Legal Frameworks for Green Hydrogen Subsidies: Comparative Lessons for Thailand's Energy Transition*

กรอบกฎหมายสำหรับการอุดหนุนไฮโดรเจนสีเขียว: บทเรียนเชิงเปรียบเทียบเพื่อการเปลี่ยนผ่านด้านพลังงานของประเทศไทย

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Received 15 November 2025; Revised 18 June 2026; Accepted 29 June 2026

Abstract

To achieve Thailand's net-zero emissions target, the deployment of green hydrogen is essential. However, its implementation is hindered by the significant green premium, a barrier driven by high operational expenditure (OPEX) rather than capital expenditure (CAPEX). This research article argues that Thailand's current legal framework, based on the Board of Investment (BOI)'s investment promotion measures, which focuses on the CAPEX incentive model, is structurally misaligned and incapable of solving this OPEX-driven problem. Therefore, a tax holiday on profit is valueless for an industry if a project cannot become profitable initially. The study applies a comprehensive comparative law analysis of subsidy models in the United States, the United Kingdom, Germany, and Japan to analyze the insufficiency of the BOI's measures and propose operable and bankable alternatives. It recommends that a new legal and financial framework for Thailand should be established with three integrated components: (1) a two-way Contract for Difference (CfD) for long-term risk diversification; (2) a GX Bond mechanism for debt financing, modeled after Japan and guaranteed by a future carbon tax; and (3) a Multi-Criteria Auction (MCA) to ensure project

* This article is developed from the research project entitled "Guideline for Legal Development to Support the Utilization of Hydrogen as a Fuel in Transportation Sector in Thailand," funded by the Science, Research and Innovation Promotion Fund under the Fiscal Year 2024 budget.

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readiness and effective procurement. This paradigm shifts from providing passive incentives to becoming an active state partner is essential for creating a bankable market.

Keywords: Green Hydrogen, Legal Framework, Green Premium, Contract for Difference, Subsidies

บทคัดย่อ

เพื่อให้บรรลุเป้าหมายการปล่อยก๊าซเรือนกระจกสุทธิเป็นศูนย์ของไทย การใช้ไฮโดรเจนสีเขียวจึงเป็นเรื่องที่จำเป็นอย่างยิ่ง อย่างไรก็ตาม การดำเนินการดังกล่าวกลับเผชิญอุปสรรคสำคัญจากส่วนต่างต้นทุนพลังงานสะอาด ซึ่งเป็นปัญหาที่เกิดจากค่าใช้จ่ายในการดำเนินงาน (OPEX) ไม่ใช่ค่าใช้จ่ายในการลงทุน (CAPEX) บทความวิจัยนี้ชี้ให้เห็นว่า กรอบทางกฎหมาย ปัจจุบันของไทย ผ่านมาตรการส่งเสริมการลงทุนของคณะกรรมการส่งเสริมการลงทุน (BOI) ซึ่งมุ่งเน้นการให้สิทธิประโยชน์ด้านค่าใช้จ่ายลงทุนนั้น ไม่สอดคล้องเชิงโครงสร้าง และไม่สามารถแก้ปัญหาต้นทุนในส่วนของค่าใช้จ่ายในการดำเนินงานได้ ดังนั้น การยกเว้นภาษีเงินได้จึงไร้ความหมายสำหรับอุตสาหกรรมที่โครงการไม่สามารถสร้างกำไรได้ ในระยะเริ่มแรก งานวิจัยนี้ใช้วิธีวิจัยเชิงกฎหมายเปรียบเทียบ เพื่อวิเคราะห์ต้นแบบการอุดหนุนใน สหรัฐอเมริกา สหราชอาณาจักร เยอรมนี และญี่ปุ่น เพื่อชี้ให้เห็นความไม่เพียงพอของมาตรการส่งเสริมการลงทุน และเสนอทางเลือกที่สามารถปฏิบัติได้จริงและเข้าถึงแหล่งทุนได้ โดยมีข้อเสนอแนะว่าควรมีการจัดตั้งกรอบทางกฎหมายและการเงิน สำหรับประเทศไทยที่ประกอบด้วย 3 เสาหลัก ได้แก่ (1) การใช้สัญญาซื้อขายส่วนต่าง (CfD) แบบสองทาง เพื่อ การกระจายความเสี่ยง ระยะยาว (2) กลไกการคลังแบบ GX Bond โดยมีต้นแบบมาจาก ประเทศญี่ปุ่น ซึ่งค้ำประกันด้วยรายได้จากภาษีคาร์บอนในอนาคต และ (3) การจัดสรรด้วยการประมูลแบบหลายหลักเกณฑ์ (MCA) เพื่อคัดกรองโครงการที่มีความพร้อมและสร้างประสิทธิภาพในการจัดซื้อจัดจ้าง การเปลี่ยนกระบวนทัศน์จากการเป็นผู้ให้สิทธิประโยชน์เชิงรับไปสู่การเป็นหุ้นส่วนเชิงรุกของรัฐ นี้ ถือเป็นสิ่งจำเป็นอย่างยิ่งในการสร้างตลาดที่สามารถเข้าถึงแหล่งทุนได้จริง

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1. Introduction

The global energy paradigm is in the midst of a profound structural transformation, driven by the dual imperatives of energy security and climate change mitigation.[1] As nations articulate pathways to net zero economies, green hydrogen, produced via electrolysis powered by renewable energy, has emerged as a fundamental technology, essential for decarbonizing hard-to-abate industrial sectors where direct electrification proves unviable.[2] The Kingdom of Thailand has explicitly embraced this transition, anchoring its national development strategy in the Bio-Circular-Green (BCG) economic model and integrating green hydrogen into its Draft National Energy Plan (NEP), specifically the National Power Development Plan (PDP2024).[3] This strategic integration serves as a cornerstone for Thailand to elevate its climate ambition under the third Nationally Determined Contribution (NDC 3.0), which emphasizes the role of green hydrogen in decarbonizing the energy and industrial sectors to meet the 2035 intermediate targets and the ultimate goal of Net Zero by 2050. This ambition, however, confronts a significant economic and legal challenge.

