In this context, the function is: “How to legally construct a credible, verifiable, and operable definition of ‘clean hydrogen’ to enable market creation and subsidy deployment.”

- **Structuralism (The ‘Structure’):** The analysis then proceeds to identify and compare the different legal tools, regulatory designs, and institutional arrangements (the structures) that each jurisdiction has created to achieve this common function.

3.2 Rationale for Jurisdictional Selection: Three Regulatory Models of Legal Framework

The selection of the six jurisdictions to compare, the United States (US), Canada, the European Union (EU), South Korea, Australia, and Japan, is not random. It is a purposeful

¹⁶ Ralf Michaels, ‘The Functional Method of Comparative Law’ in Mathias Reimann and Reinhard Zimmermann (eds) *The Oxford Handbook of Comparative Law* (Oxford University Press 2006) 342.

¹⁷ *ibid* 369-372.

selection designed to capture the full spectrum of regulatory innovation. These jurisdictions are selected because their legal frameworks represent the three dominant regulatory models or typologies of legal framework for certification:

1. Regulatory Model 1: “Subsidy-as-Certification” (The Tiered Tax/Investment Models): This regulatory model includes jurisdictions where the certification criteria (e.g., emissions tiers) are directly embedded within the primary subsidy legislation itself (e.g., a tax code).

○ Exemplars: The United States (IRA Section 45V Production Tax Credit) and Canada (Clean Hydrogen Investment Tax Credit).

While both models utilize tax codes, their economic mechanisms differ: a Production Tax Credit (PTC) in the US functions as an output-based OPEX subsidy linked to the actual volume of clean hydrogen produced, whereas an Investment Tax Credit (ITC) in Canada operates as an input-based CAPEX subsidy reducing initial construction costs. Despite this difference, both models share the core legal characteristic of embedding verification tiers directly into the subsidy eligibility criteria.

2. Regulatory Model 2: “Formal Stand-alone Certification” (The GO Models): This regulatory model includes jurisdictions that first create a separate legal instrument (e.g., a Guarantee of Origin - GO) as a formal certificate of attributes. This certificate then functions as the prerequisite for accessing different markets or support schemes.

○ Exemplars: The European Union (RFNBO criteria and CertifHy), South Korea (Clean Hydrogen Certification System linked to its CHPS mandate), and Australia (national Guarantee of Origin scheme).

3. Regulatory Model 3: “Standard-as-Prerequisite” (The Eligibility Model): This regulatory model represents a streamlined approach where the law defines a minimum standard for ‘cleanliness’, which acts as a simple prerequisite or entry ticket for producers to become eligible to participate in separate subsidy programs.

○ Exemplar: Japan (Legal standard for eligibility in its Contracts for Difference (CFD) support program. A CFD is a long-term contractual mechanism that guarantees a fixed revenue level, or strike price, for producers; if the market price falls below this strike price, the government pays the difference, effectively bridging the cost gap between low-carbon hydrogen and conventional fuels to mitigate investment risk.)

This typology provides a systematic basis for comparison, allowing the analysis to move beyond individual case studies to a higher-level synthesis of regulatory archetypes.

3.3 Data Collection and the Analytical-Structural Framework

The methodology is executed through documentary research, analyzing two categories of data:

- **Primary Sources:** The principal legal and regulatory instruments from the six selected jurisdictions. This includes Acts of Parliament/Congress, governmental regulations, delegated acts (such as those under the EU's Renewable Energy Directive), and official standards documents.

- **Secondary Sources:** Peer-reviewed academic articles, reputable industry reports, and policy analyses that interpret, critique, or explain the context and operation of these primary legal sources.

The data collected from these sources is subjected to a systematic content analysis.¹⁸ To ensure a rigorous and structured comparison, this analysis uses the seven core elements identified in Section 2.4 (Legal Basis, System Boundaries, Thresholds, Complexity/Additional Conditions, Chain of Custody, Technology Neutrality, and Market Impact). In the language of comparative law, these seven elements function as the *tertium comparationis* (the third element of comparison), a common, neutral yardstick against which the different legal structures of the six jurisdictions can be systematically measured, compared, and contrasted.¹⁹ This framework allows the research to identify commonalities, divergences, and best practices relevant to Thailand.

4. Results: Comparative Legal Analysis of Certification Frameworks

This section presents the core findings derived from the comparative analysis of international legal frameworks for clean hydrogen certification. The analysis categorizes the identified legal frameworks into three principal regulatory models, based on their fundamental approach to linking hydrogen attributes with regulatory recognition or market value.

¹⁸ Judith Resnik and Dennis Curtis, *Representing Justice: Invention, Controversy, and Rights in City-States and Democratic Courtrooms* (Yale University Press 2011) 103.

¹⁹ Mark Van Hoecke, *Methodology of Comparative Legal Research* (Hart Publishing 2015) 45-47.

4.1 Regulatory Model 1: “Subsidy-as-Certification” (The Tiered Models)

This regulatory model is characterized by the direct integration of certification criteria within the legislative or regulatory text that establishes a subsidy mechanism (e.g., tax credits). Instead of creating a separate, tradable certificate (like a GO or Renewable Energy Certificate (REC)), the law itself defines varying levels of ‘cleanliness’ based on specific metrics (typically GHG emissions intensity) and directly assigns a corresponding monetary value or subsidy level to hydrogen meeting those criteria. The qualification for the subsidy inherently acts as the certification of the hydrogen’s attribute level. This approach essentially monetizes the environmental attribute directly through the subsidy framework.

4.1.1 United States Model (IRA Section 45V)

Legal Framework: The US model is legally grounded in Title 26 of the United States Code (U.S.C.) § 45V (Internal Revenue Code Section 45V), as enacted by the Inflation Reduction Act (IRA) of 2022.²⁰ The legislation itself serves as the certification mechanism by defining eligibility for production tax credits (PTC) based on lifecycle greenhouse gas emissions.²¹ It establishes four distinct tiers of support, directly linking the emissions intensity of the produced hydrogen to a specific tax credit value per kilogram (\$/kg).²² This provides a powerful operational expenditure (OPEX) subsidy.²³

Thresholds: The four tiers are defined based on lifecycle GHG emissions, calculated on a Well-to-Gate system boundary (a lifecycle assessment scope that accounts for all greenhouse gas emissions from the upstream extraction and processing of raw materials, up to the point where the hydrogen is produced and ready to leave the facility gate, excluding downstream transportation and end-use emissions):

- Tier 1 (Maximum Credit): 0 - 0.45 kgCO_{2e}/kgH₂, receives 3.00/kgH₂ (base credit \$0.60/kg, multiplied by 5 if wage and apprenticeship requirements are met).
- Tier 2: >0.45 - 1.5 kgCO_{2e}/kgH₂, receives 1.00/kgH₂ (base credit \$0.20/kg, multiplied by 5).

