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Compliance-Driven Dependence EU RFNBO Certification in Green Hydrogen Supply Chains

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- formatting footnotes and reference entries, including legal citations to EU legislation and its article references, and maintaining the reference library;
- translating source documents and quotations from Spanish (Chile and Uruguay) and Portuguese (Brazil), which I checked against the originals;
- cross-checking my own derived figures and arithmetic;
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The substance of the thesis is my own. The research design, the primary-source work – the interviews, freedom-of-information requests and the environmental and regulatory filings analysed here – the argument, the analysis and the conclusions were developed by me. The tool did not conduct the research, choose the evidence or determine the findings. I have reviewed all material it helped produce and take full responsibility for the final text, including any errors.

JACOB SOWTER

21 JULY 2026

To Mum and Dad,

Thank you for everything.

Abstract

The European Union certifies green hydrogen for its market through the Renewable Fuels of Non-Biological Origin (RFNBO) rules, which impose detailed electricity and carbon criteria on producers wherever they operate. This thesis asks how those rules shape hydrogen projects beyond the Union's borders, and what they do to the industrial prospects of the states that host them. It takes Chile, an early exporter, as its case, and process-traces HIF Global's Haru Oni plant in Magallanes – the first extra-EU site to gain full RFNBO certification – from before the rules were adopted, through certification, to the start of operations. Two comparators discipline the account: Brazil, whose national strategy shows another path was open, and a same-developer project in Uruguay. The evidence is documentary first, drawing on the legal corpus, certification records, and environmental filings, with interviews interpreting rather than carrying it.

The thesis reaches three findings. First, certification works through two axes, electricity and carbon, and operates anticipatorily, fixing a project's design before any product is sold. Second, the rules amplify demand for hardware – electrolysers, turbines, and balance-of-plant – that global manufacturing concentration, not the rules themselves, ultimately sources from China. Third, Chile governs neither the criteria its flagship sector is built against, nor the supply chain it builds with. The result is a compliance-driven dependence that neither the certificate nor current policy makes visible.

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Abbreviations

AAP – Autorización Ambiental Previa (Uruguay) {Prior Environmental Authorisation}

ALUR – Alcoholes del Uruguay S.A. (Uruguay) {Alcohols of Uruguay}

ANCAP – Administración Nacional de Combustibles, Alcohol y Pórtland (Uruguay) {National Administration of Fuels, Alcohol and Portland Cement}

BMWi – Bundesministerium für Wirtschaft und Energie (Germany) {Federal Ministry for Economic Affairs and Energy}

BNDES – Banco Nacional de Desenvolvimento Econômico e Social (Brazil) {National Bank for Economic and Social Development}

CDR – Commission Delegated Regulation (EU)

CertHiLAC – Clean Hydrogen Certification System for Latin America and the Caribbean

CORFO – Corporación de Fomento de la Producción (Chile) {Production Development Corporation}

CRMA – Critical Raw Materials Act (Regulation (EU) 2024/1252)

DAC – Direct air capture

DG ENER / DG CLIMA – Directorate-General for Energy / for Climate Action, European Commission

DINACEA – Dirección Nacional de Calidad y Evaluación Ambiental (Uruguay) {National Directorate for Environmental Quality and Assessment}

ECA – European Court of Auditors

EDF – Électricité de France (France) {Electricity of France}

EIA – Estudio de Impacto Ambiental (Chile, Uruguay) {Environmental Impact Study}

EIB – European Investment Bank

EPE – Empresa de Pesquisa Energética (Brazil) {Energy Research Office}

ETS – Emissions trading system

EUDR – EU Deforestation Regulation (Regulation (EU) 2023/1115)

FID – Final investment decision

GDPR – General Data Protection Regulation (Regulation (EU) 2016/679)

GHG – Greenhouse gas

HIF – Highly Innovative Fuels (project developer)

HNH – HNH Energy (green-ammonia project, Magallanes)

ICCT – International Council on Clean Transportation

ICSARA – Informe Consolidado de Solicitud de Aclaraciones, Rectificaciones y/o Ampliaciones (Chile) {Consolidated Report on Requests for Clarification, Rectification and/or Expansion}

IEA – International Energy Agency

IF23 / IF24 / IF25 – European Hydrogen Bank auction rounds under the Innovation Fund, 2023, 2024 and 2025

ILUC – Indirect land-use change

IR – Implementing Regulation (EU)

IRENA – International Renewable Energy Agency

ISCC – International Sustainability and Carbon Certification

ISPI – Istituto per gli Studi di Politica Internazionale (Italy) {Institute for International Political Studies}

ITA – Interim Trade Agreement (EU–Chile)

JRC – Joint Research Centre (European Commission)

KfW – Kreditanstalt für Wiederaufbau (Germany) {Reconstruction Credit Institute}

LHV – Lower heating value

LNG – Liquefied natural gas

MIEM – Ministerio de Industria, Energía y Minería (Uruguay) {Ministry of Industry, Energy and Mining}

NZIA – Net-Zero Industry Act (Regulation (EU) 2024/1735)

PEM – Proton exchange membrane (electrolyser)

PHBC – Programa de Desenvolvimento do Hidrogênio de Baixo Carbono (Brazil) {Low-Carbon Hydrogen Development Programme}

PPA – Power purchase agreement

PV – Photovoltaic

RCA – Resolución de Calificación Ambiental (Chile) {Environmental Qualification Resolution}

REACH – Registration, Evaluation, Authorisation and Restriction of Chemicals (Regulation (EC) No 1907/2006)

RED / RED II / RED III – Renewable Energy Directive (Directives 2009/28/EC, (EU) 2018/2001 and (EU) 2023/2413)

RFNBO – Renewable fuel of non-biological origin

SBCH2 – Sistema Brasileiro de Certificação do Hidrogênio (Brazil) {Brazilian Hydrogen Certification System}

SEA – Servicio de Evaluación Ambiental (Chile) {Environmental Assessment Service}

SEIA – Sistema de Evaluación de Impacto Ambiental (Chile) {Environmental Impact Assessment System}

TBT – Agreement on Technical Barriers to Trade (WTO)

TSO – Transmission system operator

VAL – Viabilidad Ambiental de Localización (Uruguay) {Environmental Viability of Location}

WTO – World Trade Organisation

Chapter 1 – Introduction

Renewable Fuels of Non-Biological Origin (RFNBOs) are defined by the European Union as "liquid and gaseous fuels the energy content of which is derived from renewable sources other than biomass."[1] In practice they are hydrogen made by electrolysis, used directly or as e-fuels and ammonia in hard-to-electrify sectors.[2]

In May 2022, REPowerEU, the Union's response to Russia's invasion of Ukraine, included a renewable hydrogen import objective of 10 Mt (million tonnes) by 2030.[3] In November 2023, the EU's third Renewable Energy Directive, Directive 2023/2413 (RED III), entered into force, introducing binding targets for RFNBOs and thus creating the EU demand-side architecture.[4]

On the supply side, the Commission adopted two delegated regulations in February 2023 to set the terms by which green hydrogen can be considered an RFNBO. Commission Delegated Regulation 2023/1184 set the criteria for electricity used to produce green hydrogen, while Commission Delegated Regulation 2023/1185 set the greenhouse-gas methodology and the eligibility of carbon inputs in hydrogen-derived fuels.[5]

The thesis examines the effects of these rules on projects in third countries producing green hydrogen and hydrogen-derived fuels for export to the EU. HIF Global's Haru Oni plant in Chilean Patagonia is the first facility outside the EU to achieve RFNBO certification and thus provides the case study.[6]

Three sub-questions structure the analysis. First, through which operational mechanisms does RFNBO legislation affect project design and sequencing? This questions runs along two axes: electricity (additionality and temporal-geographic correlation) and carbon (CO2 eligibility and the greenhouse-gas threshold). Second,

[1] Directive (EU) 2018/2001, Article 2, point (36), as amended by Directive (EU) 2023/2413, Article 1(1)(g)
[2] Please see Annex A for a primer on green hydrogen, its derivatives, the reasons for certification and its limits.
[3] COM(2022) 230 final (REPowerEU Plan)
[4] Directive (EU) 2023/2413 (RED III)
[5] Commission Delegated Regulation (EU) 2023/1184; Commission Delegated Regulation (EU) 2023/1185
[6] (HIF Global, 2025a)

how do EU rules affect Chile's ability to shape its own hydrogen policy? Third, to what extent does this legislation deepen supply-chain dependence on China?

The thesis weighs the RFNBO framework against cost, finance, and demand as competing explanations for the observed outcome.

The criteria apply identically to production inside and outside the Union.[7] Producers in third countries selling into the Single Market must therefore meet EU standards, despite no international agreement obliging them to; the EU exercises its market power through territorial extension.[8] Chile's opportunity to develop its green hydrogen industry is thus shaped by rules it did not write. Because the RFNBO regime does not specify equipment origin, it may amplify reliance on Chinese suppliers within third-country projects.

The thesis proceeds in seven chapters. Chapter 2 sets out the methodology, namely the hypotheses, case selection, data, and limitations. Chapter 3 reviews three bodies of literature that anchor the thesis' analytical framework. Chapter 4 establishes the regulatory framework and the state of the market it regulates. Chapter 5 presents the case analysis, examining Haru Oni as a process-traced study, alongside counterfactual and comparative case studies. Chapter 6 analyses equipment origin – the demand the rules generate, the supply chains required to meet it, and a comparison with the EU's domestic efforts to ensure diversification – and closes with the attribution assessment. Chapter 7 concludes, drawing out theoretical implications and briefly setting out policy directions.[9]

[7] Delegated Regulation (EU) 2023/1184, Art 9
[8] (Damro, 2012; Scott, 2014)
[9] Full policy recommendations are reserved for the addendum, to be provided at a later date.

Chapter 2 – Methodology

2.1 Research Design

The thesis makes a causal claim: the EU's RFNBO rules shape what gets built in Chile, how it is built, and how much hardware a project must buy. Without them, project designs, volumes, and outcomes would differ. Equipment origin and domestic capability sit outside the legislation's reach, and the claim does not extend to them. The claim is tested by process tracing. This method is apt because the legal architecture leaves a chain of documents: legal texts, scheme rulebooks and certificates, environmental filings, and corporate disclosures. Each link can be tested against the prediction, following Beach and Pedersen's theory-testing variant and weighing each piece of evidence with Collier's tests.[10] Since the governing instrument is itself a paper trail, the chain can be examined step by step, not inferred from correlation.

HIF Global's Haru Oni is the first extra-EU RFNBO site to receive full EU certification, and the only one publicly recorded as of July 2026.[11] Chile therefore provides the case, and the project is process-traced from before the rules' adoption through certification to the start of operations. Three contrasts then test the hypotheses, one internal and two external.

Internally, Haru Oni is contrasted with the full-scale projects that followed it, testing whether grandfathering affected what was built and bought. The contrast can disconfirm the thesis, since identical procurement under shelter and under cost pressure would count against the mechanism.