The transition from a fossil fuel-based energy system to this clean alternative is not a simple technological substitution as it involves overcoming a structural market failure embodied by the green premium.[4] This research paper argues that Thailand's primary legal mechanism for industrial promotion, the incentive framework of the Board of Investment (BOI), is structurally insufficient to offset this premium. The BOI's model, predicated on reducing capital expenditure (CAPEX) through tax incentives, is fundamentally misaligned with the nature of the green hydrogen cost barrier, which is dominated by operational expenditure (OPEX). This paper posits that an operable and legal framework for Thailand requires a new paradigm that incorporating OPEX-based subsidies. To design such a framework, this analysis conducts a comprehensive comparative legal analysis of the primary incentive models now competing globally by dissecting the Production Tax Credit (PTC) of the United States, the Contracts for Difference (CfD) models used in Germany and the United Kingdom, and the R&D-focused approach of Japan. By examining these contrasting legal frameworks, this paper

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[1] Xianyou Pan and others, 'The effects of government subsidies on the economic profits of hydrogen energy enterprises - An analysis based on A-share listed enterprises in China' (2023) 211 Renewable Energy 445, 445 <https://doi.org/10.1016/j.renene.2023.04.093> accessed 7 November 2025.

[2] Bijay B Pradhan and others, 'Role of green hydrogen in the decarbonization of the energy system in Thailand' (2024) 51 Energy Strategy Reviews 101311, 1 <https://doi.org/10.1016/j.esr.2024.101311> accessed 7 November 2025.

[3] ibid 2.

[4] John Chandler and John Paterson, 'Selling sunshine: Emerging challenges in the certification of hydrogen' (2025) 43(1) Journal of Energy & Natural Resources Law 47,48 <https://doi.org/10.1080/02646811.2024.2344363> accessed 7 November 2025.

develops a policy-adaptation and design recommendation formulated for Thailand's specific legal and economic context.

1.1 The Problem: The "Green Premium" as the Primary Barrier

The core challenge hindering the green hydrogen economy is a significant cost disparity. The hydrogen market is segmented by production pathway[5] resulting in a profound market failure where the most prevalent and cheapest production method (grey hydrogen) is also the most carbon-intensive, while the climate-aligned solution (green hydrogen) remains economically uncompetitive. This disparity is defined as the green premium, the significant cost gap separating green hydrogen from its incumbent, fossil-fuel-based competitor, grey hydrogen. [6]

Grey hydrogen remains the cheapest product, establishing a market baseline at $1.50–$2.50 per kilogram. Blue hydrogen presents a marginal cost increase at $2.00–$3.50/kg. Green hydrogen, by contrast, is currently estimated to cost between $3.50 and $6.00 per kilogram.[7] This 2-to-4-fold price gap renders it uncompetitive on a levelized cost basis.[8] Viability may only be achieved if a green premium of 4.55x is applied, a condition the free market will not support without intervention.[9]

A legal framework designed to close this gap must first correctly analyze its source. The Levelized Cost of Hydrogen (LCOH) is a function of both initial capital expenditure (CAPEX) and ongoing operational expenditure (OPEX).[10] CAPEX refers to the one-time costs to acquire or construct assets, such as the electrolyzer stack, balance-of-plant equipment, and

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[5] Hydrogen is categorized by its production method and carbon intensity. Grey hydrogen is produced from natural gas (methane) via steam methane reforming (SMR) without carbon capture. Blue hydrogen follows a similar process but incorporates carbon capture and storage (CCS) technology to reduce emissions. Green hydrogen is produced through water electrolysis powered exclusively by renewable energy sources, resulting in zero operational carbon emissions.

[6] Chandler and Paterson (n 4) 48.

[7] Ayatte I Atteya and others, 'A Comprehensive Review on The Potential of Green Hydrogen in Empowering the Low-Carbon Economy: Development Status, Ongoing Trends and Key Challenges' (2023) 2(1) Green Energy and Environmental Technology 1, 22–24 <https://doi.org/10.5772/geet.23> accessed 7 November 2025.

[8] Abhinav Jindal, Gireesh Shrimali and Nishant Tiwary, 'At scale adoption of Green Hydrogen in Indian Industry: Costs, subsidies and policies' (2024) 83 Energy for Sustainable Development 101549 https://doi.org/10.1016/j.esd.2024.101549 accessed 7 November 2025.

[9] Chandler and Paterson (n 4) 48.

[10] 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(2) Hydrogen 26, 6 <https://doi.org/10.3390/hydrogen6020026> accessed 7 November 2025.

construction.[11] OPEX, by contrast, represents the recurring, day-to-day costs, dominated by the cost of renewable electricity, but also including maintenance, water feedstock, and labor.[12]

While CAPEX, primarily the cost of the electrolyzer, is a significant component, techno-economic analyses unanimously identify OPEX as the dominant and decisive cost driver.[13] The LCOH of green hydrogen is markedly influenced by the Levelized Cost of Electricity (LCOE), as the renewable electricity feedstock constitutes a major part of the overall costs. Achieving cost parity would require renewable electricity costs below $20–$30/MWh, a price point not consistently available.[14] This defines the legal problem: the Green Premium is not an investment problem, it is an operational problem. A facility could, hypothetically, have its entire CAPEX subsidized to zero and still be unbankable if the operational cost of its electricity feedstock makes its final product uncompetitive. Any legal subsidy framework that fails to address the OPEX component is, by definition, an incomplete solution.[15]

1.2 The Thesis on Insufficiency of Thailand's CAPEX-Based Incentives

This paper's central thesis is that Thailand's existing legal framework for investment promotion, while historically effective, is structurally insufficient to catalyze a green hydrogen economy due to its exclusive focus on CAPEX incentives. Thailand's industrial policy is executed principally through the Board of Investment (BOI), whose legal mandate is to attract investment by de-risking capital outlay. Its primary legal tools are fundamentally CAPEX-oriented and comprise the following components.