²⁰ Donna M Attanasio and Meghan Briggs (n 8) 36.

²¹ *ibid* 479.

²² *ibid* 36–37.

²³ Andrzej Graczyk, Paweł Brusilo and Alicja Małgorzata Graczyk, ‘Hydrogen as a Renewable Fuel of Non-Biological Origins in the European Union—The Emerging Market and Regulatory Framework’ (2025) 18 *Energies* 617 <<https://doi.org/10.3390/en18030617>> accessed 30 October 2025.

○ Tier 3: $>1.5 - 2.5 \text{ kgCO}_2\text{e/kgH}_2$, receives $0.75/\text{kgH}_2$ (base credit $\$0.15/\text{kg}$, multiplied by 5).

○ Tier 4 (Minimum Credit): $>2.5 - 4.0 \text{ kgCO}_2\text{e/kgH}_2$, receives $0.60/\text{kgH}_2$ (base credit $\$0.12/\text{kg}$, multiplied by 5).

Hydrogen produced with emissions exceeding $4.0 \text{ kgCO}_2\text{e/kgH}_2$ is ineligible for the credit.²⁴

Measurement: Lifecycle GHG emissions (Well-to-Gate) must be determined using the most recent Greenhouse gases, Regulated Emissions, and Energy use in Technologies (GREET) model developed by Argonne National Laboratory, specifically the ‘45VH2-GREET’ version, or its successor.²⁵ Producers may also petition the Secretary of the Treasury for a Provisional Emissions Rate (PER) determination if their pathway’s emissions are not reflected in the current GREET model. Strict rules also apply regarding the use of renewable energy credits (RECs) and power purchase agreements (PPAs) to qualify grid-connected electricity inputs, guided by the strict “Three Pillars” principles to prevent unintended increases in grid emissions:

1. **Additionality (or Incrementality):** The renewable electricity must be sourced from newly built generation capacity (typically coming online within 36 months of the hydrogen facility) to ensure it adds new clean energy to the grid rather than cannibalizing existing renewable resources.

2. **Temporal Matching:** The generation of renewable electricity and the production of hydrogen must occur within the same time window (transitioning from annual to strict hourly matching by 2028) to accurately reflect real-time zero-emission production.

3. **Deliverability (Geographic Correlation):** The renewable energy source and the hydrogen production facility must be located within the same electrical grid region to ensure physical transmission viability without exacerbating grid congestion.²⁶

Characteristics: The 45V credit is designed to be technology-neutral, meaning any production pathway can qualify provided it meets the emissions thresholds.²⁷ It provides a strong, direct OPEX support linked explicitly to environmental performance, incentivizing producers to achieve the lowest possible emissions intensity to maximize

²⁴ Donna M Attanasio and Meghan Briggs (n 8) 36–37.

²⁵ *ibid* 39.

²⁶ Francisca Gallegos, ‘The Art of Certifying Hydrogen: A New Era in International Trade’ (n 3) 7.

²⁷ Donna M Attanasio and Meghan Briggs (n 8) 37.



the credit value.²⁸ Verification is handled through IRS processes, requiring third-party attestation.²⁹

4.1.2 Canada Model (Clean Hydrogen ITC)

Legal Framework: Canada's approach, detailed in Budget 2023 and subsequent legislative proposals, utilizes a refundable Investment Tax Credit (ITC) focused on incentivizing capital expenditures (CAPEX) for clean hydrogen projects.³⁰ This mechanism is formally enacted under Section 127.48 of the Income Tax Act (Canada), which was passed into law via the Budget Implementation Act, 2024. Similar to the US model, the legislation ties the level of support directly to the environmental performance, defining three tiers based on Carbon Intensity (CI).³¹ The ITC provides upfront support for the initial investment in clean hydrogen production facilities.³²

Thresholds: The three CI tiers determine the percentage of eligible project capital costs that can be claimed as a refundable tax credit:

- Tier 1 (Maximum Credit): $< 0.75 \text{ kgCO}_2\text{e/kgH}_2$, eligible for a 40% ITC.
- Tier 2: $\geq 0.75 - < 2 \text{ kgCO}_2\text{e/kgH}_2$, eligible for a 25% ITC.
- Tier 3 (Minimum Credit): $\geq 2 - < 4 \text{ kgCO}_2\text{e/kgH}_2$, eligible for a 15% ITC.

Projects with a CI of $4 \text{ kgCO}_2\text{e/kgH}_2$ or higher are ineligible. Projects must also meet labour requirements (prevailing wages and apprenticeships) to receive the full credit rates; otherwise, the rates are reduced by 10 percentage points.³³

Measurement: Carbon intensity must be calculated based on the lifecycle analysis methodology outlined in the government's Fuel Life Cycle Assessment (LCA) Model, maintained by Environment and Climate Change Canada.³⁴ This model assesses emissions from Well-to-Gate, similar to the US approach. The eligibility of energy inputs, including electricity and natural gas, must adhere to specific verification requirements defined within this framework.

²⁸ Ibrar Ahmad, Jamil Afzal, and Siraj Ahmad, 'Regulatory Analysis of Energy Law and Hydrogen Economy' (n 6) 241.

²⁹ Francisca Gallegos (n 1) 260.

³⁰ Francisca Gallegos (n 3) 7.

³¹ *ibid* 7, 13.

³² *ibid* 7.

³³ Francisca Gallegos (n 1) 267

³⁴ Francisca Gallegos (n 3) 7, 13

Characteristics: The Canadian Clean Hydrogen ITC is also technology-neutral, focusing on the CI outcome rather than the production method.³⁵ It primarily supports initial capital investment (CAPEX), contrasting with the US focus on OPEX. Verification of the CI assessment will be required as part of the tax credit application process, likely involving third-party validation against the Fuel LCA Model.³⁶

4.2 Regulatory Model 2: Formal Certification Systems (The Stand-alone Models)

This regulatory model involves the state or a designated body first establishing a distinct certificate (such as a Guarantee of Origin - GO) as a separate legal object or instrument. This certificate formally attests to specific attributes of hydrogen (e.g., production method, renewable energy input, carbon intensity). Subsequently, possession or cancellation of these certificates becomes a prerequisite or condition for accessing specific markets, receiving subsidies under other programs, or fulfilling regulatory obligations. Unlike the “Subsidy-as-Certification” models, the certificate exists independently of a specific subsidy value, although it is designed to interact with market mechanisms or support schemes.