The two external contrasts each isolate a variable. Brazil faced the same EU rules, but where Chile aligned with the EU's standard, Brazil created its own national standard – isolating the domestic-policy variable. Uruguay keeps the developer fixed, with HIF operating there under a different carbon geography, isolating the carbon variable (both developed at §2.3). The guiding question throughout is whether each outcome would be

[10] (Beach & Pedersen, 2019; Collier, 2011)
[11] (HIF Global, 2025b; TÜV SÜD Industrie Service GmbH, 2026)

different if EU demand existed but the RFNBO rules did not. Outcome by outcome, the rules may emerge as causal for one and irrelevant to another.[12]

2.2 Research Questions and Hypotheses

The thesis asks how the EU's production rules affect a third country selling into the Single Market, and splits that question three ways (RQ1-RQ3 below). Four hypotheses serve three questions because the rules have two axes: the electricity criteria (H1) and the carbon criteria (H2) sit in separate delegated acts, and the case returns a different verdict on each. H3 and H4 both concern agency, over the rules in H3 and over the supply chain in H4 (Exhibit 2, Panel A).

RQ1 – Through which mechanisms do the rules affect project design and sequencing?

H1 (electricity axis) predicts that additionality, and temporal and geographical correlation requirements push developers to oversize renewable generation, add battery storage, and adopt off-grid, dispersed configurations. If true, it is observable in the ratio of generation to electrolyser capacity, in the presence and sizing of storage, and in filed engineering decisions. Conversely, lean designs drawing on the grid would count against H1.

H2 (carbon axis) predicts that CO_2 eligibility rules, interacting with domestic resource geography, shape site selection, carbon sourcing, and final investment decisions (FIDs). It is observable in sourcing strategies – biogenic where co-located feedstock exists, direct air capture (DAC) technology where it is not – and in the same developer's divergent sourcing across Chile and Uruguay. If sourcing shows no geographic pattern, H2 fails.

The two axes are expected to differ in impact. At remote Chilean sites the carbon rules should bind harder than the electricity rules, because off-grid projects build dedicated generation and additionality barely applies (Annex B); §5.7 returns the verdict.

RQ2 – Does Chile get to shape the rules its own hydrogen sector is built on?

[12] (Bennett & Checkel, 2015)

Since Chile's room for manoeuvre cannot be measured directly, H3 is tested against the policies Chile adopts. H3 (policy window) holds that the power to define compliant hydrogen sits in Brussels, not Santiago, which limits Chile's ability to shape its own industry. The green-windows literature (Chapter 3) treats such a rule as setting the terms of the opportunity without predetermining the outcome. H3 predicts policy arranged around the EU standard: no domestic standard, and no equipment-origin or local-capability conditions on the sector. Facing the same rules, Brazil legislated its own national standard instead, so an alternative was available to a comparable producer (§5.5). H3 fails if Chile's instruments show independent standard-setting or capability conditions like Brazil's. Chapters 5 and 6 evaluate the three green-windows benchmarks of Chapter 3.

RQ3 – Does the legislation deepen reliance on Chinese hardware?

H4 (amplification) predicts that the rules inflate and shape the volume of hardware a compliant project must buy. The rules are origin-neutral and contain no countervailing provision, so in a market where manufacturing is concentrated in China, they amplify dependence on Chinese hardware.

Supplier origin, configuration and scale, and project viability are separate outcomes on which the rules may bear differently, so testing H4 means examining each against the §2.1 counterfactual.[13] On supplier origin, projects would buy electrolysers and turbines on cost with or without the delegated regulations, so if cost explains the observed pattern the rules make no difference. On configuration and scale, nothing without the criteria forces oversized generation, dedicated storage or temporal correlation, so filed engineering showing these features is evidence the rules bite. On project viability, weak demand exists either way, so stalled projects count against the rules only insofar as compliance cost and regulatory uncertainty add to the pressure, amplifying, not causing; §5.4 returns the verdict on each.

[13] (Fearon, 1991)

Exhibit 2, Panel B sets out the test and the verdicts Chapter 5 reaches. H4 fails if the rules in fact drive supplier origin, if a compliant project needs no more hardware than an unregulated one, or if the rules leave configuration unchanged.

A further prediction underlies H1 and H4. New energy technologies pass through a sheltered early phase, when policy support makes higher-cost, varied procurement affordable, before cost pressure pushes the industry onto the cheapest supply.[14] The Chilean cases sit on either side of that shift: the grandfathered pilot, sheltered from the strictest rules and able to afford European equipment, and the fully regulated successor, exposed to cost pressure. The prediction is that the two diverge in where their equipment is made (Exhibit 2, Panel C).

Had the pilot used Chinese equipment, it would show that cost, not regulatory shelter, governs procurement, and the mechanism would fail. It did not: Haru Oni sourced European core equipment, as predicted. Nonetheless, this outcome is uninformative, because the plant was part-financed by an 8.23-million-euro German federal grant and built with German industrial partners, both of which would likely favour European equipment irrespective of whether the shelter mechanism operates.[15] European equipment is thus equally consistent with the hypothesis and its rejection. The decisive evidence therefore lies with the fully regulated projects, where no comparable confound operates and cost alone remains to explain supplier selection (Chapter 6).

2.3 Case Selection

Chile is a deliberately demanding place to test the central claim that externally set certification narrows a latecomer's room to build its own industry. It holds one of the world's strongest renewable endowments: an estimated 1,700 gigawatts of technical potential against roughly 37 gigawatts of installed national capacity.[16] Furthermore, it has a tradition of industrial policy, seen in its salmon and fruit export sectors and today institutionalised in CORFO, the national development agency.[17] Through Haru Oni, it had the earliest third-country exposure to the rules. Chile's resources, institutions and

[14] (Kobos et al., 2006; Wilson, 2012)
[15] (BMWi, 2020)
[16] (Chilean Ministry of Energy, 2021, p. 4; Chilean National Energy Commission, 2025, p. 3)
[17] (CORFO, 2023; Lebdioui, 2019, 2025)

head start make it the place where the effect should be hardest to find, so finding it here would be informative.[18] The timing toughens the test: the 2026 strategy update lowered national targets,[19] the EU's criteria are under review while remaining binding,[20] and the first full certification cycle completed in June 2026.[21]

Within Chile, Haru Oni provides the process trace: operating since December 2022, it was first certified 23 June 2025 and renewed 16 June 2026.[22] It runs a 1.2-megawatt electrolyser powered by a 3.4-megawatt off-grid wind turbine.[23] Because it predates the delegated acts and additionality never applied to its direct-connection route, nothing obliged it to build to the criteria – which makes it the case where compliance is least expected on legal grounds.[24] That it complied regardless would be strong evidence, in the least-likely-case sense, that market access, not legal obligation, drives compliance.[25]

As laid out in §2.1, two comparison cases sit outside Chile, each isolating one variable. Brazil met the same EU rules but legislated its own, looser standard – a carbon ceiling roughly double the EU's – with producers exporting to the EU certifying separately.[26] Uruguay holds the developer constant: HIF's Paysandú project has a local biogenic-carbon base its Magallanes sites lack.[27] Neither is a second process trace.

HNH Energy is the closest alternative set aside – a US$11-billion green-ammonia project in Magallanes. It would be a second large, regulated project in the same region as H2 Magallanes (another instance rather than a new variable).[28] Projects built for non-EU markets fall away on a more basic ground: their design answers to cost and destination geography, not the RFNBO criteria. HyEx illustrates the category – Engie and Enaex's solar-powered green-ammonia project in Antofagasta, sized to replace the

[18] (Lebdioui, 2025; Orihuela et al., 2025)
[19] (Ministerio de Energía, 2026)
[20] (Fuel Cells Works, 2026)
[21] (TÜV SÜD Industrie Service GmbH, 2026)
[22] (TÜV SÜD Industrie Service GmbH, 2025, 2026)
[23] (HIF Global, 2026)
[24] Delegated Regulation (EU) 2023/1184
[25] (George & Bennett, 2005)
[26] Lei 14.948/2024 (Brazil), Art 4, XII
[27] (ALUR et al., 2024; HIF Global, 2024)
[28] (Cooperativa.cl, 2024)

imported ammonia Enaex turns into mining explosives at Mejillones, an offtake no EU criterion touches.[29]

2.4 Design Evolution

The design changed as the research progressed. The main constraint on the study is evidential, and the proposal had allowed for it: project-level procurement – who bought which equipment, and why – is not on the public record. H2 Magallanes is the clearest illustration. TotalEnergies filed the project's environmental study, then in September 2025 asked to suspend the evaluation to rework the design; the authority granted a suspension running to December 2026.[30] Nothing had been procured, and nothing was disclosed. The study therefore reads the rules against what the public record does hold: filed engineering, which shows a project’s intended design, regardless of whether its procurement is settled.

That a project can stall does not unsettle the argument, because the evidence is already filed. An environmental study records what a developer committed to build under the rules it expected, and it stays on the record whether the project proceeds or not; the same holds for Haru Oni's certification record. The argument rests on those fixed records and the sector around them.

Two other changes tightened the design. First, scope: the study began on green hydrogen alone and widened to the full RFNBO family, which brought the carbon criteria forward. Hydrogen itself needs no carbon input, but the fuels derived from it do. E-methanol, e-gasoline and sustainable aviation fuel all require CO_2, and the EU defines which sources qualify. Those are the fuels a remote producer exports, so the carbon axis moved to the centre of the study. The interviews later bore this out, the lead auditor naming carbon eligibility as the constraint on which projects fail.

Second, the study's early framing ran between the EU and China, and treated Chile mainly as the place where the two met. Exchanges with development-economics colleagues corrected that, and what the rules do to Chile's own industrial prospects

[29] (Enaex, 2022)
[30] (El Mercurio / Emol, 2025; TotalEnergies H2 Magallanes, 2025)

became RQ2, a question in its own right, no longer a by-product of the supply-chain account.

2.5 Evidence and access

The evidence is documentary first, with interviews interpreting rather than carrying it and no central claim resting on an interview alone. There are four documentary layers. First, the legal corpus: directives, delegated and implementing regulations, recognition decisions, and Commission guidance, read on EUR-Lex with article and paragraph references verified against the consolidated text. Second, the certification layer: the recognised schemes' system documents[31] and the published Haru Oni certificate and audit report.[32] Third, the project layer: Chile's environmental-assessment *expedientes* with their filed engineering and suspension resolutions,[33] corporate disclosures, and the German federal grant record behind Haru Oni.[34] Fourth, the policy layer: Chilean strategies and CORFO records,[35] EU strategy and funding instruments, and the international agencies' assessments.[36]

Two further kinds of evidence sit alongside the documents. Published techno-economic modelling prices what the criteria require: the cost premium hourly matching carries over annual accounting, and the effect of the additionality rule on project economics.[37] Where no published figure exists, the thesis makes its own indicative calculation, stating its assumptions and source parameters and set out at Annex E. The CO_2 transport arithmetic at §5.3 is the main instance.