1.2.1 Corporate Income Tax (CIT) Holidays providing exemptions from CIT for up to eight years.[16]

1.2.2 Import Duty Exemptions waiving tariffs on the import of machinery and equipment.[17]

This framework was effective for CAPEX-intensive industries like automotive, but it is misaligned with the green hydrogen challenge. As established, the Green Premium is an OPEX-driven problem; the BOI framework offers a CAPEX-driven solution. This creates a structural

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[11] 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 Technologies and Environmental Policy 2573, 2575 <https://doi.org/10.1007/s10098-024-02752-y> accessed 7 November 2025.

[12] Nayebossadri, Walsh and Smailes (n 10) 7.

[13] Atteya and others (n 7) 24.

[14] Nayebossadri, Walsh and Smailes (n 10) 32.

[15] Chandler and Paterson (n 4) 49.

[16] Announcement of the Board of Investment No. 8/2565 Re: Policies and Criteria for Investment Promotion (dated 8 December 2022).

[17] ibid.

misalignment: A Corporate Income Tax (CIT) holiday is a tax incentive on "profit". A green hydrogen project facing a two-to-four-fold cost disadvantage will not generate a profit, rendering the CIT holiday valueless. An import duty waiver reduces initial project cost but does nothing to solve the primary economic vulnerability: the high, recurring, daily cost of renewable electricity.

The BOI framework, therefore, fails to address the fundamental barrier to bankability. It reduces investment risk but cannot guarantee operational viability. This legal insufficiency necessitates an analysis of alternative frameworks, specifically the models of the United States, Germany, the United Kingdom, and Japan.

1. The United States: The Production Tax Credit (PTC) Model

The Inflation Reduction Act (IRA) of 2022 provides a direct, OPEX-based subsidy. Its Section 45V Clean Hydrogen Production Tax Credit pays qualified producers up to $3.00 per kilogram of clean hydrogen produced. This ten-year credit directly counteracts the production cost, guaranteeing revenue certainty.[18]

2. Germany: The Contracts for Difference (CfD) Double-Auction Model

Germany's H2Global initiative is a procurement-based OPEX subsidy. It employs a state-run intermediary to execute a double-auction. It signs 10-year purchase agreements with producers (lowest bid) and sells to domestic off-takers (highest bid). Public funds pay the difference.[19]

3. The United Kingdom: The CfD and Price Control Model

The UK employs a related OPEX-support strategy via its Contracts for Difference (CfD) policy. This framework de-risks new low-carbon hydrogen projects by establishing Price controls (cap and floor). This intervention guarantees a price for producers, subsidizing the operational cost differential.[20]

4. Japan: The Green Innovation Fund Model

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[18] Donna M Attanasio and Meghan Briggs, '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* (Cambridge University Press 2024) 31 <https://doi.org/10.1017/9781009459259.004> accessed 7 November 2025.

[19] Alexander Hoogsteyn and others, 'Interactions and Distortions of Different Support Policies for Green Hydrogen' (2025) 141 Energy Economics 108042, 6 <https://doi.org/10.1016/j.eneco.2024.108042> accessed 7 November 2025.

[20] ibid 5.

Japan's approach is centered on R&D support. The Green Innovation Fund provides financial support for R&D and implementation of green technologies. This appears to prioritize technology development (CAPEX/R&D) over direct, production-based (OPEX) subsidies.[21]

This comparative analysis reveals a clear divergence in legal strategy. The thesis that OPEX subsidies are superior is supported by emerging policy analysis. OPEX-based models like CfDs align more closely with market outcomes. Crucially, studies have found that production-based incentives (like a PTC) are significantly more effective in GHG emissions reduction than capital subsidies.[22] This paper proceeds from this thesis. Its novel contribution is a rigorous, comparative legal analysis of these divergent subsidy models, conducted specifically for the purpose of designing an operable legal framework for Thailand. The subsequent chapters will deconstruct the techno-economics of LCOH in the Thai context; provide a formal legal analysis of the BOI's limitations; execute the comparative analysis; and synthesize these findings to propose a novel, hybrid legal framework.

2. Research Methodology and Conceptual Framework

2.1 Research Design

This study adopts a qualitative research paradigm, employing the comparative law methodology to analyze and compare the design and legal and financial frameworks of subsidy models across jurisdictions. This method provides a neutral language to evaluate the underlying functions of distinct legal solutions to the green premium, thereby assessing the feasibility of legal adaptation for Thailand.

The research adopts a Socio-Legal Comparative Law approach, using a small-N comparative design with theoretically informed sampling. Cases were not selected as countries but as representations of subsidy archetypes: Thailand (Baseline CAPEX), the United States (Fixed Premium), the United Kingdom and Japan (Risk-Sharing), and Germany (Market-Maker).

The object of analysis is the legal and financial framework, defined as the integrated system of legal rules, institutional arrangements, and the necessary, sustainable funding source required for climate finance. The methodology proceeds in two steps: first, a qualitative mapping and deconstruction of each framework (legislation, instrument, funding), followed by a functional comparison of how each design addresses the core policy problem and distributes implementation responsibilities.

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[21] Wenting Cheng and Sora Lee, 'How Green Are the National Hydrogen Strategies?' (2022) 14 Sustainability 1930, 16 <https://doi.org/10.3390/su14031930> accessed 7 November 2025.

[22] Chandler and Paterson (n 4) 49.

2.2 Conceptualizing Green Hydrogen: From Market Failure to Legal Framework

To fully comprehend the necessity of a specialized regulatory regime, it is imperative to first conceptualize green hydrogen not merely as a technological innovation, but as a structural economic challenge that requires a specific legal response.