4.2.1 “Rigorous and Complex” Model (EU RFNBO & CertifHy)

Legal Framework: The European Union employs a complex, dual-layered approach. The primary legal basis is established under Directive (EU) 2018/2001 (RED II), as amended by Directive (EU) 2023/2413 (RED III), which defines Renewable Fuels of Non-Biological Origin (RFNBOs), including renewable hydrogen. The specific technical requirements for RFNBOs are detailed in two key regulations: Commission Delegated Regulation (EU) 2023/1184, which sets out the rules for the production of renewable hydrogen from electricity, and Commission Delegated Regulation (EU) 2023/1185, which establishes the methodology for calculating greenhouse gas emission savings.³⁷

³⁵ Wenting Cheng and Sora Lee (n 2) 1936.

³⁶ Francisca Gallegos (n 3) 7.

³⁷ Leigh Hancher and Simina Suci, ‘Hydrogen Regulation in Europe: The EU’s ‘Hydrogen and Decarbonised Gas Market’ – Best Practice or Missed Opportunity?’ in Ruven Fleming (ed) *The Cambridge Handbook of Hydrogen and the Law* (CUP 2024) 17 <<https://doi.org/10.1017/9781009459259>> accessed 30 October 2025; Andrzej Graczyk, Paweł Brusilo and Alicja Małgorzata Graczyk (n 23) 617.

Alongside this, the CertifHy scheme, initially an industry-led project now evolving towards wider EU recognition, provides a voluntary Guarantee of Origin (GO) system for certifying renewable and low-carbon hydrogen based on its own (historically distinct but now aligning) criteria.³⁸ The legal RFNBO definition acts as a mandatory standard for compliance markets, while CertifHy aims to facilitate voluntary market transparency and trade.³⁹

Criteria (RFNBO): The RFNBO criteria are arguably the most stringent globally. Under Article 25 and 28 of RED II (and corresponding Annexes in the Delegated Regulations), hydrogen must achieve a lifecycle GHG emissions saving of at least 70% compared to a fossil fuel comparator (94 gCO_{2e}/MJ). Critically, pursuant to Articles 3-7 of Commission Delegated Regulation (EU) 2023/1184, it must also meet strict rules regarding the renewable electricity used, often termed the “three pillars”:

- **Additionality (Article 5):** The renewable electricity must come from new, unsubsidised renewable generation facilities.

- **Temporal Correlation (Article 6):** Production must match consumption on an hourly basis (with transitional rules allowing monthly matching until 2030).

- **Geographic Correlation (Article 7):** Production and consumption must occur within the same bidding zone, or adjacent zones if electricity prices are positive.⁴⁰

Criteria (CertifHy): Initially (Phase II), CertifHy defined ‘green’ hydrogen based on a 60% GHG reduction threshold compared to Steam Methane Reforming (SMR) (equivalent to < 36.4 gCO_{2e}/MJ_{H₂} or approx. 4.37 kgCO_{2e}/kgH₂), measured at the ‘Point of Production’ boundary. CertifHy also offered a ‘low-carbon’ label. However, with the finalisation of the RED Delegated Acts, CertifHy is aligning its ‘green’/renewable definition with the stricter RFNBO criteria to ensure market relevance.⁴¹

³⁸ Anthony Velazquez Abad and Paul E Dodds, ‘Green hydrogen characterisation initiatives: Definitions, standards, guarantees of origin, and challenges’ (2020) 138 Energy Policy 111300, 49, 61–62 <<https://doi.org/10.1016/j.enpol.2020.111300>> accessed 30 October 2025; Fred Gale and others, ‘Renewable hydrogen standards, certifications, and labels: A State-of-the-Art Review from a Sustainability Systems Governance Perspective’ (2024) 59 International Journal of Hydrogen Energy 654 <<https://doi.org/10.1016/j.ijhydene.2024.02.038>> accessed 30 October 2025.

³⁹ John Chandler and John Paterson, ‘Selling sunshine Emerging challenges in the certification of hydrogen’ (2025) 43 Journal of Energy & Natural Resources Law 41, 49 <<https://doi.org/10.1080/02646811.2024.2344363>> accessed 30 October 2025.

⁴⁰ Andrzej Graczyk, Paweł Brusilo and Alicja Małgorzata Graczyk (n 23) 617.

⁴¹ Anthony Velazquez Abad and Paul E Dodds (n 38).

Tracking: The RFNBO framework mandates a Mass Balance system for tracking renewable hydrogen through infrastructure, ensuring the certified quantities match physical flows within defined system boundaries.⁴² CertifHy, however, historically operated using a Book & Claim model, where certificates could be traded independently of the physical hydrogen flow. This discrepancy presents challenges for interoperability, although CertifHy aims to adapt.⁴³

Market Impact: The complexity and stringency of the RFNBO rules, particularly the additionality and temporal correlation requirements, have faced criticism for creating significant implementation hurdles, investment uncertainty, and potentially hindering the bankability of projects.⁴⁴ Academic reviews and industry reports highlight that these stringent conditions can lead to higher development costs and complex certification requirements that hinder large-scale adoption.⁴⁵

4.2.2 “Pragmatic and Tiered” Model (South Korea)

Legal Framework: South Korea enacted the world’s first comprehensive legislation for the hydrogen sector, the Hydrogen Economy Promotion and Hydrogen Safety Management Act (commonly referred to as the “Hydrogen Act”) in 2020. The legal basis for the certification system was formally established through the 2022 amendment of the Act, specifically under Article 25-2 (Certification of Clean Hydrogen).⁴⁶ Under this Act, the government implemented a mandatory Clean Hydrogen Certification

⁴² Jonathan Schmid and others, ‘Is it green? Designing a blockchain-based certification system for the EU hydrogen market’ (2024) 7 *Frontiers in Blockchain* 1408743 <<https://doi.org/10.3389/fbloc.2024.1408743>> accessed 30 October 2025.