The interviews cover the certification chain link by link. Three are attributable and cited: the developer's regional commercial lead, in written answers;[38] the producers' association's chief strategy officer, in a recorded interview;[39] and the certificate's lead

[31] ISCC EU 202-6; ISCC EU 203; ISCC EU 205-1; CertifHy GHG & Sustainability v1.6; CertifHy Traceability & Chain of Custody v1.6
[32] (TÜV SÜD Industrie Service GmbH, 2026)
[33] (HIF Chile 1 SpA, 2025; TotalEnergies, 2025; TotalEnergies H2 Magallanes, 2025)
[34] (BMWi, 2020)
[35] (Chilean Ministry of Energy, 2020; CORFO, 2023, 2025; Ministerio de Energía, 2026)
[36] (Buffi & Motola, 2026; International Energy Agency, 2024, 2025a, 2026a; IRENA, 2022)
[37] (Hordvei et al., 2025; Langenmayr & Ruppert, 2023; Linsel & Bertsch, 2026; Namazifard et al., 2025; Ruhnau & Schiele, 2023; White et al., 2025)
[38] (A. Pedinian Mohr, personal communication, 1 July 2026)
[39] (T. Block, personal communication, 7 July 2026)

auditor, named but speaking on general frameworks only, the audit itself being confidential.[40] Brazil's planning agency answered in writing.[41] Two further exchanges are not citable: one given on background by a Commission trade official, and one whose author declined attribution. Neither is quoted; both are logged in Annex D. Respondents chose between a call and written questions, and several preferred to write. Annex D logs every approach, outcome and the terms of attribution.

2.6 Ethics

Consent was obtained for each exchange, It was agreed at the time how each contribution could be attributed (by name, by role, or as background) and is honoured accordingly (recorded in Annex D); one contribution whose author declined attribution is not used. Where respondents discussed commercially sensitive procurement, the thesis reports at country level only, never by firm. Recordings were made for transcription alone and deleted at submission; public records are used under their public-access regimes. (The full consent and data-handling protocol is at Annex H.)

2.7 Scope, cutoff and limitations

The scope covers Chile's regulatory and industrial position under the RFNBO rules, the project population, the certification record, and the policy response. The empirical window runs from 2020, when Haru Oni's design was fixed, to the submission date of 19 July 2026, and that cutoff is by design, not convenience. The object of study is live: the production criteria are under active review, the first full certification cycle completed during the final month of writing, and projects are moving in and out of suspension. An earlier cutoff would have meant knowingly submitting a thesis already out of date. The cost of that choice is a thesis written to the deadline. Material arriving afterwards is handled by the dated addendum, which records developments after the cutoff, the revision of the delegated acts chief among them.

Access remained unfinished at the cutoff, not closed. One approach is settled: the certification scheme declined an interview. The rest are recent and still open,

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[40] (S. Rößler, personal communication, 17 July 2026)
[41] (EPE, personal communication, 15 July 2026)

reasonably so, being only weeks old: the EU's delegation in Santiago offered an interview for just after the cutoff; the Chilean energy ministry had returned a procedural acknowledgement, its statutory response window running into August; and CORFO had redirected the query into the statutory lobbying channel. None of these is a refusal, and the thesis reads nothing into the silence.

Five limitations are material. First, commercial confidentiality: procurement terms are not disclosed, so the thesis reads what a project is designed to require, not what it has bought, and declares where gaps are filled with inference (§2.4, §2.5). Second, the operating base is thin – few certified plants exist globally, so audit-layer evidence is sparse and claims are sized accordingly. Third, scope: this is one corridor, so what generalises is the mechanism, not the magnitudes; and modelling places derivative-export economics in the 2030s,[42] which is why the thesis examines what the rules do now to design, certification, and policy rather than trade volumes that do not yet exist. Fourth, the Commission is reviewing the criteria, limiting the findings to rules as they are, not as they might become – managed by the cutoff and the addendum protocol (§2.7). Fifth, it is impossible to observe what these projects would have been without the rules, so the causal claims rest on argument rather than observation; the outcome-by-outcome structure of §2.2 disciplines that argument, but the limit stands.

A late interview can deepen the account of how the rules work in practice, and correct points of detail. It cannot change what the certificate records, what the delegated acts require, or what the projects have filed. That is where the central findings sit.

[42] (Galimova et al., 2023)

Chapter 3 – Literature Review & Analytical Framework

This chapter examines the three bodies of literature that bear on the thesis - the EU's capacity to govern extraterritorially, green windows of opportunity and latecomer industrialisation, and industrial policy and the de-risking of supply chains - before synthesising the analytical framework.

3.1 State of the Art

Three literatures bear on this thesis, and behind all three sits an older question. The dependency and structuralist traditions asked what it does to a country's prospects to enter the world economy at the bottom of a production hierarchy. Their answers named three mechanisms: terms of trade that move against primary exporters over time, so that the same volume of exports buys less; technological subordination, where the technology in use is designed and owned elsewhere; and the enclave, a modern export sector operating alongside the domestic economy without connecting to it.[43]

The value-chain literature translated that question into two others – who sets the terms on which a chain operates, and whether taking part in one transmits capability.[44] It also brought the standard-setter into the frame. In a buyer-driven chain the lead firm owns no factories; it governs through the specifications it imposes on the suppliers who do. That is the nearest antecedent to a corridor governed by certification, and the difference is the one this thesis hinges on: here the specifier is a regulator rather than a buyer.

Chile's own economic history has long been interpreted in these registers – a sequence of primary-export cycles, nitrate and then copper, generating rents and episodes of institutional strength without proportionate manufacturing capability. It is the record on which the country's diversification debate still turns.[45]

The thesis does not adopt the dependency framework or test the tradition's necessity claims; the comparisons in Chapter 5 probe the margins of manoeuvre the strong version denies. What the lineage supplies is the question the newer literatures inherit,

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[43] (Cardoso & Faletto, 1979; Dos Santos, 1970; Prebisch, 1950; Singer, 1950)
[44] (Gereffi, 1994; Gereffi et al., 2005)
[45] (Lebdioui, 2019, 2020)

and that this thesis asks of a new sector: whether it becomes a development platform or another enclave, certified this time. The three literatures that follow each take up part of it – the EU's external regulatory reach (§3.1.1), how latecomers build capability and when (§3.1.2), and the manufacturing base the transition runs on (§3.1.3).

3.1.1 External governance and the Brussels Effect

The EU's external regulatory reach rests on a prior feature of its character. Majone characterises the Union as a 'regulatory state', governing through arm's-length, rule-based regulation rather than the interventionist economic planning of the post-war European state.[46] The accounts below show that character projecting beyond the Union's borders.

Bradford’s *Brussels Effect* extends this insight, examining how EU standards become de facto[47] global standards not through treaties but through the Union’s market size and regulatory capacity, and firms’ willingness to standardise production around the strictest rule they face.[48] Where Manners' normative-power tradition reads the EU's external influence as example-setting,[49] the accounts this thesis follows are harder-edged. Damro's ‘Market Power Europe’ places that influence in the externalisation, deliberate or incidental, of its internal market rules and regulatory practices.[50] Scott specifies the legal mechanism. EU law reaches beyond its borders not by asserting extraterritorial jurisdiction but through ‘territorial extension’, conditioning market access on compliance with EU-defined standards regardless of where production occurs, a technique whose legitimacy legal scholarship continues to debate.[51] Goldthau and Sitter, on energy specifically, argue that regulatory power is the only form of influence consistent with the EU’s normative values.[52]

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[46] (Majone, 1994, 1997)
[47] Bradford notes that regulation becomes de jure global standards when third states legislate the EU’s rulebook into their own law, such as in GDPR. It is worth stating that this thesis focuses on the de facto channel, since no Chilean statute adopts the EU’s criteria; the rule reaches producers commercially, through the offtake contracts that make EU-market access conditional on compliance.
[48] (Bradford, 2012, 2020)
[49] (Manners, 2002)
[50] (Damro, 2012, 2015)
[51] (Feld, 2026; Scott, 2014)
[52] (Goldthau & Sitter, 2020)

This literature does not ask what an EU standard does to the producing country's own industrial prospects. Its concern is regulatory convergence, not development, and, where optimistic, it expects a race to the top. Yet where compliance requires hardware made elsewhere, exporting EU standards may deepen dependence rather than extend control. The thesis takes up this decoupling of regulatory from industrial power, which turns on whether the effect is divisible.

As Bradford explains, the strong Brussels Effect depends on non-divisibility – on production being impractical to split between EU-facing and other streams.[53] Empirical work bears this out. Weber, documenting the EU's deforestation regulation in Ghanaian cocoa, finds fragmentation occurs, rather than wholesale adoption, where compliance is separable across product streams.[54] Bastos Lima and Schilling-Vacaflor locate the mechanism more precisely. Divisibility, on their account, need not occur within a producer at all: it can be organised at sector level, where producers sort themselves so that compliant output reaches the EU and the rest goes elsewhere. Where an industry has traders and intermediaries to do that sorting, no single firm need split anything.[55] Whether RFNBO certification satisfies this condition, and at what level any divisibility would operate, is the question the framework below takes up.

3.1.2 Green windows of opportunity and latecomer industrialisation

The second literature asks how and when countries that industrialise late acquire the capability to compete. Here, latecomer means late to industrial capability, not to any particular market: a country building its industrial base after the technological frontier has moved on. Its central finding is that late industrialisation is learning, through absorbing and improving existing technologies, rather than of inventing new ones.[56] A distinction separates production capacity, the ability to operate a plant designed elsewhere, from technological capability, the ability to improve that plant, adapt it, and eventually design and build one. The first can be bought. The second is built up slowly, through engineers trained, faults diagnosed, and designs attempted.[57] A country can

[53] (Bradford, 2012)
[54] (Weber, 2025)
[55] (Bastos Lima & Schilling-Vacaflor, 2024)
[56] (Amsden, 1989)
[57] (Bell & Pavitt, 1993; Lall, 1992)

host a large volume of production for a long time and acquire very little capability from it.