Green hydrogen, produced through water electrolysis powered by renewable energy, is technically proven but economically disadvantaged. Its deployment is primarily hindered by the green premium, the persistent cost differential between clean hydrogen and its cheaper, carbon-intensive counterparts (grey or fossil-based hydrogen). Unlike traditional renewable energy projects (e.g., solar or wind) where capital expenditure (CAPEX) is the primary hurdle, green hydrogen production incurs substantial and continuous operational expenditures (OPEX), largely driven by the cost of renewable electricity required for electrolysis.

This fundamental concept, the OPEX-driven green premium, necessitates a paradigm shift in legal design. Traditional passive legal instruments, such as the static tax holidays or import duty exemptions currently utilized in Thailand, are structurally inadequate to close this continuous operational gap. Therefore, the physical and economic reality of green hydrogen must be translated into an active legal framework, which relies on three interconnected components:

1. Price Certainty through Contractual Frameworks (CfD)

The economic need to hedge against volatile OPEX and unpredictable market prices translates legally into the necessity for long-term, binding public-private contracts. A two-way Contract for Difference (CfD) serves as the core legal instrument that legally allocates market risk between the state and the private sector by guaranteeing a strike price, thereby ensuring the project's bankability.

2. Efficient Allocation through Administrative Mechanisms (MCA)

Because state funds are limited, the legal framework must include a transparent administrative procedure to select the most efficient developers. Multi-Criteria Auctions (MCA) function as the regulatory mechanism to allocate subsidies based on both financial bids and technical/environmental criteria.

3. Sustainable Financing through Legal and financial Instruments

The massive fiscal commitment required to honor long-term CfD contracts cannot rely on annual discretionary budgets. Thus, the legal framework must be supported by statutory funding mechanisms, such as carbon pricing or specialized sovereign bonds (e.g., GX Bonds), firmly grounded in the polluter-pays principle.

By conceptualizing green hydrogen through this lens, it becomes evident that a robust legal framework must evolve beyond mere investment promotion and transition toward dynamic risk-allocation contracts. This conceptual foundation dictates the comparative analysis of the legal models implemented in the UK, the EU, and Japan in the subsequent sections.

3. Results

This comparative legal analysis scrutinizes the architectural design of international subsidy frameworks, with the objective of identifying an operable model for Thailand. The central challenge in stimulating green hydrogen production is not technological but economic involving overcoming the significant green premium between low-carbon hydrogen and its incumbent, high-carbon (fossil fuel-based) counterpart. An operable legal framework, therefore, must be specifically designed to close this specific economic gap.

This analysis first establishes Thailand's current incentive scheme as the baseline, proceeding to critique its structural inadequacies. It then deconstructs three distinct "Models" of operationally-focused (OPEX) subsidy frameworks implemented in leading jurisdictions comprising (1) Fixed Premium mechanisms, exemplified by the United States, (2) Contract for Difference (CfD) mechanisms, as deployed in Japan and the United Kingdom, and (3) Market-Maker mechanisms, pioneered by Germany.

3.1 The Insufficiency of CAPEX-Based Incentives as Thai Baseline

To design an effective new framework, one must first analyze the legal and economic insufficiency of the status quo. Thailand’s current de facto framework for promoting novel energy investments rests not on dedicated energy legislation, but on the general, tax-based incentives provided by the Thailand Board of Investment (BOI).[23] This analysis reveals the BOI framework to be structurally mismatched with the financial realities of the green hydrogen sector.

The primary legal instrument available to a potential green hydrogen producer in Thailand is the Investment Promotion Act, B.E. 2520 (1977), administered by the BOI. Given its high-technology and environmental focus, green hydrogen production would likely qualify for the highest category of incentives, such as those under the 'A1' classification. These incentives are designed to attract investment in strategic high-priority sectors.[24]

The legal and financial framework of the BOI A1 package is almost exclusively tax-based and front-loaded. The principal benefits include:

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[23] Bijay B Pradhan and others (n 2) 1.

[24] Thailand Board of Investment, *A Guide to Investment Promotion 2025* (2025) 33.

1. Corporate Income Tax (CIT) Exemption: A complete exemption from CIT for a period of eight years, without a cap on the total amount.

2. Further Tax Reduction: Following the expiration of the eight-year holiday, a potential 50% reduction in CIT for a subsequent period.

3. Import Duty Waivers: Exemption from import duties on machinery and raw materials.

4. Non-Tax Incentives: Ancillary benefits such as permits for foreign land ownership and streamlined processes for bringing in foreign expatriates and skilled technicians.[25]

The legal structure's purpose is clear and focused on reducing the upfront cost of establishing a project (via machinery import duty waivers) and to enhance the future profitability of a successful operation (via tax holidays).

3.2 Model 1: Fixed Premium Mechanisms (The US Model)

The first and most direct framework model of OPEX subsidies is the Fixed Premium, often termed a one-way subsidy. This model is most aggressively deployed by the United States through its Inflation Reduction Act (IRA), which leverages the federal tax code as a powerful, non-discretionary delivery mechanism.[26]

3.2.1 Legal Framework: The Inflation Reduction Act (IRA) Section 45V

The legal basis for the US model is the Inflation Reduction Act (IRA) of 2022 (NPC 2025). The specific instrument is the Section 45V of the Internal Revenue Code, which creates a new "Clean Hydrogen Production Tax Credit" (PTC).[27] The design of the Section 45V mechanism is defined by three key characteristics:

1. Fixed Premium

It provides a fixed, tiered subsidy payment per kilogram of hydrogen produced. The highest tier, for producers with the lowest lifecycle emissions, provides a credit of up to $3.00/kg.[28]

2. Technology-Neutral Standard

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[25] ibid 12–13.