⁴³ Ibid; Lee V White and others (n 3) 119139.

⁴⁴ Erlend Hordvei and others (n 5) 7–8; Lee V White and others, ‘Implications for cost-competitiveness of misalignment in hydrogen certification’ (2025) 204 *Energy Policy* 114661 <<https://doi.org/10.1016/j.enpol.2025.114661>> accessed 30 October 2025; John Chandler and John Paterson (n 39) 53; Andrzej Graczyk, Paweł Brusito and Alicja Małgorzata Graczyk (n 23) 617; Maximilian Kuhn and Peter Koop, ‘Standardizing Hydrogen Certification: Enhance Traceability, Transparency, and Market Access’ (H2Global Stiftung Policy Brief 2023) 4 <https://www.dvgw.de/medien/dvgw/verein/aktuelles/news/Standardizing_Hydrogen_Certification.pdf> accessed 30 October 2025.

⁴⁵ Erlend Hordvei and others (n 5) 7–8; Lee V White and others (n 44) 114661; John Chandler and John Paterson (n 39) 53; Andrzej Graczyk, Paweł Brusito and Alicja Małgorzata Graczyk (n 23) 617; Francisca Gallegos, ‘The Art of Certifying Hydrogen: A New Era in International Trade’ (n 3) 18; Francisca Gallegos (n 1) 246; Jonathan Schmid and others (n 42) 62; Daniel Goodwin and others (n 11) 103970.

⁴⁶ Jae-Eun Shin, ‘Hydrogen Technology Development and Policy Status by Value Chain in South Korea’ (2022) 15 *Energies* 8983 <<https://doi.org/10.3390/en15238983>> accessed 30 October 2025.

System in 2024.⁴⁷ The system is designed to be pragmatic and technology-neutral, focusing on verified emissions intensity rather than specific production pathways.⁴⁸

Criteria: The certification sets a baseline threshold for ‘clean hydrogen’ at 4 kgCO₂e/kgH₂, calculated on a Well-to-Gate system boundary. Crucially, it further differentiates hydrogen into four distinct grades based on emissions performance, allowing for nuanced market signals and incentives:

- Grade 1: 0 – 0.1 kgCO₂e/kgH₂
- Grade 2: >0.1 – 1.0 kgCO₂e/kgH₂
- Grade 3: >1.0 – 2.0 kgCO₂e/kgH₂
- Grade 4: >2.0 – 4.0 kgCO₂e/kgH₂⁴⁹

Enforcement: Certification is a mandatory requirement for participation in South Korea’s Clean Hydrogen Portfolio Standard (CHPS) market, launched simultaneously in 2024.⁵⁰ The CHPS obligates certain power producers to procure clean hydrogen, creating a guaranteed demand. Bids in the CHPS auction receive preferential treatment based on the hydrogen’s certified grade, providing stronger incentives for lower-emission production.⁵¹ Additionally, Article 25-4 provides the legal authority for the Ministry of Trade, Industry and Energy (MOTIE) to designate specialized agencies to manage the certification and verification processes.

Tracking: The system utilizes a Mass Balance approach for tracking certified hydrogen through the supply chain.

4.2.3 “Flexible and Unbundled” Model (Australia GO)

Legal Framework: Australia passed the Guarantee of Origin Act 2024 (Cth), which establishes the statutory framework for a national Guarantee of Origin (GO) scheme.⁵² This scheme represents a unique legal innovation by focusing on flexibility through the unbundling of certificates. Under Part 2 of the Act, the legislation provides

⁴⁷ Yunji Kim and others, ‘An Analysis of Greenhouse Gas Emissions in Electrolysis for Certifying Clean Hydrogen’ (2024) 17 *Energies* 3698 <<https://doi.org/10.3390/en17153698>> accessed 30 October 2025.

⁴⁸ *ibid* 3698.

⁴⁹ *ibid* 3698; Kyeong-Mi Kim and Dongwoo Kim, ‘Life Cycle Assessment of Greenhouse Gas Emissions in Hydrogen Production via Water Electrolysis in South Korea’ (2024) 16 *Sustainability* 11010 <<https://doi.org/10.3390/su162411010>> accessed 30 October 2025.

⁵⁰ Yunji Kim and others (n 47) 3698.

⁵¹ *ibid* 3698.; Jae-Eun Shin (n 46) 8983.

⁵² Lee V White and others (n 44) 114661; John Chandler and John Paterson (n 39) 61–62.

the legal basis for creating and managing digital certificates that verify the attributes of hydrogen and other low-emission products. It separates the certification of the product itself from the certification of the renewable electricity used in its production, allowing these attributes to be tracked and potentially traded differently.⁵³

Criteria (Unbundling): The scheme creates two main types of certificates:

○ **Product GO (PGO):** This certificate is attached to a specific batch of hydrogen (or other eligible product). It details the product’s attributes, including its verified carbon intensity (Well-to-Gate), but it is not tradable separately from the physical product.⁵⁴ It serves primarily as an informational label for the product batch.

○ **Renewable Electricity GO (REGO):** This certificate represents 1 MWh of eligible renewable electricity generation. Crucially, REGOs are tradable and can be purchased and surrendered by hydrogen producers (among others) to verify the renewable origin of the electricity they consume, similar to existing Renewable Energy Certificates (RECs).⁵⁵

Enforcement: The GO scheme itself does not directly provide subsidies but functions as flexible “legal groundwork” or an enabling framework.⁵⁶ The Clean Energy Regulator is empowered to administer the scheme, ensuring that PGOs and REGOs meet strict verification standards. The PGOs, with their verified emissions data, are designed to be used by producers to demonstrate eligibility for other government support programs, such as the forthcoming Hydrogen Production Tax Incentive announced in the 2024 Budget.⁵⁷ The tradable REGOs provide a mechanism for producers to substantiate renewable electricity claims within the rules set by those support programs or by voluntary market standards.⁵⁸ This unbundled approach allows different support schemes or market requirements to specify how REGOs must be used (e.g., matching rules) without needing to alter the core GO legislation itself.

⁵³ John Chandler and John Paterson (n 39) 61; Lee V White and others (n 44) 114661.

⁵⁴ Daniel Goodwin and others (n 11) 103970; John Chandler and John Paterson (n 39) 49.

⁵⁵ John Chandler and John Paterson (n 39) 61; Lee V White and others (n 44) 114661.