Capability does not accumulate at a constant rate; the opportunity to build it appears at particular moments. When the underlying technology changes, the plant, skills, and supplier relationships that made an incumbent competitive lose much of their value, because that advantage was specific to the displaced technology. Incumbents are slow to write those assets off, which opens a gap a latecomer can enter.[58] These openings are windows of opportunity, and they come in three kinds: a technological window when a new technology resets the field; a demand-side window when a market appears or shifts; an institutional window created by policy or regulation.[59]

A window does not decide the outcome. Whether the opportunity is taken depends on the capability already in place and on the industrial policy applied once the window opens, a question studied directly for middle-income countries entering green value chains.[60] Work on the East Asian developmental states describes how a government converts a window: directing credit to the targeted sector, attaching performance conditions to the support, and holding to that commitment long enough for capability to form.[61] Two countries facing the same window can therefore diverge, and windows have been missed by well-placed latecomers.[62]

In green markets the institutional window is the decisive one. European demand for RFNBOs did not arise and then attract regulation; it exists because policy created it, through the mandates and targets of RED III and the definitions attached to them. Hydrogen itself has long had industrial buyers, but demand for hydrogen that counts as renewable does not exist independently of the rule defining it. Where policy constitutes a market this way, the rules defining the product are the terms of the opportunity itself.[63] The literature treats that window as something a latecomer's own government can

[58] (Lee & Malerba, 2017; Perez & Soete, 1988)
[59] (Lema et al., 2020)
[60] (Lema et al., 2025)
[61] (Thurbon et al., 2023)
[62] (Hansen et al., 2026)
[63] (Lema et al., 2020)

shape, or something negotiated between states. Neither describes this case: the rules constituting Chile's export market are written in Brussels, without Chilean participation.

Two further strands set what the thesis expects to find. The first is sceptical. Green industrial policy in Chile has been read as trapped between ambition and constraint, its lithium and hydrogen strategies promising a capability the instruments do not deliver.[64] A wider literature warns that a shift to low-carbon production can reproduce existing dependence rather than escape it.[65] Against this sits the optimistic case, that green hydrogen offers latecomers a route into a new industrial revolution.[66] The thesis assumes neither verdict: the two make opposite predictions about capability, and the Chilean record is where they are tested.

The second strand explains why the stakes compound. Manufacturing capability exhibits increasing returns. Unit costs fall by a roughly constant proportion with each doubling of cumulative output, the experience-curve effect, so a producer that has already built more builds more cheaply again.[67] Scale economies and a thickening supplier base reinforce it. The cost gap between an established producer and an entrant widens with every additional unit the incumbent ships, so arriving late to production is costly even where natural resources are abundant. That is the position a resource-rich latecomer occupies when the equipment is made somewhere else.

Two studies come closest to asking this. An ex-ante assessment of structure and agency in Chilean and Namibian green hydrogen makes the latecomer's room to act its focus, without treating the foreign rule-set as the structure that narrows it.[68] A survey of latecomer barriers in low-emission hydrogen names certification schemes among the obstacles that Global North export markets impose, but treats them as compliance cost and regulatory risk produced by fragmentation, rather than as the structure constituting the market a latecomer is entering.[69] That is the question this thesis takes

[64] (Carrasco et al., 2026; Orihuela et al., 2025)
[65] (Braunstein & Chuchko, 2025; Middelanis et al., 2025)
[66] (J. Mathews, 2023)
[67] (Kobos et al., 2006; J. A. Mathews & Reinert, 2014)
[68] (Scholvin & Kalvelage, 2025)
[69] (Altenburg & Strohmaier, 2025)

up, and the framework in §3.3 turns it into three benchmarks against which Chapters 5 and 6 assess the Chilean record.

3.1.3 Supply chains, industrial policy and de-risking

The third literature is about who manufactures the equipment the energy transition runs on, and how Europe has responded to the answer. Manufacturing is concentrated. Chinese plants account for roughly 60% of world electrolyser manufacturing capacity,[70] with solar[71] and storage batteries more concentrated still (developed in §6.1).[72] [73]

Four things explain the concentration, and they compound. Plants are built at a scale that spreads fixed costs across very large volumes, so unit costs fall. Firms are vertically integrated, making cells, stacks, and components in-house rather than buying them, so no margin is paid away at each step and no supplier can interrupt the line. Repetition improves yields and cycle times, which is the learning effect described at §3.1.2 running at national scale. And sustained public support, in credit, land, and guaranteed domestic demand, let firms build at that scale before the market justified it.[74]

The literature interprets these facts through energy security, and in doing so has redefined it. The classical concern was fuel: securing supply at tolerable cost, with climate entering later as a third objective. Cherp and Jewell recast the concept more generally as low vulnerability of vital energy systems, which detaches it from any particular commodity.[75] Russia's weaponisation of gas supply in 2022 made that vulnerability concrete and moved it up the political agenda.

What the transition changed was where the vulnerability sits. A system that burns fuel depends on a flow bought continuously from whoever holds the reserves. A system that harvests wind and sunlight depends instead on the equipment that captures them, bought at the point of construction and then operated, and that equipment comes from

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[70] (International Energy Agency, 2026a)
[71] (International Energy Agency, 2022)
[72] (Hughes, 2026)
[73] The electrolyser figure carries a qualification developed at §6.1: concentration is uneven across technologies, and in the proton-exchange-membrane (PEM) machines suited to variable renewable input, non-Chinese manufacturing still holds a substantial share. (J. Li et al., 2025)
[74] (J. Li et al., 2025; Naughton, 2021)
[75] (Cherp & Jewell, 2014)

the concentrated supply chains described above. The dependency changes form rather than ending. It moves from the fuel to the machine, and from geology to manufacturing.[76]

Europe's response has not only been regulatory, but also fiscal, spending internally: the Hydrogen Bank auctions and the Important Projects of Common European Interest put money behind domestic manufacturing. But that spending carries conditions, and they reach further than the money: funding stops at the border, governing what is built in Europe, while the rule crosses it – imported fuel is certified or it is not. The instruments themselves are examined in Chapter 6; what matters here is the literature's mixed assessment. The push to open strategic autonomy and economic security is judged coherent in ambition and uneven in execution, and directed inward, concerned with Europe's own build-out rather than with the production systems its rules reach abroad.[77] Gabor supplies the sharpest development-side critique: de-risking is a model in which public balance sheets absorb private risk while the structural questions, who manufactures and who learns, go unasked, an analysis extended to green hydrogen directly.[78]

Hydrogen certification has also been surveyed, as a matter of scheme design and practitioner perception rather than of industrial consequence.[79] However, the connection to the hardware question is missing. Certification is examined as a cost of market access, or as a problem of interoperability between schemes. As a constraint that reprices and resizes project designs, it has been modelled;[80] as an institution that determines the equipment a sector must buy, from whom, and with what consequences for the producing country's industrial prospects, it has not.

H4 makes this connection. The question is not whether stringent production rules dictate who supplies the hardware, since existing cost advantages may settle that on

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[76] (IRENA, 2022, pp. 70, 78–80, 89; Quitzow & Zabanova, 2025, p. 4) The relocation also weakens the dependency: control over technologies affects the installed stock only gradually, and affected countries can adapt by building manufacturing capacity of their own. What persists in the older form is upstream material supply.
[77] (García-Herrero et al., 2023; Pogorel & Cappelletti, 2024)
[78] (Gabor, 2021; cf. Gabor & Sylla, 2023)
[79] (Goodwin et al., 2024)
[80] (BNDES, 2022)

their own. It is whether, by inflating the volume of hardware compliance requires, those rules deepen a dependence that cost had already created.

3.2 Adjacent studies and the gap

Several recent studies approach the intersection this thesis occupies, and what each leaves out defines the gap; Exhibit 3 tabulates them.

The closest work examines the EU's external hydrogen relations directly. Weko and Quitzow analyse them as a shift from external governance towards energy diplomacy, treating the certification rules as background;[81] this thesis takes the opposite premise, that the standard remains the operative instrument. Zabanova and Quitzow name a hydrogen Brussels Effect in passing, without carrying it to a mechanism or to a producer country.[82]

A second body examines what hydrogen export does to producing countries, but casts the EU in a different role. The hydrogen-justice literature interprets Southern hydrogen through green extractivism and green colonialism, frames in which resources extracted for Northern decarbonisation reproduce colonial patterns of value transfer, with Morocco, Namibia, and Chile among its cases.[83] In these accounts the EU appears as buyer, financier or power, and rarely as rule-maker. Dejonghe and Van de Graaf offer the nearest conceptual competitor, a typology of risks in Global-South hydrogen trade and of producer-country responses, at a level of generality that does not enter any single regime's mechanics.[84] Bacil and colleagues supply the development-economics counterpart on exporters' linkage prospects;[85] country studies of Chilean hydrogen governance provide domestic-political grounding without the external-rule dimension;[86] and Eder and Rammer interpret the EU–Chile relationship through a dependency lens without entering the delegated acts' mechanics.[87]

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[81] (Weko & Quitzow, 2026)
[82] (Zabanova & Quitzow, 2025)
[83] (Backhouse et al., 2025; Kalt et al., 2023; Müller et al., 2022; Tunn et al., 2024)
[84] (Dejonghe & Van de Graaf, 2025)
[85] (Bacil et al., 2026)
[86] (Flores Fernández, 2026; Jaña Maureira, 2024)
[87] (Eder & Rammer, 2025)

A third body studies the rules themselves, but not what they do to industrial structure. Techno-economic work quantifies what the criteria cost a third-country producer, without a theory of the producing state.[88] Hydrogen certification has also been surveyed in its own right, as a matter of scheme design and practitioner perception rather than of industrial consequence.[89] Weber supplies the closest methodological parallel from adjacent terrain, tracing the EU Deforestation Regulation's effects on Ghanaian cocoa and finding fragmentation – compliance for the EU-bound stream, business as usual elsewhere – which corroborates the divisibility logic developed below.[90]

Two 2025 works bracket the gap most closely. Goecke maps the doctrinal compliance obstacles Chilean producers face under the delegated acts (bidding-zone equivalence, correlation evidence, the direct-connection route) in a legal register. It does not theorise rule-export as power, treat equipment or supply chains, nor ask the industrial-agency question.[91] Orihuela, Irarrázaval, and Flores analyse Chile's green hydrogen and lithium industrial policies through the green-windows lens on rich interview evidence; there the EU appears as industrial-policy competitor and trade-agreement constraint, and the certification regime structuring the export market does not enter the analysis.[92] One maps the rules without the window; the other maps the window without the rules. The seam between them – the EU's certification regime analysed as the externally set institutional terms of Chile's green window, with equipment origin and attribution addressed explicitly – is where this thesis sits.

3.3 The analytical framework

The framework combines three elements, stated here and applied from Chapter 5.

First, Market Power Europe through territorial extension supplies the account of what kind of power the RFNBO regime is. Damro's concept holds that the EU's typical external action is the externalisation of its market rules; Scott specifies the legal form that externalisation takes when the Union conditions market access on conduct

[88] (Linsel & Bertsch, 2026; Schumm et al., 2025; White et al., 2025)
[89] (Goodwin et al., 2024)
[90] (Weber, 2025)
[91] (Goecke, 2025)
[92] (Orihuela et al., 2025)

performed abroad without asserting jurisdiction over it.[93] These are descriptive categories, and whether the RFNBO regime instantiates them is a question for the analysis.