[26] Laima Eicke, 'US Hydrogen Policy: Paving the Way for Energy Independence or Fueling the Geopolitical Competition of Subsidies?' in Rainer Quitzow and Yana Zabanova (eds), *The Geopolitics of Hydrogen Volume 2: Major Economies and Their Strategies* (Springer Nature Switzerland 2025) 88 <https://doi.org/10.1007/978-3-031-84022-7_4> accessed 7 November 2025.

[27] Attanasio and Briggs (n 18) 35.

[28] Eicke (n 26) 89.

The credit is not legally defined by production method (e.g., green or blue). Instead, it is technology-neutral and performance-based. Qualification for the different tiers, including the maximum $3.00/kg credit, depends on achieving a specified lifecycle greenhouse gas (GHG) emissions rate, measured in kilograms of CO_2-equivalent per kilogram of hydrogen ($kgCO_2e/kgH_2$).[29]

3. Tax-Based Delivery

The subsidy is delivered as a tax credit. This allows producers to claim the value of the credit against their federal tax liabilities. The IRA also introduced transferability and direct pay, allowing producers with little or no tax liability (like a new project) to effectively monetise the credit, either by selling it or receiving a direct cash refund from the Treasury.[30]

3.2.2 Mechanism and Risk Allocation: High Certainty, High State Risk

The Section 45V framework is a powerful yet inflexible legal mechanism. Its primary feature is its legal simplicity and non-discretionary nature, a structured for maximum deployment speed and investment certainty.[31]

Unlike a competitive auction, the Section 45V tax credit functions as a statutory entitlement. Any producer who can legally demonstrate compliance with the ex-ante GHG emissions criteria automatically qualifies for the credit. Developers need not win a competitive bid or negotiate a complex contract with a government agency , as they must simply build their production facilities and produce clean hydrogen in accordance with published regulations. This approach provides unparalleled investment certainty, removes administrative friction, and acts as a mass deployment strategy designed to catalyze projects at immense scale.[32]

This simplicity, however, comes at the cost of transferring all market risk from the private developer to the state (the US Treasury).[33] This risk is twofold:

1. Market Price Risk

The Section 45V is a one-way payment, not a two-way CfD. The $3.00/kg credit is paid regardless of the actual market price of hydrogen. If the market price for hydrogen were

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[29] ibid.

[30] Attanasio and Briggs (n 18) 37.

[31] Eicke (n 26) 88.

[32] ibid.

[33] Yana Zabanova and Rainer Quitzow, 'Hydrogen Policy in the EU: Navigating the Union's Internal Dynamics and Geopolitical Challenges' in Rainer Quitzow and Yana Zabanova (eds), *The Geopolitics of Hydrogen Volume 2: Major Economies and Their Strategies* (Springer Nature Switzerland 2025) 26 <https://doi.org/10.1007/978-3-031-84022-7_2> accessed 7 November 2025.

to rise significantly (e.g., due to a carbon tax or supply shortage) such that the producer is already profitable, the producer would receive the high market price plus the full $3.00/kg subsidy. This creates a significant risk of over-subsidization and provides windfall profits to producers at the state's expense.[34]

2. Volume Risk (Uncapped Fiscal Liability)

The total fiscal cost to the US Treasury is uncapped because the credit is a non-discretionary entitlement. The total subsidy amount is bound only by the total volume of qualified hydrogen produced in the country. There is no pre-defined budget, unlike the Japanese JPY 3 trillion cap or the German EUR 900 million pilot.[35]

In essence, the US Section 45V model is a high-certainty, high-risk framework. It prioritizes speed and scale above fiscal efficiency, rendering it a powerful but fiscally imprecise instrument.[36]

3.3 Model 2: Risk-Sharing Mechanisms (The Contract for Difference)

The second family of OPEX subsidies is the Contract for Difference (CfD). This model is structurally more sophisticated than the fixed premium, as it is explicitly designed as a risk-sharing instrument. It directly avoids the over-subsidization risk of the US model by establishing a long-term contractual partnership between the state and the producer.

3.3.1The two-Way Contract for Difference (CfD) as Conceptual Framework

A two-way CfD is a long-term private law contract between a producer and a state-backed counterparty. Its legal and financial mechanism is defined by two key, pre-agreed prices:

1. The Strike Price (or Base Price)

A fixed price per unit (e.g., $/kg) that represents the producer's total cost of production plus a reasonable rate of return. This price is what the producer needs to be profitable and is often "discovered" through a competitive auction.

2. The Reference Price

A fluctuating price that acts as a benchmark for the commodity's market value. This is typically based on the price of the incumbent fossil fuel (e.g., grey hydrogen, natural gas, or coal).[37]

The CfD mechanism operates as a two-way symmetrical payment flow:

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[34] Hoogsteyn and others (n 19) 5, 20.

[35] Eicke (n 26) 88.

[36] ibid.

[37] Hoogsteyn and others (n 19) 11.

- When Reference Price < Strike Price

The market price is too low for the producer to be profitable. The state pays the producer the difference, ensuring the producer always receives their required Strike Price.

- When Reference Price > Strike Price

The market price has risen above the producer's required price (e.g., due to a fossil fuel price spike). The producer pays back the difference (the windfall) to the state.

This legal framework achieves an optimal balance. It provides the producer with absolute revenue certainty (guaranteeing receipt of the Strike Price for the life of the contract), which renders the project bankable. Simultaneously, it provides the state with robust fiscal protection from over-subsidization, as it automatically recovers any windfall profits.[38]

3.3.2 Case Study 1: The Japanese Model (Debt-Financed, Future-Taxed)

Japan has adopted a highly innovative CfD model, establishing a sophisticated legal and financial framework to fund its transition.[39]

- **Legal Framework**

The framework is anchored in two key pieces of legislation as follow: (1) the GX (Green Transformation) Promotion Act and (2) the Hydrogen Society Promotion Act, enacted in May 2024.[40]

- **Contractual Design**

The Hydrogen Society Promotion Act empowers the government, via the Japan Organization for Metals and Energy Security (JOGMEC), to establish a CfD subsidy scheme. This scheme offers 15-year CfD contracts that function as two-way CfDs. JOGMEC will pay the difference between the producer's pre-agreed Base Price and the fluctuating Reference Price.[41]

- **Funding Framework**

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[38] ibid.