⁵⁶ John Chandler and John Paterson (n 39) 49.

⁵⁷ Daniel Goodwin and others (n 11) 103970.

⁵⁸ Lee V White and others (n 44) 114661.

4.3 Regulatory Model 3: “Standard-as-Prerequisite” (The Simple Model)

This third regulatory model represents a more streamlined approach where the primary legal framework does not involve creating tiered subsidy levels (like Regulatory Model 1) or establishing a formal, stand-alone, tradable certificate system (like Regulatory Model 2) as the central mechanism. Instead, the core legislation or its subordinate regulations define a specific minimum standard for what qualifies as ‘clean’ or ‘low-carbon’ hydrogen. Meeting this legally defined standard then acts as a simple prerequisite, an entry ticket, for producers to become eligible to apply for or participate in separate support mechanisms, such as Contracts for Difference (CFDs) or other incentive programs. The focus is on setting a baseline qualification through a standard, rather than embedding the certification directly into the subsidy value or creating a complex certificate market.

4.3.1 Japan Model (Legal Standard for CFD Eligibility)

Legal Framework: Japan’s model exemplifies this approach, primarily through its Hydrogen Society Promotion Act (Act No. 37 of 2024) (officially, the Act for Promoting the Supply and Utilization of Low-Carbon Hydrogen and its Derivatives for the Smooth Transition to a Decarbonized Growth-Oriented Economic Structure), enacted in May 2024.⁵⁹ This legislation provides the legal foundation for supporting the entire supply chain of low-carbon hydrogen and its derivatives (like ammonia). Instead of instituting a complex, multi-tiered certification system akin to the US or a stand-alone GO scheme like Australia, Article 2 of the Act delegates the specific quantitative definition and minimum standard for “low-carbon hydrogen” (and its derivatives) to be detailed in subsequent ministerial ordinances, likely from the Ministry of Economy, Trade and Industry (METI).⁶⁰

Enforcement: The primary function of meeting this forthcoming legal standard is to serve as a prerequisite for eligibility to receive government subsidies, most notably through the planned Contracts for Difference (CFD) mechanism.⁶¹ Pursuant to

⁵⁹ Yuma Osaki and Llewelyn Hughes, ‘Japan: Putting Hydrogen at the Core of Its Decarbonisation Strategy’ in Rainer Quitzow and Yana Zabanova (eds) *The Geopolitics of Hydrogen* (Springer 2025) 105-106 <https://doi.org/10.1007/978-3-031-84022-7_5> accessed 30 October 2025.

⁶⁰ *ibid*; Stefan Bube and others, ‘Sustainability regulations for PtX projects: Scope and impact analysis’ (2025) 9 Joule 101966 <<https://doi.org/10.1016/j.joule.2025.101966>> accessed 30 October 2025.

⁶¹ Yuma Osaki and Llewelyn Hughes (n 59) 113; Ibrar Ahmad, Jamil Afzal, and Siraj Ahmad (n 6) 210.

Article 7 of the Act, producers must have their “Business Plans for the Supply of Low-Carbon Hydrogen” officially approved by the competent minister. Once approved, these certified suppliers become eligible for price-gap subsidies (CFD) administered by the Japan Organization for Metals and Energy Security (JOGMEC), which aims to cover the price gap between low-carbon hydrogen and conventional fuels. The standard acts as the gatekeeper for accessing the subsidy program, rather than the subsidy itself defining the tiers of cleanliness.⁶²

Measurement/Criteria: At the time of the Act’s passage, the specific quantitative criteria (e.g., GHG emission thresholds in $kgCO_2e/kgH_2$, system boundaries like Well-to-Gate) for the low-carbon standard were still under consideration and expected to be elaborated in the forthcoming METI ordinances.⁶³ Japan’s Basic Hydrogen Strategy aims for a supply cost comparable to conventional energy, suggesting a pragmatic approach potentially balancing environmental ambition with economic feasibility might influence the final standard.⁶⁴

Legal Concerns: This model, particularly the anticipated standard, has drawn criticism for potentially lacking sufficient environmental stringency.⁶⁵ Concerns exist that the definition of low-carbon might be broad enough to include significant volumes of ‘blue’ hydrogen (produced from fossil fuels with Carbon Capture and Storage - CCS), rather than prioritizing ‘green’ hydrogen from renewables.⁶⁶ Critics argue that subsidizing blue hydrogen, particularly using funds raised through Japan’s Green Transformation (GX) Economy Transition Bonds (GX Bonds), risks creating a carbon lock-in effect, potentially perpetuating reliance on fossil fuel infrastructure and diverting investment from truly zero-emission green hydrogen pathways.⁶⁷ The effectiveness of this model in driving deep decarbonization will heavily depend on the final stringency of the standard set by METI.

⁶² Yuma Osaki and Llewelyn Hughes (n 59) 113.

⁶³ Stefan Bube and others (n 60) 101966.

⁶⁴ Ibrar Ahmad, Jamil Afzal, and Siraj Ahmad, ‘International and Comparative Law Perspectives of Hydrogen Economy’ in Ibrar Ahmad, Jamil Afzal, and Siraj Ahmad (eds) *Legal Framework of Green Hydrogen Production and Hydrogen Economy for Sustainable Development* (SCOPUA Books 2025) 74-77 <<https://doi.org/10.64060/978-627-7898-00-7-3>> accessed 30 October 2025.

⁶⁵ *ibid.*

⁶⁶ *Ibid.*

⁶⁷ Wenting Cheng and Sora Lee (n 2) 1930; Ibrar Ahmad, Jamil Afzal, and Siraj Ahmad (n 64) 176.

4.4 Synthesis and Structured Comparative Analysis

The following comparative synthesis table (Table 1) compares the six jurisdictions across the 7 structural dimensions identified in the methodology. The data in this table is synthesized directly from the research findings presented in Sections 4.1-4.3.