Two features of this externalisation shape what the regime can do to a producer. The first is what compliance demands: where most instruments the external-governance literature studies require only procedural compliance – paperwork rather than a different product – a standard whose criteria reach into physical production, requiring particular electricity, carbon, and plant configurations, demands material compliance. What it externalises is industrial structure rather than administrative cost, a distinction developed at §5.1.[94] The second is the channel. In Lavenex and Schimmelfennig's terms the EU governs outsiders through hierarchy, networks or its markets. The EU's effect on Chile falls in neither the hierarchy nor the network channel, but in the market mode, where the burden of adjustment falls entirely on the third country.[95]

Second, the Brussels Effect supplies testable conditions. Bradford's account specifies when unilateral EU rules become global de facto standards, and Chapter 5 scores its five conditions: a large internal market whose access is worth the compliance cost; the regulatory capacity to write and enforce sophisticated rules; a political preference for strict standards; an inelastic target, one that cannot relocate to escape the rule; and non-divisibility, the impracticability of maintaining separate production streams for different regulatory regimes, so that firms standardise globally on the EU rule.[96] The canonical trading-up cases ran on non-divisibility. Vogel's California Effect worked because reformulating a product line for one strict market was cheaper than running two, and REACH globalised chemical formulations on the same logic.[97] Divisibility is the hinge of the conversion mechanism: where production is divisible, a firm can comply for the EU-bound stream and carry on as before, and the standard governs conduct without converting the market. International agencies have observed the corollary from the scheme side, that certification systems covering only some attributes let producers

[93] (Damro, 2012; Scott, 2014)
[94] (Hadjiyianni, 2021; Scott, 2014)
[95] (Lavenex, 2004; Lavenex & Schimmelfennig, 2009)
[96] (Bradford, 2012, 2020)
[97] (Bradford, 2020; Vogel, 1995)

retain advantages on the ones left uncovered.[98] Divisibility is a property of products, of the accounting rules that track them, and of the level at which producers can sort output between markets. For certified fuels the chain-of-custody rules fix all three, which makes the condition empirically identifiable here. Hydrogen at this stage has no trader layer to perform the sorting Bastos Lima and Schilling-Vacaflor describe, so the level at which any divisibility would operate is itself in question – the one Chapter 5 resolves. Exhibit 4 tabulates the five conditions for later assessment.

Third, the green-windows synthesis supplies the latecomer's side. For the window assessment RQ2 requires, the literature yields three observable criteria. Capability formation: whether hosting the sector builds domestic technological capability rather than throughput. Standard-setting agency: whether the state shapes the rules its hydrogen sector answers to, or only positions itself within them. Linkage creation: whether the sector connects to the domestic economy beyond the project fence.[99]

The three elements join at a single observation: the RFNBO regime is an institutional window whose terms are set outside the latecomer's polity. What external term-setting changes is where the decisive lever sits. What must be verified, what may be counted and what is left unexamined are all decided elsewhere, and those decisions allocate options between incumbents and entrants before any transaction occurs. The domestic response, though narrowed, remains the latecomer's own.

That last point disciplines the causal claim, and the dependency tradition supplies its licence. Cardoso and Faletto insisted on situations of dependency rather than a sentence of it, and the tradition's recent rehabilitation treats it as a research programme about constrained choice.[100] Constraint narrows the options without settling which is taken. The amplification hypothesis specified in Chapter 2 applies that discipline to this case: externally set terms are expected to shape the scale and configuration of what a latecomer builds, while leaving untouched the cost structures that determine from whom it buys.

[98] (IRENA, 2022)
[99] (Hobday, 1995; Lall, 1992; Lema et al., 2020)
[100] (Antunes de Oliveira & Kvangraven, 2023; Cardoso & Faletto, 1979; Kvangraven, 2021)

The framework therefore predicts a characterisation that Chapter 5 begins by testing: that the RFNBO regime meets most of Bradford's conditions on paper while failing non-divisibility in a way the scheme documents make precise – with consequences for what it can and cannot govern.

Chapter 4 – The RFNBO framework and its market

The empirical chapters turn on a body of EU law whose full architecture, scheme documents and derived figures are set out at Annex B. This chapter states only what the analysis leans on: what the rules require, how they are certified, and the state of the market they construct.

The regime rests on the Renewable Energy Directive (Directive 2018/2001 as amended by RED III, Directive 2023/2413), which defines renewable fuels of non-biological origin (RFNBOs) and delegates the production criteria to two Commission Delegated Regulations of 10 February 2023: 2023/1184 for electricity and 2023/1185 for greenhouse gases.

The criteria run on two axes. The electricity axis governs when the power drawn into electrolysis counts as fully renewable. A grid-connected producer must, in the general case, satisfy three conditions: additionality (the renewable capacity newly built and unsupported, Article 5), temporal correlation (generation and consumption matched monthly, then hourly from 1 January 2030, Article 6), and geographical correlation (generator and electrolyser in the same or a coupled bidding zone, Article 7). A producer wired off-grid to its own dedicated generation under Article 3 escapes the correlation machinery. The carbon axis requires a lifecycle greenhouse-gas saving of at least 70% against a fossil comparator of 94 gCO_2e/MJ (Article 29a(1)), leaving a ceiling of 28.2 gCO_2e/MJ, or about 3.4 kgCO_2e/kgH_2. Only five categories of captured CO_2 qualify (point 10 of the 2023/1185 Annex); the industrial-capture route at point 10(a) is gated on an effective carbon price that most producer countries do not levy, leaving direct air capture and biogenic carbon as the practical sources.

Compliance is certified, not measured at the border. A producer certifies through a recognised voluntary scheme, which audits against the criteria and issues a proof of sustainability entered in the Union Database. Chain of custody runs on mass balance under Article 19 of Implementing Regulation 2022/996: certified and uncertified molecules may share infrastructure provided the paper account balances within a three-month period, so regulatory identity attaches to quantities within a bounded site, not to firms. The methodology counts emissions from input supply but expressly excludes one category – "Emissions from the manufacture of machinery and equipment shall not be taken into account." Nothing in the evidence model records where the electrolyser, turbines or cells were made. The framework is, on this point, origin-blind as to equipment.

The demand these rules serve is still assembling. RED III sets binding RFNBO shares in industry (42% by 2030) and transport, but transposition was incomplete at the cutoff, and only about 6% of announced global e-fuels projects had reached final investment decision by mid-2026. The criteria were themselves under review at submission. The full account – the scheme documents, the derivation of the figures and the state of the market – is at Annex B, with legislation locators at Annex C and workings at Annex E.

Chapter 5 turns to the case: what these rules did to the design, certification and prospects of a project built to meet them.

Chapter 5 – Case Analysis

5.1 RFNBO regime as market power

In the framework's terms (§3.3), the regime is Market Power Europe through territorial extension – additionality, correlation and carbon eligibility govern how fuel is produced in Chile. Yet nothing Chilean carries them since no law transposes the delegated acts, no agreement binds Chile, and the rules take effect only through the certificate required by EU offtakers. External governance runs through the market alone, and the burden of adjustment falls on the third country.

One feature distinguishes this regime from most that the external-governance literature studies: it demands material rather than procedural compliance. Where the Timber Regulation imposed a due-diligence duty[101] and aviation's entry into the ETS a financial duty,[102] neither told anyone what to build. The RFNBO criteria do: the age and connection of the generating plant, the matching of its output, the source of the carbon molecule. What crosses the border is not an administrative cost but a specification for industrial plant, and that is why the following chapter is about hardware.

Measured against Bradford's five conditions, the regime scores high on four.[103] The EU market is large, albeit constructed by mandate rather than pre-existing. Regulatory capacity is evident in two delegated acts and a recognition apparatus. The standards are strict. And the regulatory target is inelastic on the demand side: mandated EU consumption cannot relocate to escape the rule.

Two features of that demand qualify the point. The IEA records progress on demand creation as slow, giving incomplete transposition of the Renewable Energy Directive as its example.[104] The industry target, too, is expressed as a share rather than a volume – 42% of the hydrogen consumed in European industry. Dr Stefan Rößler, lead auditor for the Haru Oni certificate, identifies the consequence from inside the certification

[101] Regulation (EU) No 995/2010 (EU Timber Regulation)
[102] Directive 2008/101/EC (aviation in the EU ETS)
[103] (Bradford, 2012)
[104] (International Energy Agency, 2026a, p. 199)

system: with "the chemical industry mainly moving out of Europe due to high energy prices, bureaucratic hurdles", the denominator shrinks, and "if the demand just decreases, no one is willing to produce it."[105] A percentage of a contracting industrial base is a smaller absolute volume than the same percentage of a growing one.

The fifth condition is where the regime fails, and not by accident. Fuel is fungible, so no molecule can be followed from plant to buyer, and the chain-of-custody machinery of Annex B exists precisely to hold separate regulatory identities inside one physical flow – booking the uncertified quantities alongside the certified.[106] Compliance is costly (additionality, correlation, eligible carbon each add cost), and only the EU market pays the premium for it. Certifying output for markets that do not reward the green attribute is uneconomic, which makes splitting rational and gold-plating irrational.

That machinery is in routine use. ISCC's mass-balance guidance lists RFNBO hydrogen, ammonia, methane and Fischer-Tropsch fuels among the product categories administered within the general mass-balance system, on the same terms as any other certified commodity.[107] At the Rheinland refinery a ten-megawatt electrolyser has fed renewable hydrogen into a conventional refinery's shared hydrogen system since 2021: a renewable regulatory identity maintained inside a fossil physical flow.[108] The case shows the accounting can hold two identities in one flow, not that producers split output by destination regime.

Whether that formal divisibility matters in practice is an empirical question, and the case answers it at §5.7.

5.2 Haru Oni: design under anticipated rules

The process trace begins before the rules existed. Haru Oni's development began in 2020, with the European market as its commercial destination from the outset. As the developer puts it, "the plant was aiming for complying with EU rules because our customer (Porsche) was focused in EU market."[109] The Porsche offtake is recorded in

[105] (S. Rößler, personal communication, 17 July 2026)
[106] Implementing Regulation (EU) 2022/996, Art 19(2)(f) and (l); ISCC EU 203, §4.4.2
[107] ISCC EU 203-02 (Mass Balance Guidance)
[108] (REFHYNE Project Consortium, n.d.)
[109] (A. Pedinian Mohr, personal communication, 1 July 2026)

HIF's supply-agreement announcement.[110] The tie was, in his words, "100% linked" to the European market. Neither the delegated acts, adopted in February 2023, nor any recognised RFNBO scheme, recognised in December 2024, existed at that point. The plant was designed against the criteria all the same, "considering our internal knowledge on how the RFNBO rules were going to be approved", and the developer confirms: "Haru Oni was designed against the anticipated RFNBO criteria."[111]

The plant is small by design. Its build cost of roughly US$78 million and output in the low hundreds of thousands of litres a year are those of a demonstration facility. Its analytical weight comes from position rather than scale. It is the one site where the full chain from anticipated rule to issued certificate can be observed.