[39] 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 Nature Switzerland 2025) 113 <https://doi.org/10.1007/978-3-031-84022-7_5> accessed 7 November 2025.

[40] 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) 75 <https://doi.org/10.64060/978-627-7898-00-7-3> accessed 7 November 2025.

[41] Osaki and Hughes (n 39) 113.

The most innovative aspect of the Japanese model is its funding. It employs a finance-and-defer model that legally separates the act of spending from the act of taxing.

1. Upfront Funding (Today)

The GX Promotion Act authorizes the issuance of JPY 20 trillion (approx. $130 billion) in "GX Economic Transition Bonds. This is debt-financing. From this total, JPY 3 trillion (approx. $20 billion) is allocated to fund the hydrogen CfD program for 15 years. This allows the government to immediately fund the long-term contracts and catalyze the market without raising taxes today.[42]

2. Repayment (Tomorrow)

The legal framework already provides for the repayment of this debt. The GX bonds will be redeemed in the future using revenue from a new, legally mandated fossil fuel levy. This new carbon tax is scheduled to be introduced in FY2028[43] and will be levied on fossil fuel importers.[44]

This legal and financial structure is politically astute. It provides massive, immediate, and long-term support to producers, while deferring the politically sensitive act of imposing a carbon tax until the transition is more advanced and its benefits are more visible.

3.3.3 Case Study 2: The UK Model (Levy-Financed, 'Polluter Pays')

The United Kingdom has also selected the two-way CfD as its preferred instrument, though its legal and funding framework provides a stark and informative contrast to Japan's model.

- **Legal Framework**

The primary enabling legislation is the Energy Act 2023.[45] This Act provides the Secretary of State with the statutory power to create and fund the hydrogen subsidy mechanism.[46]

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[42] ibid.

[43] FY2028 refers to the Japanese Fiscal Year 2028, which commences on April 1, 2028, and concludes on March 31, 2029.

[44] Cheng and Lee (n 21) 1930.

[45] 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* (SCOPUA Books 2025) 99 <https://doi.org/10.64060/978-627-7898-00-7-4> accessed 7 November 2025.

[46] Energy Act 2023, Part 2 (Decarbonisation), c. 52 (UK).

- **Contractual Design**

The subsidy is delivered through the Hydrogen Production Business Model (HPBM). The specific contract awarded to successful producers is the Low Carbon Hydrogen Agreement (LCHA). The LCHA is a 15-year, two-way CfD, legally analogous to the contracts that successfully scaled the UK's offshore wind industry.[47]

- **Allocation Mechanism**

Unlike the US Section 45V (an entitlement), LCHA contracts are not automatic. They are awarded competitively through periodic auctions known as Hydrogen Allocation Rounds (HAR). The HAR process functions as a critical price discovery mechanism, compelling producers to compete against each other by bidding the lowest possible Strike Price they are willing to accept to win the 15-year contract. This ensures a far more efficient use of public funds than the US fixed-premium model, as the subsidy is set by the market, not by statute.[48]

- **Funding Framework**

The UK's funding design is a contemporaneous polluter pays model, legally distinct from Japan's debt-based approach.

1.The Energy Act 2023 provides the legal basis for a hydrogen levy.

2. This levy is legally structured as a "Gas Shipper Obligation (GSO)".

3. This is a hypothecated (earmarked) levy placed directly on the companies that ship natural gas through the national grid (the incumbent fossil fuel industry).

4. The revenue collected from this GSO levy is then used to pay for the LCHA contracts.[49]

This framework socializes the cost of the green hydrogen transition contemporaneously across the users of the polluting fuel it is intended to replace. Unlike Japan, there is no debt-financing or deferral, as the cost is (in theory) paid as it is incurred, directly linking the new green industry to the legacy brown one.

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[47] Silvia Weko, 'The UK Hydrogen Strategy: Industrial Decarbonization and Industrial Policy' in Rainer Quitzow and Yana Zabanova (eds), *The Geopolitics of Hydrogen Volume 2: Major Economies and Their Strategies* (Springer 2025) 135 <https://doi.org/10.1007/978-3-031-84022-7_6> accessed 7 November 2025.

[48] Rainer Quitzow and Yana Zabanova, 'The Emerging Geopolitics of Hydrogen: Navigating Uncertainty and Industrial Legacies Within the Net-Zero Transition' in Rainer Quitzow and Yana Zabanova (eds), *The Geopolitics of Hydrogen Volume 2: Major Economies and Their Strategies* (Springer 2025) 210 <https://doi.org/10.1007/978-3-031-84022-7_9> accessed 7 November 2025.

[49] Weko (n 47) 129, 134.

3.4 Model 3: The Market-Maker Mechanism (Germany's H2Global)

The final and most architecturally complex model is the Market-Maker, pioneered by Germany. This mechanism, known as H2Global, positions the state beyond the role of a simple subsidizer (US) or a risk-sharing counterparty (UK/Japan) and into the role of a central market intermediary.