Table 1: Comparative Synthesis of International Certification Legal Frameworks

Structural Element	Regulatory Model 1: US	Regulatory Model 1: Canada	Regulatory Model 2: EU	Regulatory Model 2: South Korea	Regulatory Model 2: Australia	Regulatory Model 3: Japan
1. Legal Basis	Internal Revenue Code (IRA Sec 45V)	Budget Legislation (Clean Hydrogen ITC)	Delegated Acts under RED	Hydrogen Act (2020)	GO Act (2023)	Hydrogen Society Promotion Act (Act 2024)
2. GHG Scope	Well-to-Gate (45VH2-GREET)	Well-to-Gate (Fuel LCA Model)	Lifecycle (RFNBO)	Well-to-Gate	Well-to-Gate	TBD (Expected Well-to-Gate)
3. GHG Thresholds	4 Tiers (0 - 4.0 $kgCO_2e$)	3 Tiers (0 - 4.0 $kgCO_2e$)	70% GHG Saving (vs. 94 gCO_2e/MJ)	4 Grades (0 - 4.0 $kgCO_2e$)	(Not set) Reports measured CI	Single Standard (TBD)
4. Complexity/ Add'l Conditions	High (3 Pillars: Incrementality, Temporal, Deliverability)	Medium (Labour requirements)	Very High (Additionality, Temporal, Geo-match)	Medium (K H2 2024)	Low (Unbundled Certificates)	Low
5. Tracking Method	(N/A - Tax Credit)	(N/A - Tax Credit)	Mass Balance (RFNBO) / Book & Claim (CertifHy)	Mass Balance	PGO (Non-tradable) + REGO (Tradable)	(N/A)
6. Technology Neutrality	Yes (in principle)	Yes	Debatable (Biased toward Electrolysis)	Yes	Yes	No (Risk of bias to Blue H2)
7. Market Impact / Subsidy Link	Direct (Subsidy = Certification)	Direct (CAPEX Support)	Prerequisite (for RED targets)	Prerequisite (for CHPS market)	Enabling Framework (for future incentives)	Prerequisite (for CFD)

A synthetic analysis of Table 1 reveals three key findings:

1. Convergence on Technical Criteria: There is a clear convergence among key jurisdictions (notably the US, Canada, and South Korea) in adopting (1) a ‘Well-to-Gate’ calculation scope and (2) ‘Tiered/Graded’ emissions thresholds with a top ceiling of $4.0 \text{ kgCO}_2\text{e/kgH}_2$ to define ‘Clean Hydrogen’.

2. Divergence on Legal Instruments: Although technical criteria are converging, the legal instruments used to enforce them are starkly divergent, split between (Regulatory Model 1) embedding them in tax law (US/Canada) and (Regulatory Model 2) creating separate, stand-alone Acts/legislation (South Korea/Australia).

3. The EU Outlier: The EU is a clear outlier with the highest level of complexity in additional conditions (Additionality, Temporal matching), which the data in Section 4.2.1 confirms has created significant project implementation challenges, serving as a cautionary tale about premature over-complexity.

These findings suggest that the key question for Thailand is not which technical criteria to choose (as a clear international trend exists), but which legal instrument is best suited to implement those international criteria within the Thai context, leading to the compatibility analysis in the next section.

4.5 Legal and Institutional Compatibility Analysis for Thailand

While Section 4.4 identified the best international models, this section shifts the focus from horizontal comparative law to vertical legal application. Its objective is to analyze whether the proposed hybrid model (based on South Korea and Australia) is compatible with, or faces constraints under, Thailand’s current legal and institutional framework. This analysis is anchored in the principles of Regulatory Coherence and Legal Certainty, which are critical rule-of-law components necessary to attract long-term investment.

4.5.1 The Operability Crisis: Thailand’s Subsidy Paradox

As identified in Sections 1.2 and 2.2, Thailand faces a crisis of legal operability. In the specific context of subsidizing certified green hydrogen, operability denotes the legal-administrative capacity of a framework to transform an intangible environmental attribute, low-carbon intensity, into a subsidisable legal entitlement through a transparent and objective verification chain. It is the functional ability of the law to bridge the gap between a physical molecule and a monetary reward. Despite clear policy intent to

support clean hydrogen via Board of Investment (BOI) incentives, these incentives are functionally inoperable.

The primary cause is a legal gap: the lack of a legal definition, national standard, and credible verification system for clean hydrogen, the requisite object of subsidy. Without this operability, the fiscal incentive remains legally detached from its intended object. This current state creates regulatory paralysis and violates the principle of Legal Certainty, hindering investment decisions for large-scale projects that require regulatory clarity.

4.5.2 Institutional and Legal Constraints for a Tiered, Well-to-Gate Hybrid Model

The proposal to adopt a hybrid model (blending South Korea's tiered 'Well-to-Gate' criteria with Australia's flexible certificate legal framework) in Thailand faces three significant institutional and legal obstacles, rendering it incompatible with the current legal framework:

A. Investment Promotion Act, B.E. 2520 (1977): A "Category vs. Granularity" Constraint

A primary legal constraint concerns the interpretation of the Investment Promotion Act, B.E. 2520 (1977), specifically whether Section 16 empowers the Board of Investment (BOI) to grant "tiered" incentives based on granular environmental performance (e.g., $kgCO_2e$ intensity), or if its authority is statutorily limited to granting benefits based on the broader "category" of the promoted activity (e.g., a green activity). Although historical BOI practice, such as in its electric vehicle policies, has typically favored incentives based on the type of activity or required inputs rather than tiered environmental outputs, this precedent does not necessarily signify a definitive statutory limitation, particularly given the broad promotional powers conferred by Section 16 of the Act. The analysis suggests the principal obstacle is not a statutory constraint regarding the BOI's authority to grant incentives, but rather a critical institutional and coherence constraint. The BOI is constituted as an Investment Promotion Agency, not an Environmental Standard-Setting Body. Consequently, its functional inability to deploy tiered benefits stems from its inherent reliance on inter-agency coordination; it must reference a credible, external standard established by a technically expert agency rather than creating one internally, which would be outside its institutional expertise and mandate.

However, the current absence of such a standard is a symptom of fragmented statutory mandates across the broader regulatory framework. It is not necessarily an administrative failure of other agencies, but rather a legal limitation. As analyzed subsequently, the expert agencies are statutorily constrained: the Energy Regulatory Commission (ERC) lacks jurisdiction over hydrogen as an energy source (Section B), and TISI’s legislative mandate focuses on physical product safety rather than complex lifecycle emissions accounting (Section C). Furthermore, environmental agencies possessing the requisite technical expertise in greenhouse gas accounting, such as the Thailand Greenhouse Gas Management Organization (TGO), operate primarily within the sphere of voluntary carbon markets (e.g., T-VER). They currently lack the overarching statutory authority to mandate environmental certification for the purpose of industrial and energy subsidies. This fragmented landscape leaves the BOI without a legally binding, national reference standard to operationalize its tiered incentives, creating a fundamental Regulatory Coherence gap.