The design carries the criteria's signature. The plant is off-grid: a single directly connected wind turbine feeds the electrolyser. That is the direct-connection route of Article 3, which requires no matching of generation to consumption in time or place, and because the turbine was commissioned with the fuel plant the 36-month vintage condition is satisfied by construction. Generation is oversized relative to electrolysis, 3.4 MW of wind against a 1.2 MW electrolyser.[112] That ratio is consistent with H1, but a demonstration plant of this size is weak evidence for it: turbines come in standard sizes, and design margin at pilot scale has explanations unrelated to the criteria. The oversizing signal the analysis relies on is the storage and backup architecture of the filed designs (§5.4). What the ratio cannot carry, the developer's own confirmation does.

Anticipating the criteria required no inside knowledge. RED II created the RFNBO category in 2018 and directed the Commission to adopt the electricity methodology by 31 December 2021, Art 27(3), seventh subparagraph (now Art 27(6)). The criteria were therefore not merely foreseeable but statutorily due, and then overdue, throughout the plant's design and construction. The contested parameters, additionality and correlation, were debated in the Commission's public consultation on the draft act in mid-2022, while the plant was being built.[113] An off-grid, directly connected, new-build

[110] (HIF Global, 2025c)
[111] (A. Pedinian Mohr, personal communication, 1 July 2026)
[112] (HIF Global, 2026)
[113] (Hydrogen Europe, 2022)

configuration was robust to any plausible version of the outcome. A developer designing for the centre of gravity of that debate would have built what Haru Oni built.

The site matters to the design as much as the rules do. Magallanes offers wind among Chile's best, at average capacity factors near 50%,[114] and effectively no regional grid at project scale, the local system being small and cut off from Chile's central network. A project there is off-grid before any rule requires it to be, so geography settles in advance a question the criteria would otherwise pose. The same geography disposes of the location criterion for grid-drawing projects in the region. On the lead auditor's account, Magallanes has "a very rather small energy grid with no interconnection neither to adjacent Argentina nor to the rest of Chile. So this is by default its own bidding zone... So this criteria is off the table from the very beginning."[115]

Certification followed the regulatory calendar with a lag of months at each step. ISCC PLUS came first, in 2023,[116] on the developer's account "the closest certification scheme available, similar to ISCC EU RFNBO" at a time when no EU-recognised RFNBO scheme existed. Recognition of ISCC EU followed in December 2024,[117] and the developer "immediately worked our way to get the RFNBO certification."[118] The first certificate against the RED III framework issued on 23 June 2025,[119] and the renewal on 16 June 2026, following an on-site audit conducted 20–22 April, recording two minor non-conformities, both in the management system, and none in traceability, chain of custody, or greenhouse-gas accounting.[120]

Three qualifications matter. The first concerns what the anticipation shows. Building to criteria years ahead of their adoption is the regime operating through expectation rather than obligation. It is strong evidence that the production rules govern conduct before the demand architecture they serve has arrived – which is a claim about the criteria in

[114] (Chilean Ministry of Energy, 2021)
[115] (S. Rößler, personal communication, 17 July 2026)
[116] (HIF Global, 2023)
[117] Commission Implementing Decision (EU) 2024/3176
[118] (A. Pedinian Mohr, personal communication, 1 July 2026)
[119] (TÜV SÜD Industrie Service GmbH, 2025)
[120] (HIF Global, 2025a; TÜV SÜD Industrie Service GmbH, 2026)

the delegated acts, not about the RED III targets, whose transposition remains incomplete (Annex B).

The second concerns procurement. The pilot's core equipment is European: a Siemens Silyzer 200 electrolyser, a proton-exchange-membrane machine, which is the technology suited to variable wind input and the segment where non-Chinese manufacturing retains a substantial share (§6.1),[121] and a Siemens Gamesa turbine. Chapter 2's formative-phase prediction expects European procurement at a sheltered project, and an €8.23 million German federal grant plausibly points the same way.[122] The developer attributes the choice to strategic partnerships[123] – which is the confound §2.2 identified, acknowledged by the firm that made the purchase. Below those core units the picture is less European. The methanol-to-gasoline unit was built by Sinopec under an ExxonMobil licence, alongside a capture prototype supplied by Global Thermostat, a US direct-air-capture manufacturer.[124] Even the European pilot carries Chinese engineering in its balance-of-plant. The pilot therefore settles nothing about supplier origin in either direction.

The third concerns grandfathering, which does less work here than its text suggests. Article 11 disapplies only the additionality conditions on grid-drawn electricity (Annex B), and Haru Oni took the direct-connection route under Article 3, where additionality never applied; its 36-month vintage it met by construction. Asked whether grandfathering changed his thinking on design and timing, the developer answered "for the Chilean projects not really."[125] The energy comes from an onsite directly connected turbine, and there is no Magallanes grid large enough to supply projects of that size anyway. The binding constraints lie elsewhere: in correlation mechanics for grid-connected designs and in carbon.

[121] (HIF Global, 2026; Hydrogen Council, 2022)
[122] (BMWi, 2020)
[123] (A. Pedinian Mohr, personal communication, 1 July 2026)
[124] (OECD, 2023)
[125] (A. Pedinian Mohr, personal communication, 1 July 2026)

5.3 Carbon eligibility and project design

The carbon criteria have reshaped Haru Oni in operation. The plant's early public narrative featured DAC; its operating configuration rests on interim biogenic CO_2 from fermentation sources, with DAC being added.[126] The developer puts it plainly: "For RFNBO EU production, the CO2 eligibility is fundamental, and this means is fully driving the design of the plant, optimization, feedstock strategy and contracting rules."[127]

Chapter 4 sets out the regulatory logic. Point 10(a)'s industrial-capture route is gated by an effective-carbon-pricing condition, which Chile does not meet. That leaves two practical routes: DAC, expensive at pilot scale, and biogenic carbon, which Magallanes does not have locally.

Chile's biogenic CO_2 is concentrated in the Biobío region – more than seven million tonnes registered in 2022, largely from the cellulose industry – roughly 2,000 km north of the plant.[128] Transporting CO_2 that far counts against the fuel under the methodology, and the arithmetic is unforgiving. On an indicative calculation set out at Annex E, road transport over that distance would consume roughly half the fuel's entire greenhouse-gas budget before any process emissions are counted. The figures are order-of-magnitude, but they explain the behaviour observed: no remote e-fuels project trucks its carbon far. Where a project can source eligible carbon therefore determines where it can be built.

DAC removes the geographic constraint but imposes an energetic one. At 1.5 to 3 megawatt-hours per tonne of CO_2 it adds roughly 22–44% to a project's electricity demand,[129] competing with the electrolyser for the same power the electricity criteria govern. This is where the carbon axis feeds back into the electricity axis.

[126] (industrydecarbonization.com, 2023)
[127] (A. Pedinian Mohr, personal communication, 1 July 2026)
[128] (Hinicio, 2024; TotalEnergies H2 Magallanes, 2025; distance is the author's own estimate — great-circle Concepción to Punta Arenas is approximately 1,824 km, and greater by road or sea.)
[129] (Eke et al., 2025); see Annex E

The axis does not reach every project. Ammonia contains no carbon, so such projects sit outside these criteria altogether. That is why the carbon axis selects e-fuel projects as its cases, and why H2 Magallanes' binding constraints are electricity-side.

H2 predicts that carbon eligibility interacts with geography to shape design, and the prediction is visible inside a single project's evolution. The constraint did not appear in Haru Oni's certificate as a failure. It appeared in the project's sourcing strategy as an adaptation.

Dr Stefan Rößler generalises the observation from the audit side, and his account locates the asymmetry precisely between the two delegated acts. The electricity rules, he says, are "really, really high detail considered in the framework", covering "all eventualities where the electricity may come from… direct connection, grid connection, so on and so forth". The carbon conditions are not: "they're very strict and they're not business oriented whatsoever." The eligibility design produces a paradox he sets out directly. A producer "could build a furnace heated by waste wood" in South America, where there are "insane amounts of what they consider waste wood", and – provided its power and steam serve the facility – capture its CO_2 as an eligible source, even though that carbon is intentionally produced for capture. Meanwhile an existing fermentation plant that has vented CO_2 for years is ineligible without a national carbon price. His conclusion, voicing the rule's effect: "we would rather have them vent their CO2 than capture it and utilize it for RFNBO, which is, as of now, the only lucrative market I can use CO2 for."[130]

That is not a marginal complaint. On his account, projects "failed in early stage because they did not manage to get an eligible carbon source secured" – a constraint that stops projects before they start, rather than one they engineer around. The Uruguayan comparison at §5.6 supplies the control: same developer, constructible biogenic carbon, opposite outcome.

[130] (S. Rößler, personal communication, 17 July 2026)

5.4 The counterfactual, outcome by outcome

Testing H4 requires the rules' contribution to be separated from cost, finance and demand, and RQ3 is only answered honestly one outcome at a time. For each observed outcome the question is the same: would it plausibly obtain in a world with EU demand but no production criteria, everything else held constant? The standard in that world is annual matching – the loosest of the options described at Annex B, under which a producer balances generation against consumption across a whole year rather than hour by hour.

Take supplier origin first. In the counterfactual world projects still buy electrolysers, turbines and storage, and they still buy on cost. The developer's account of what drives procurement for the regional projects lists exactly those factors, and regulatory compliance does not appear among them.[131] That is what the rules themselves would lead one to expect, since nothing in the criteria attaches to equipment. Chinese manufacturing cost advantages exist independently of the EU rulebook.[132] The rules are causally inert at the node where origin is decided.

Configuration and scale are where the counterfactual bites. Without the criteria a Magallanes exporter still builds wind power, but nothing would force oversized generation, dedicated storage, single-site direct connection, or hour-resolved accounting.[133] Annual matching against a national grid mix permits leaner configurations, and it is the standard most certification regimes still apply.

The filed engineering shows the opposite. H2 Magallanes' environmental study commits to 616 turbines of 8 MW, each feeding seven electrolysis centres of some 3.85 GW, producing around 640,000 tonnes of hydrogen a year for an ammonia complex sized at up to 10,800 tonnes a day, at a cost close to US$16 billion,[134] with a battery system and gas backup interconnected between the process area and the electrolysis centres.[135] Generation is dispersed across the site rather than drawn from a public grid. The

[131] (A. Pedinian Mohr, personal communication, 1 July 2026)
[132] (International Energy Agency, 2025a, 2026a, pp. 94–104)
[133] (León et al., 2023)
[134] (TotalEnergies H2 Magallanes, 2025)
[135] (TotalEnergies H2 Magallanes, 2025)

engineering rationale for that arrangement is matching variable generation to conversion inside the project boundary, which is the hourly-matching problem materialised at five-gigawatt scale. The two projects are set side by side at Exhibit 6.

The modelling literature prices the same signature. Hourly matching adds on the order of a quarter to a third to hydrogen production cost against annual accounting,[136] and system studies find additionality the largest single component of the package.[137] Filed engineering is a conservative witness: it records what a developer commits to under the rules it expects, before any fuel is sold. Configuration and scale are rule-dependent. This sets the hardware bill Chapter 6 analyses.