3.4.1 Legal Framework: The Double Auction Intermediary

The H2Global model does not create a direct contract between the producer and the state. Instead, the state uses federal funds (e.g., an initial EUR 900 million pilot fund from the Federal Ministry for Economic Affairs and Climate Action) to capitalise a special-purpose intermediary, a private company named Hydrogen Intermediary Company (HINTCO).[50]

HINTCO then operates as a market maker, using a double auction mechanism governed by public procurement law. This mechanism is designed to deliberately absorb risk by splitting the market into two distinct auctions with different time horizons.[51]

3.4.2 Mechanism: De-Risking Supply, Creating Demand

The "Double Auction" separates the purchase and sale of hydrogen into two distinct sides:

1. Purchase-Side (Creating Bankability)

HINTCO runs a global auction to buy hydrogen and its derivatives (like ammonia and e-methanol). It awards long-term, 10-year Hydrogen Purchase Agreements (HPAs) to the international producers who bid the lowest price. This 10-year contract provides the long-term, stable revenue certainty that producers need to secure project financing and get built.[52]

2. Sales-Side (Creating a Spot Market)

HINTCO then takes the hydrogen and it has contracted to buy and runs a separate, independent auction to sell it to European offtakers (in chemical, steel, or energy sectors). It awards short-term, 1-year Hydrogen Sales Agreements (HSAs) to the buyers who bid the highest price.[53]

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[50] Yana Zabanova and Rainer Quitzow, 'Hydrogen Policy in the EU: Navigating the Union's Internal Dynamics and Geopolitical Challenges' in Rainer Quitzow and Yana Zabanova (eds), *The Geopolitics of Hydrogen Volume 2: Major Economies and Their Strategies* (Springer 2025) 27 <https://doi.org/10.1007/978-3-031-84022-7_2> accessed 7 November 2025.

[51] ibid.

[52] ibid 27–28.

[53] ibid 29.

The state subsidy (the EUR 900 million fund) is used to cover the negative spread, the inevitable and intentional loss HINTCO incurs by buying at a high, long-term, bankable price and selling at a low, short-term, market-clearing price.[54]

3.4.3 Analysis: The State as Strategic Risk-Absorber

The H2Global framework is a uniquely strategic instrument that simultaneously solves two distinct market failures, one on the supply side and one on the demand side.

1. The state, acting through HINTCO, absorbs two critical risks that would otherwise prevent the market from forming:

- **Price Risk**

It absorbs the entire spread between the high cost of first-of-a-kind production and the low price the nascent market is willing to pay.

- **Temporal Risk**

It reconciles the fundamental mismatch between producer needs (long-term, 10-year revenue certainty) and buyer needs (short-term, 1-year flexibility to avoid being locked into a high-price fuel).

2. This model serves a dual purpose that other models only address in part. The 10-year HPA provides producer bankability, just as the UK and Japan CfDs do, but the 1-year HSA achieves something more profound, i.e., true market price discovery. The UK and Japan CfD models often use fossil fuel benchmarks (like natural gas) as their reference price. This tethers the green hydrogen market to the economics of the old energy system.

H2Global, by contrast, creates a new, independent, and liquid market for green hydrogen. Its short-term auctions discover the true market-clearing price that European industry is actually willing to pay for the green commodity itself. This is the most interventionist of the three models, but it is also the one most strategically designed to create a liquid, self-sustaining, and independent market for green hydrogen.

4. Conclusion and Recommendations

4.1 Conclusion

The analysis concludes that Thailand's aim to develop a green hydrogen economy is obstructed by the green premium, a fundamental market failure that its current legal and financial instrument is structurally incapable of solving. The paper mandates a paradigm shift in Thai legal design, i.e., moving from the passive, *ex-ante* CAPEX incentives of the Board of

[54] ibid 27.

Investment (BOI) to active, *ex-post* operational expenditure (OPEX) support, delivered through a long-term and bankable contractual framework.

The core problem is a persistent operational cost barrier, as the LCOH for green hydrogen ($3.50–$6.00/kg) remains uncompetitive against grey hydrogen ($1.50–$2.50/kg). This premium is dominated by OPEX, particularly the cost of renewable electricity. The paper's central finding is the structural misalignment of the BOI framework. The BOI, a CAPEX-driven solution offering CIT holidays and import duty waivers, is misaligned with the OPEX-driven problem. The BOI's principal incentive, the CIT holiday, is valueless for a pre-profit industry. A project that cannot compete on operational expenditures will generate no profit, rendering a tax exemption on that profit worthless. As established, a facility could have its CAPEX subsidized to zero and *still* be unbankable.

Therefore, an operable framework is defined as a bankable one. An inoperable framework is one that fails to provide the long-term, predictable revenue certainty required to attract non-recourse project finance.

To address this challenge, this paper outlines an operable and bankable legal and financial framework built on three integrated components:

1. The Instrument: A 15-year, two-way Low Carbon Hydrogen Agreement (CfD) for risk-sharing and revenue certainty.

2. The Funding: A GX Bond model (based on Japan's) for long-term, bankable capital, repaid by a future, hypothecated carbon levy.

3. The Allocation: A Multi-Criteria Auction (MCA) that balances price discovery with risk-mitigating non-price criteria like project readiness.

By shifting legally from a passive incentive to an active contractual partner, Thailand can transcend the green premium and construct the market conditions which is necessary to become a regional leader in the green hydrogen economy.

4.2 Recommendation

4.2.1 A two-way Contract for Difference (CfD) as the Core Legal Instrument

The first recommendation is the adoption of a two-way Contract for Difference (CfD) as the core legal instrument for delivering OPEX support. This mechanism is demonstrably superior, offering the balanced risk allocation essential for both bankability and long-term fiscal responsibility.

The paper recommends Thailand reject the fixed premium model, such as the US IRA Section 45V PTC. The 45V is an inflexible legal mechanism, a one-way payment that

allocates 100% of market price risk to the state. This creates an unacceptable risk of over-subsidization and windfall profits.

By contrast, the two-way CfD is architecturally sophisticated and fiscally prudent; it is a long-term risk management and risk-sharing tool. Its legal mechanism is a private-law contract defined by two pre-agreed price points:

- The Strike Price: A price ($/kg) "discovered" via competitive auction, representing the producer's cost plus a bankable rate of return.
- The Reference Price: A fluctuating market benchmark, such as the price of grey hydrogen or a natural gas index.