B. Energy Industry Act, B.E. 2550 (2007): The “Jurisdictional Vacuum”

A second critical constraint emerges from a significant jurisdictional vacuum within Thailand’s energy law landscape. Fundamentally, the Energy Industry Act, B.E. 2550 (2007) does not legally define hydrogen as energy. Under the statutory definitions provided in Section 5 of the Act, “energy” is explicitly and exhaustively confined to electricity and natural gas. Consequently, an “energy business” is statutorily limited solely to the electricity and natural gas industries. Because hydrogen is entirely excluded from these foundational definitions in Section 5, its production fails to be classified as a regulated energy activity. Therefore, it does not fall under the statutory jurisdiction of the ERC. This omission creates severe Regulatory Incoherence, leaving the expert regulator (ERC) statutorily sidelined and lacking the authority to implement or monitor the technical ‘Well-to-Gate’ standards required by the Ministry of Energy’s advancing hydrogen policy.

C. Industrial Product Standards Act, B.E. 2511 (1968): The “Product vs. Process” Ambiguity

A third constraint arises from legal ambiguity regarding the Thai Industrial Standards Institute (TISI). An analysis of the Industrial Product Standards Act, B.E. 2511 (1968) reveals that while Section 3 defines “standard” broadly to include methods of manufacture, the Institute’s de facto role has for decades focused on final product

safety rather than the complex, process-based verification required for ‘Well-to-Gate’ (WtG) assessments.

However, attempting to shoehorn clean hydrogen certification into this Act presents a profound legal certainty risk stemming from the fundamental jurisprudential distinction between a Product and a Process. Physically and chemically, a molecule of green hydrogen is indistinguishable from a molecule of grey (fossil-based) hydrogen. The ‘cleanliness’ is not a physical characteristic or quality of the product itself, but rather an invisible environmental attribute derived entirely from its lifecycle production process (e.g., its carbon footprint).

While Section 3 mentions methods of manufacture, the teleological intent of the Act (as evidenced by its 1968 legislative history) and decades of TISI’s de facto institutional practice have been strictly anchored in ensuring the physical safety, durability, and performance of final industrial goods for consumer protection and industrial promotion. This interpretation is not merely an administrative choice by the agency, but a reflection of the statutory purpose of the time, which did not contemplate global climate mitigation or lifecycle carbon accounting.

A crucial distinction must be made regarding the roles of other agencies. While the Department of Industrial Works (DIW), under the Factory Act, B.E. 2535, possesses the mandate to regulate pollution (e.g., waste, air, and water emissions), its jurisdiction is focused on point-of-source pollution control to prevent local environmental nuisances. Clean hydrogen certification, however, is not a matter of pollution control, but a matter of environmental status certification involving complex Well-to-Gate (WtG) accounting, such as tracking indirect methane leakage from upstream gas extraction, which falls outside the DIW’s source-based regulatory paradigm. Similarly, while the ERC regulates emissions from energy businesses, it remains statutorily sidelined due to the definitional barriers in Section 5 of the Energy Industry Act.

Consequently, treating hydrogen’s environmental footprint merely as a kind of industrial product creates a highly fragile legal foundation. Reliance on TISI alone creates a significant legal certainty risk, as an investor could plausibly challenge TISI’s authority in the Administrative Court, arguing that a lifecycle process standard, especially one involving upstream methane leakage, is *ultra vires* to the Act’s primary intent of product quality control.

D. Fuel Oils Control Act, B.E. 2542 (1999): The Mandate-Standard Mismatch

A final and crucial constraint is found in the Fuel Oils Control Act, B.E. 2542 (1999). Although the Ministry of Energy has recently issued the Notification of the Ministry of Energy Re: Prescribing Hydrogen and Ammonia as Fuel Oil under the Fuel Oils Control Act, B.E. 2542, B.E. 2568 (2025), this notification does not automatically empower the Department of Energy Business to function as a Clean Hydrogen Certification Body. The statutory purpose of the Act, as defined in Section 7, is focused primarily on the safety, storage, and transport of fuel oils to ensure public security. Utilizing this Act as a legal basis for green hydrogen certification would be problematic, as the Department lacks both the statutory mandate and the institutional expertise for greenhouse gas accounting. Consequently, any attempt by the Department to issue environmental certification rules under this Act could be legally vulnerable to challenges regarding administrative authority, as the certification of cleanliness for subsidies is distinct from the regulation of safety for fuel control.

4.5.3 Conclusion: The Path to Regulatory Coherence

This analysis in Section 4.5 confirms that the hybrid model, while an international best practice, is incompatible with Thailand's current legal and institutional framework. It faces (1) BOI's coherence gap, (2) the ERC's jurisdictional vacuum, and (3) TISI's legal certainty risk.

Therefore, implementing this system cannot be achieved by mere policy or ministerial announcements. It necessitates normative legal reform to create a coherent and stable legal foundation, which leads to the recommendations in Section 5.

5. Conclusion and Legal Recommendations

5.1 Concluding Remarks

The global push towards decarbonization has positioned clean hydrogen as a pivotal energy carrier, especially for hard-to-abate sectors. Thailand, with its challenging Net Zero (2050) targets, has recognized this potential, as seen in support measures like BOI incentives.

However, this research underscores a critical finding: a robust, legally defined, and operational clean hydrogen certification system is not merely an optional addition but an indispensable legal prerequisite for the success of any subsidy or support mechanism aimed at fostering a domestic clean hydrogen market. Without a clear

definition of the object of subsidy, incentives remain fundamentally inoperable, unable to reliably differentiate and reward hydrogen based on its environmental credentials.

Thailand's current legal gap, the absence of a national standard, definition, and verification system, creates significant uncertainty, hinders investment, and delays the sector's development. Therefore, accelerating the establishment of a national legal and regulatory framework for clean hydrogen certification is the most urgent priority to unlock investment, operationalize existing support schemes, and credibly advance Thailand's hydrogen ambitions. To address this urgency effectively, Thailand should adopt a "two-track" legislative strategy. In the short-term (Immediate Action), the government should issue interim measures, such as official interpretative guidelines from the BOI to provide temporary clarity on "clean" criteria. While this interim measure can provide immediate relief, they are inherently fragile. Therefore, in the long-term (Sustainable Reform), these short-term fixes must transition into a formal, *sui generis* national framework to provide the high degree of legal certainty and institutional stability required for massive, multi-decade capital mobilization.