Project viability rests on weaker evidence than either of the other two. It combines the documented record with reasoned judgment about a counterfactual demand world, and the claim is sized accordingly.

Chile's project population contracted during the window. H2 Magallanes filed its environmental study in May 2025 and its consolidated agency observations drew more than 800 items.[138] In September 2025 TotalEnergies requested suspension of the evaluation to 31 March 2027, granted only to 7 December 2026, to optimise the design and conduct further campaigns.[139] Around it, the field thinned. The regional industry association paused activities,[140] Ignis put its ammonia initiatives on hold,[141] and EDF cancelled its Magallanes project.[142] HIF moved in the opposite direction: its Cabo Negro expansion was approved in November 2025 at US$830 million for 173,600 tonnes of e-methanol a year, with the associated Faro del Sur wind park approved in February 2026 at the third attempt.[143] More than half of announced Chilean projects stood postponed

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[136] (Ruhnau & Schiele, 2023)
[137] (Hordvei et al., 2025; Namazifard et al., 2025)
[138] (TotalEnergies, 2025; TotalEnergies H2 Magallanes, 2025)
[139] (El Mercurio / Emol, 2025; pv magazine Latam, 2025; TotalEnergies H2 Magallanes, 2025)
[140] (Emol, 2026)
[141] (Fuel Cells Works, 2025)
[142] (Martin, 2025)
[143] (HIF Chile 1 SpA, 2025; HIF Chile & Enel Green Power, 2026; prior filings SEIA expedientes 2156419025, Res. Desistimiento 20221200196 of 6 October 2022, and 2160733311, Res. Desistimiento 20231200195 of 18 December 2023)

or cancelled by 2025 on the IEA's count,[144] and the 2026 review generalised the finding to the global export pipeline while reclassifying Chile's as far from realisation.[145]

In the counterfactual world the demand shortfall persists – unmet offtake, incomplete transposition, uncertain mandates – so suspensions plausibly occur regardless. What the rules add is cost and uncertainty at the margin. Compliance-driven configurations raise capital intensity, and a review that reopens the criteria adds regulatory risk to bankability, a channel industry submissions assert,[146] and the IEA records developers citing the criteria's costs amid regulatory uncertainty.[147] Rößler's account from the audit side matches it: developers fail to reach final investment decisions and run out of money under that uncertainty, especially on carbon eligibility, while the industrial hydrogen demand that would carry them is falling rather than rising.[148] Suspensions are demand-driven and rule-amplified. The rules are a contributing condition, not a sufficient one.

Exhibit 2, Panel B set out these three tests as predictions. The verdicts returned here answer them: inert on origin, decisive on configuration, amplifying on viability. That pattern is the empirical content of the amplification claim, and Chapter 6 carries it into the supply-chain analysis.

5.5 Brazil: the same rules, a segmented response

Brazil met the same external regime with a different domestic architecture. The 2024 framework law created a national low-carbon hydrogen system, the SBCH2. It defines low-carbon hydrogen at up to 7 kgCO_2e per kilogram – roughly double the EU's derived ceiling of 3.4 (Annex B) – and establishes a certification architecture now being implemented through the regulator.[149] A companion law created the PHBC programme of auctioned fiscal support.[150] Brazilian producers selling into the EU certify separately against the EU criteria.

[144] (International Energy Agency, 2025a, p. 83)
[145] (International Energy Agency, 2026a, pp. 86, 93, 198)
[146] (eFuel Alliance, 2026)
[147] (International Energy Agency, 2026a, p. 85)
[148] (S. Rößler, personal communication, 17 July 2026)
[149] Lei 14.948/2024 (Brazil), Art 4, XII
[150] Lei 14.990/2024 (Brazil)

The state's own planning agency describes the design intention plainly. It is an emissions-focused, technology-agnostic standard that avoids "requirements of difficult implementation in the context of a market under creation" (translated from the Portuguese). Domestic use and export are treated as complementary objectives, without planning-level trade-offs between them. Recent international flexibilisation is interpreted as gradual convergence toward this understanding, "by imposition of factual reality".[151] The effect is segmentation operating in fact rather than through any export-specific statute: a domestic standard for the internal market, with EU-facing exporters certifying separately where the export demands it.

Brazil shows that an alternative was available to Chile's single-track posture – H3's evidence in comparative form. Brazil legislated its own definitional regime rather than adopting the EU's; BNDES even sized national electrolyser demand under the draft act's correlation criteria, its constrained scenario nearly doubling the gigawatts required[152] – the Brazilian state planning under its own rules before they were even adopted.

Chile aligned single-track, promoting EU-compliant production without a distinct national standard[153] – a choice made early and deliberately. A World Bank–commissioned advisory urged Chile to design its scheme "outside-in," letting the importing markets' definitions set it, and to adopt an EU-compliant scheme on the CertifHy model.[154] Its Action Plan confirms as much: the certification system is built around import requirements[155] and CertHiLAC harmonisation[156] – compliance and alignment, without a Brazil-style domestic definition. The build runs across the decade, and the platform is operative only toward its end. In the interim, EU-recognised schemes remain the country's only live certification. Even the live promotion bill fits the pattern: a US$2.8 billion demand-side subsidy, not a certification regime.[157]

[151] (see also: Bacil et al., 2026; EPE, personal communication, 15 July 2026; Lira et al., 2025)
[152] (BNDES, 2022)
[153] (Chilean Ministry of Energy, 2020, p. 32; Ministerio de Energía, 2026, p. 7)
[154] (Hinicio, 2021, pp. 7, 40)
[155] (Ministerio de Energía, 2024, pp. 190–191)
[156] (OLADE, 2023)
[157] (Chilean Ministry of Economy, Development and Tourism, 2025)

Comparative scholarship attributes the divergence to state capacity and coalition politics rather than resource endowment.[158] This is the observable H3 predicts for Chile: instruments organised around compliance where a national strategy was available, with a benchmark case showing what the exercised alternative looks like. It is the rules-agency face of the finding; the supply-chain face is Chapter 6's.

The developer's within-portfolio view shows the same rules producing different design behaviour on either side of the comparison. Additionality is no constraint in Magallanes, because there is no grid to draw from. In Brazil it is "a hot topic", and one where "additionality criteria is definitely changing the way we develop the setup of the project and also the competitive of the project against other locations."[159] The same firm, the same rules, and the mechanism visible wherever geography does not pre-empt it.

The second feature is the equivalence question, which shows what the choice allocates. Chilean projects meet the EU's bidding-zone concept through auditor judgment under scheme guidance. Brazil's market structure was assessed centrally instead, CertifHy having published a central determination mapping Brazil's four electricity sub-markets to bidding zones.[160] The comparison does not show that segmentation is superior. It shows what the choice decides: who answers the regime's interpretive questions – a scheme's central determination in one case, a site auditor's judgment in the other.[161]

5.6 Uruguay: the carbon control

The Uruguayan comparison holds the developer constant and varies carbon geography. HIF's Paysandú project sits about six kilometres from ALUR's grain-ethanol plant, linked to it by a CO_2 pipeline, and the two signed an implementation agreement for biogenic CO_2 supply in December 2024.[162]

The filings undercut the co-location story. At full scale the plant is designed for 1,220,550 tonnes of CO_2 a year, of which 50,000 – about 4% – would come from ALUR's

[158] (Bacil et al., 2026; cf. Schorr et al., 2025)
[159] (A. Pedinian Mohr, personal communication, 1 July 2026)
[160] CertifHy Assessment on Bidding-Zone Equivalence: Brazil
[161] ISCC EU 202-6, Annex III, pp. 30–31
[162] (ALUR et al., 2024; ALUR & HIF Uruguay S.A., 2024; HIF Global, 2024)

fermentation. The remaining 920,000 are to be produced by three biomass boilers HIF builds itself, burning some 951,400 tonnes a year of forest residues trucked from within a 300-kilometre radius.[163] The developer's own project document is explicit that the boilers exist to turn forest waste into CO_2 and they are sized to run all four production trains with no ALUR supply at all.[164] Co-location is the siting rationale; purpose-built combustion is the supply. Roughly nineteen parts in twenty of the carbon are arranged for the purpose, not recovered from an existing emitter.

The signed agreement prices that distinction. It sets fermentation CO_2 at US$80 a tonne against US$10 for post-combustion CO_2, and requires RED II or III certification of both the gases and the biomass.[165] The eight-to-one gap between two biogenic streams is not a difference in the molecule; it tracks the regime's eligibility hierarchy, priced into a private contract before any certificate was sought.

That places Paysandú inside the eligibility paradox of §5.3 rather than outside it. Biomass-combustion CO_2 qualifies under point 10(c) where the sustainability criteria are met – subject to the rider excluding CO_2 from fuel burned solely to make it, a line the design addresses by feeding the boilers' power and steam to the plant.[166] Vented fermentation CO_2 in a country without a carbon price does not qualify. Uruguay's advantage over Magallanes is real, but it lies in a feedstock base that makes eligible carbon constructible. This is presented here as a live certification question rather than a settled outcome.

The electricity axis relaxes there because Uruguay's grid was 99% renewable in 2024.[167] This brings a project within Article 4(1) of the delegated regulation: where a bidding zone's renewable share exceeded 90% in the previous calendar year, grid electricity counts as fully renewable without additionality, subject to an annual cap on production hours set by the zone's renewable share. The developer confirms the point – additionality "is not an issue" in Uruguay "because Uruguay grid is over 90%

[163] (DINACEA, 2025b, pp. 6–7; HIF Uruguay S.A., 2025, pp. 28, 69–70); see Annex E.8
[164] (HIF Uruguay S.A., 2026, pp. 150–151); Delegated Regulation (EU) 2023/1185, Annex, point 10(c)
[165] (ALUR & HIF Uruguay S.A., 2024)
[166] (HIF Uruguay S.A., 2026, pp. 150–151)
[167] (ADME, 2025, p. 10; International Energy Agency, 2025b)

renewable."[168] Magallanes reaches the same outcome by the opposite route: no grid worth drawing from, so nothing for new capacity to be additional to.

Against Magallanes, where world-class wind coexists with an absence of local biogenic carbon, the contrast isolates H2's mechanism. Identical corporate capability, identical EU rules, divergent carbon geography, divergent design.

The pairing remains provisional. Environmental authorisation was pending at the cutoff, location viability having issued in November 2025, and a possible move to another site within Paysandú department was still under discussion in May 2026, with the national government contractually committed to the department.[169] The thesis uses the case as a controlled contrast on carbon sourcing only, not as an outcome comparison.

5.7 Findings on H1, H2 and divisibility

H1 is supported in the specific form predicted. Compliance-shaped configurations – oversizing, storage, off-grid direct connection – appear in project designs, and they appear anticipatorily, before the acts were adopted and before any mandate binds. The Brazilian comparison adds the mechanism operating where geography does not pre-empt it: the same developer reports additionality reshaping project setup there while calling it no constraint in Magallanes (§5.5).