Its mechanism is a symmetrical, two-sided hedging payment flow:

- When Reference Price < Strike Price

The market price is too low. The state pays the producer the difference, guaranteeing the revenue stream and ensuring bankability.

- When **Reference Price > Strike Price**

The market price is high. The producer pays the "windfall" difference *back* to the state, protecting consumers and eliminating over-subsidization.

This risk allocation is the precise solution to the operability problem. Project financiers require long-term contracts to secure investments. The two-way CfD creates this contractual hedge, providing a stable, 15-year revenue stream often necessary for renewables financing. By de-risking revenue, the CfD directly lowers the cost of capital, potentially by as much as 30 percent.

Thailand should execute a legal adaptation by adapting proven models. This includes:

1. The UK Model (The Contract)

The UK's Energy Act 2023 authorizes the Hydrogen Production Business Model (HPBM), delivered via a 15-year, bankable, two-way CfD contract called the "Low Carbon Hydrogen Agreement (LCHA)".

2. The Japanese Model (The Enabling Law)

Japan's "Hydrogen Society Promotion Act" (May 2024) creates the "legal foundation" for a 15-year CfD-type subsidy scheme.

It is recommended that Thai Parliament enact the Hydrogen Promotion Act, similar to Japanese model, which empowers a state agency to enter into 15-year, two-way CfD contracts called the Thailand's Low Carbon Hydrogen Agreement (LCHA).

4.2.2 A Sustainable and Legally Enshrined Funding Mechanism

A CfD is inoperable without a corresponding, sufficient funding legal mechanism. A 15-year CfD is a long-term fiscal commitment. Financiers will not fund projects if the state's ability to pay is subject to annual and discretionary political budgeting. The funding source must be sustainable, long-term, and legally enshrined, particularly hypothecated carbon levy.

- **Comparative Model 1: The Japanese Pay Later (Debt-Financed) Model**

Japan's GX Promotion Bill authorizes an advance investment support mechanism. It legally separates spending from revenue-raising.

  - **Funding (Today)**: The government issues JPY 20 trillion in GX Economic Transition Bonds, allocating JPY 3 trillion to fund the hydrogen CfD program for 15 years.
  - **Repayment (Tomorrow)**: The law already mandates repayment via a future fossil fuel levy on importers (starting FY2028) and revenues from an emissions trading system. This finance-and-defer model is politically astute, providing immediate, bankable certainty while deferring the tax.

- **Comparative Model 2: The UK Pay Now (Levy-Financed) Model**

The UK's Energy Act 2023 authorizes a hydrogen levy, structured as a Gas Shipper Obligation (GSO). This is a direct, contemporaneous levy on gas shipping companies, with revenues hypothecated to fund the LCHA payments.

- **A Proposed Funding Path for Thailand**

This paper recommends Thailand consider the Japanese GX Bond model, based on political and economic pragmatism. The Japanese model is superior for an emerging market by providing immediate, large-scale, bankable funding via bonds, legally enshrining the future repayment mechanism through a carbon levy to satisfy financiers, and deferring the tax to allow the industry to build value first.

4.2.3 The Criticality of Auction Design: Beyond Price-Only

The final recommendation addresses the CfD allocation mechanism, which is as important as the contract itself. While competitive auctions are essential for true price discovery, a simple price-only auction presents a major challenge. A race to the bottom encourages aggressive, unsustainably low bid prices (underbidding), resulting in low post-auction realization rates and project failure. The goal is effective procurement, not just a low price. The risk of a failed auction is the single greatest risk.

This paper therefore recommends rejecting a price-only auction in favor of a Multi-Criteria Auction (MCA). An MCA selects winners based on both bid price and legally-

defined, objective non-price criteria (NPCs). The purpose of the MCA is risk management. The risk of underbidding and project failure is a far greater cost than a marginal price increase from a well-designed MCA. The legal framework should use a weighted scoring system (e.g., 70% price, 30% NPCs).

Key NPCs must be objective, transparent, and verifiable, focusing on two clusters as follows:

1. Cluster 1: Project Deliverability (The "Readiness" Criterion)

This is the most critical NPC for ensuring "effective procurement". Following the EU's Net-Zero Industry Act (NZIA), bids should be scored on:

- Quality of project pre-development (permits, EIAs, grid agreements).
- Financial Prequalification.
- Offtake Certainty (verifiable MOUs or LOIs).

2. Cluster 2: System Quality (The "Efficiency" Criterion)

This ensures the state subsidizes high-quality, efficient technology. Verifiable criteria include:

- Energy efficiency (kWh/kg) of the electrolyzer.
- Full lifecycle carbon footprint ($kgCO_2e$ / kgH_2).
- Technological innovation.
- Socio-Economic Contribution (e.g., alignment with BCG model).

4.2.4 The Legal Instrument and Regulatory Oversight

To implement the proposed legal framework, a critical question arises regarding the appropriate legal instrument: whether to amend existing Board of Investment (BOI) announcements or to enact a dedicated Hydrogen Promotion Act. While the BOI possesses the flexibility to issue new categories for investment promotion, its legal mandate is primarily restricted to passive incentives. However, the operational expenditure (OPEX) challenges of green hydrogen require an active contractual partner capable of managing long-term fiscal outlays through Contracts for Difference (CfD). These functions exceed the traditional administrative scope of the BOI. Therefore, a dedicated Hydrogen Promotion Act is recommended to provide a robust legal basis for the state to enter into long-term private-law contracts and to authorize the cross-sectoral funding mechanisms that the current BOI framework cannot facilitate.

Furthermore, the regulatory oversight should be centralized under the Energy Regulatory Commission (ERC). As an independent regulatory body, the ERC is best positioned to act as the administrator for MCA auctions and the CfD registry. This centralized institutional arrangement will ensure the transparency required to attract international investment.