5.2 Legal Reform Proposals

To address the legal and institutional gaps analyzed in Section 4.5, normative legal reform is necessary. The following legal reform proposal is designed to create a regulatory framework with legal certainty "and regulatory coherence."

5.2.1 Foundational Proposal: The Enactment of a *Sui Generis* Hydrogen Certification Act

The foundational legal reform proposal advocates for the enactment of a new, *sui generis* statute, such as a Hydrogen Certification Act, representing the most effective and legally clean pathway forward.

A critical question arises as to why Thailand should not simply amend existing statutes, such as adding a specific chapter to the Investment Promotion Act or the Energy Industry Act, to incorporate hydrogen certification. While amending existing laws might appear administratively simpler in the short term, it faces significant jurisprudential and institutional hurdles. Adding a certification mandate to the BOI's governing Act would create an inherent conflict of roles, as a promotion agency is not designed to function as a technical environmental auditor. Conversely, amending the Energy Industry Act to include hydrogen would require a fundamental and potentially

disruptive redefinition of “energy” under Section 5, which could have unintended legal consequences for the broader power and gas markets. Furthermore, hydrogen’s dual nature as both an energy carrier and an industrial feedstock means that any single-sector law (either energy or industry-focused) would inevitably leave jurisdictional blind spots. Therefore, the analysis concludes that a new, *sui generis* Act is the only mechanism capable of providing a unified legal anchor. It allows for the creation of a cross-sectoral National Certification Authority that bridges the mandates of the BOI, ERC, and TISI without violating the original legislative intent of their respective enabling acts.

Proposing new legislation in Thailand, however, requires robust justification under the principles of Section 77 of the Constitution of the Kingdom of Thailand (2017) and the Act on Legislative Drafting and Evaluation of Law, B.E. 2562 (2019) (the RIA Act). These constitutional and statutory frameworks dictate that the State should enact new laws only to the extent of strict necessity, and when existing legal mechanisms or alternative administrative measures are demonstrably insufficient. The legal and institutional compatibility analysis presented in Section 4.5 provides this exact justification. As demonstrated, attempting to implement a certification system through subordinate legislation or by stretching the interpretation of existing, ill-suited laws, such as the definitional barriers in the Energy Industry Act or the ultra vires risks under the Industrial Product Standards Act, creates insurmountable jurisdictional vacuums and legal fragility. Because these profound structural constraints cannot be cured by mere policy announcements or ministerial regulations, the enactment of a *sui generis* Act is not merely a policy preference, but a strict legal necessity that satisfies the Section 77 threshold. This legislative approach is paramount as it furnishes the highest degree of legal certainty, thereby circumventing the significant ambiguities that arise from attempting to stretch the interpretations of existing, ill-suited laws.

Specifically, the research concludes that the Fuel Oils Control Act, B.E. 2542 (1999) is an inadequate legal basis for this purpose. While the recent 2025 Ministerial Notification has officially classified hydrogen as a “fuel oil” under the jurisdiction of the Department of Energy Business, this authority is statutorily limited to regulating safety, storage, and transport for public security. The Department currently lacks the legislative mandate and institutional expertise for greenhouse gas lifecycle accounting. Attempting to utilize the Department as a certification body for clean or green status without a new, direct statutory mandate would create significant legal vulnerability, as the environmental certification of a production process for subsidy eligibility is fundamentally distinct from

the safety regulation of a physical fuel. Concurrently, it directly resolves the critical regulatory coherence problem by empowering a single, bespoke Act to codify essential legal definitions (e.g., “clean hydrogen,” “renewable hydrogen”), establish tiered GHG thresholds, define technical calculation boundaries (e.g., Well-to-Gate) and tracking methodologies (e.g., Mass Balance), and, most importantly, definitively designate a National Certification Authority, thereby resolving the current jurisdictional disputes among the ERC, TISI, and the Department of Energy Business.

This recommended *sui generis* approach aligns closely with the international best practices observed in the leading Regulatory Model 2 jurisdictions, including South Korea and Australia.

5.2.2 Framework Design: Adopting the Pragmatic South Korea-Australia Hybrid Model

The central policy recommendation is for the newly proposed Hydrogen Certification Act (the *sui generis* legislation advocated in Section 5.2.1) to adopt a hybrid model, synthesizing the pragmatic, tiered criteria of the South Korean system with the flexible legal certificate framework utilized by Australia. This hybrid approach is designed to strike a pragmatic equilibrium, drawing critical lessons from the implementation challenges observed in other key jurisdictions. It must eschew the prohibitive complexity of the EU RFNBO model, which academic and industry analyses highlight creates significant investment uncertainty and high development costs that hinder large-scale project implementation. Simultaneously, it must avoid the sub-optimal, Japanese model, which, by relying on an undefined single standard, presents a well-documented risk of carbon lock-in by potentially subsidizing fossil-fuel-based production. The proposed hybrid model therefore adopts the international convergence criteria exemplified by South Korea, specifically (a) technology-neutrality, (b) a Well-to-Gate calculation scope, and (c) 4 Tiers/Grades (e.g., 0-4.0 $\text{kgCO}_2\text{e/kgH}_2$). This robust criteria is then paired with the operationally flexible Australian unbundled certificates legal structure, which provides (a) a non-tradable Product Certificate (PGO) for supply chain transparency, and (b) a tradable Renewable Electricity Certificate (REGO) to grant producers flexibility in substantiating renewable electricity claims without imposing the EU’s highly restrictive additionality rules.

5.2.3 Phased Implementation

A phased implementation is recommended, with the initial phase (Phase 1) prioritizing the enforcement of ‘Well-to-Gate’ calculation boundaries. This phase should critically allow producers to claim renewable status by coupling grid electricity consumption with the retirement of tradable Renewable Electricity Guarantee of Origin (REGOs), mirroring the flexible Australian model. This approach deliberately eschews the imposition of the European Union’s more stringent and complex rules, such as temporal matching (hourly) and additionality (new plants). The rationale for this pragmatic regulatory design is that it significantly lowers barriers to market entry, thereby accelerating the mobilization of essential initial investment in the nascent sector.