H2 is supported with the geography interaction at its centre. Carbon eligibility redesigned the operating pilot's sourcing. It differentiates the Chilean and Uruguayan siting logics. And it binds more tightly with distance from biogenic sources. On the case evidence the carbon axis is the harder constraint for remote Chilean sites, which inverts the literature's emphasis on the electricity rules.[170] Rößler's audit-side account supports that inversion: the electricity rules are worked out in far higher detail than the carbon conditions, which have stopped projects at early stage (§5.3).[171]

The supplier-country prediction is not settled here. The sheltered pilot procured European core equipment, as the formative-phase logic predicts, but its procurement

[168] (A. Pedinian Mohr, personal communication, 1 July 2026)
[169] (DINACEA, 2025a; MercoPress, 2026; República Oriental del Uruguay & HIF Uruguay S.A., 2025)
[170] (cf. Schumm et al., 2025; White et al., 2025)
[171] (S. Rößler, personal communication, 17 July 2026)

was confounded by German co-funding and German industrial partners (§5.2). The test therefore falls to the fully regulated successors in Chapter 6.

On divisibility, the case evidence completes the §5.1 characterisation, and the developer puts it commercially: "the business case changes completely" between markets, "one site could be very good for RFNBO production, but not competitive for US market product."[172] That is divisibility as portfolio strategy, stated as routine.

The claim this chapter can sustain is narrower than accomplished separation. No producer in the corridor has yet been documented running one plant's output as certified into the EU and uncertified elsewhere, and the industry is too young for that record to exist. The evidence establishes that every structural precondition for separation is in place and none of the conditions that produce standardisation is. The accounting permits it: mass balance books certified and uncertified quantities side by side, and the Regulation requires the uncertified ones to be recorded.[173] The economics reward it, in the developer's own words. The perimeter at which it operates is fixed by the rules themselves, which make the mass balance site-specific.[174] Non-divisibility fails ex ante, by regime's own design, not by observation.

Where the separation gets organised is the finding this case adds. Bastos Lima and Schilling-Vacaflor describe divisibility arranged at sector level, by traders and intermediaries sorting compliant output towards the EU.[175] Hydrogen has no such layer: output moves under long-term bilateral offtake, and there is no merchant tier to do the sorting. Divisibility therefore relocates into the developer's own investment programme. The corridor already shows the pattern across projects – HyEx at Antofagasta is built for domestic mining-explosives offtake[176] and needs no RFNBO certificate to serve it – and the developer describes the same sorting performed inside a single portfolio. The obvious objection, that a plant like H2 Magallanes is built whole to one specification and looks indivisible, is answered one level up: industrial strategy lives in the

[172] (A. Pedinian Mohr, personal communication, 1 July 2026)
[173] Implementing Regulation (EU) 2022/996, Art 19(2)(f)
[174] Implementing Regulation (EU) 2022/996, Art 2(22); ISCC EU 203, §4.2
[175] (Bastos Lima & Schilling-Vacaflor, 2024)
[176] (Enaex, 2022)

programme, not the plant, and there the record shows developers routing sites by regime.

A third-country government gives the same separation institutional form, as Brazil's de facto segmentation shows (§5.5).

Failure of the strong effect is not absence of effect. What remains is a narrow one: complete governance of whatever chooses to be certified. The consequence – that a regime which governs conduct without converting markets also cannot transfer capability through market conversion – is taken up in the equipment-origin analysis of Chapter 6 and the theoretical assessment of Chapter 7.

Chapter 6 – Equipment origin & supply chains

6.1 The hardware bill and the supply that meets it

The preceding chapters established that the rules shape a project's configuration and inflate its scale; this chapter examines the resulting hardware. A compliant export project in Magallanes must procure a large order of wind turbines, electrolyser capacity, battery storage, power electronics, and balance-of-plant (the supporting equipment around the core units: compressors, transformers, piping, and controls). What sizes that order is not output alone but the compliance architecture. H2 Magallanes' filed study shows the scale, some US$16 billion of hardware in one project.[177] For an exporting country, demand on that scale is not a segment of the equipment market but most of it.

Each provision drives its own hardware (mapped in Exhibit 8). Additionality and correlation force generation oversizing and storage – turbines and balance-of-plant at multiples of electrolyser nameplate, and battery systems sized to bridge matching intervals. Since storage charged in the contracted renewable hour itself counts toward correlation, the batteries are compliance instruments, not accessories.[178] Coupling variable generation to electrolysis adds power electronics: converters, rectifiers, transformers. Direct-connection siting means dedicated infrastructure instead of shared grid assets, and the carbon criteria add DAC units or biogenic-supply logistics. Compliance shapes the quantities across the bill, but never the supplier.

The supply side of that market is concentrated, and the literature offers an institutional explanation. China's manufacturing system specialises in scaling-up – rapid commercialisation of technologies at volume – a capability documented across sectors long before hydrogen.[179] China accounts for roughly 60% of the world's electrolyser manufacturing capacity. That worldwide base stood at about 58 GW a year against

[177] (TotalEnergies H2 Magallanes, 2025)
[178] (A. Wolf, personal communication, 9 June 2026)
[179] (Nahm & Steinfeld, 2014)

average expected deployment of some 9 GW, an overcapacity now driving consolidation and aggressive pricing.[180]

Concentration is not uniform across the two key electrolyser technologies. Alkaline, the mature and low-cost type, is where China's dominance runs deepest: China's base is over 90% alkaline – around 32 GW a year, against roughly 2.5 GW of PEM.[181] Chinese stack-only bids in alkaline have fallen below eighty dollars per kilowatt, about a quarter of the reference range outside China.[182] PEM, the technology suited to variable renewables, is where non-Chinese manufacturing still competes: it is around 40% of the EU's electrolyser mix,[183] and its projected 2030 expansion is led by Europe.[184] That edge is not fixed, however, since Chinese manufacturers have begun upscaling PEM.[185] Alkaline, though far cheaper, handles variable input poorly on its own, idling below a minimum load. A least-cost answer, in the cases studied, is to co-install it with a smaller PEM fraction to absorb the variability, a mix China is already scaling.[186]

The cost-optimal design therefore rests mostly on cheap alkaline, where Chinese dominance is heaviest; and as China scales PEM, the pull may run towards Chinese supply whichever way the mix falls. The European PEM edge holds for now, while the corridor's projects are buying, and the formative-phase logic decides which of them can use it: the sheltered pilot could afford the pricier Western PEM whereas a cost-optimising project at gigawatt scale may not.

At system level the gap is wide but only partly closes on export: the IEA puts a Western electrolyser system installed outside China at 1,900–2,500 dollars per kilowatt against 500–1,100 for a Chinese system at home, narrowing once engineering and contingency are added abroad.[187] Diffusion is still early, though: Chinese manufacturers took 4.7 gigawatts of orders in 2025,[188] over 90% domestic, with under 7% (just over 300 MW)

[180] (International Energy Agency, 2026a, pp. 94–98, 103)
[181] (International Energy Agency, 2026a, p. 100)
[182] (International Energy Agency, 2026a, pp. 100, 103)
[183] (Bolard et al., 2024)
[184] (International Energy Agency, 2026a, pp. 96–97)
[185] (International Energy Agency, 2026a, pp. 96, 105)
[186](Hong et al., 2024)
[187] (International Energy Agency, 2026a, pp. 97–98)
[188] Manufacturing-capacity share, order share and installed-abroad share are three different metrics, and are not read against each other here. No installed-abroad share has been published: the 2025 review

exported.[189] Domestic overcapacity is pushing the leading manufacturers outward even so: the IEA records them broadening their international engagements despite that export share. In hydrogen the pattern has begun to show, with Chinese suppliers arriving as package-builders – the Morocco case pairs a 20 MW electrolyser order at 310 dollars per kilowatt with a research centre and sixty engineers, and a Chinese-financed electrolytic-ammonia project in Kenya has reached FID.[190]

The pattern is starker still in the adjacent categories. In storage, all ten of the top global battery storage cell suppliers were China-headquartered in 2025, accounting between them for over 90% of shipments.[191] In solar, upstream stages (polysilicon and wafers) exceed 80% Chinese share.[192] In wind, Chinese turbine pricing runs about a fifth below Western equivalents in export markets,[193] and Chinese firms hold the top slots in global manufacturer rankings.[194]

Chile's procurement record shows what happens when that supply meets a hardware-intensive demand. CORFO's 2021 first call – the programme that first put state co-finance behind the export ambition[195] – awarded fifty million dollars across six projects totalling 388 MW of electrolysis, within a facility whose headline financing capacity approaches a billion dollars.[196] Its 2025 technology programme awarded support to electrolyser manufacturing ventures including the Chinese producers Hygreen Energy and Guofu, alongside Spain's Joltech – so Chilean development money is reaching the very suppliers the EU’s own instruments treat as a dependency risk.[197] This is the general pattern rather than a Chilean peculiarity: host-country green-industrial policy attracts Chinese renewable-energy investment, by signalling government commitment where the investment environment is otherwise weak.[198]

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quantified only a 5–25% installed-cost advantage for Chinese equipment abroad, and the 2026 edition (used here) reports order books instead.

189 (International Energy Agency, 2026a, pp. 101–104)
190 (International Energy Agency, 2026a, pp. 177, 223)
191 (Hughes, 2026)
192 (International Energy Agency, 2022)
193 (EnergyWatch, 2024)
194 (Enerdata, 2024)
195 (CORFO, 2021a, 2021b)
196 (CORFO, 2023)
197 (CORFO, 2025; Hydrogen Insight, 2025)
198 (Xue et al., 2024, pp. 4, 9)

The two programmes differ in one analytically important respect. Origin is disclosed when equipment is the funded object, so the 2025 factory awards name their manufacturers. Origin is never disclosed when equipment is an input: the 2021 production call's published criteria contain no supplier or origin field at all. Chile's own instruments reproduce the certificate's pattern, making origin visible only where the machine itself is the point. Meanwhile a flagship storage-backed renewable project, Grenergy's Atacama complex, procures batteries from Chinese firm BYD.[199]

The documentary record shows the invisibility is systemic. Electrolysers lack a dedicated customs classification, so trade statistics cannot track the flows.[200] The certificate treats volumes as voluntary disclosure; its audit report records no certified fuel produced yet during the first period; and its only origin field concerns feedstock (§6.2).

Nobody, in short, publishes the figure the diversification debate is about, and the institution best positioned to publish it has not yet done so.[201]

None of this is a failure. It is cost-rational procurement inside a concentrated market, by a development agency whose mandate is deployment, not supplier screening. The corridor produces a conjunction no one designed: the EU rules determine how much hardware a compliant Chilean project must buy, and in what configuration; the market pushes a dominant share, at commercial scale, towards the suppliers the EU's own domestic policy flags as a dependency risk; and no instrument in the corridor connects the two facts.

6.2 The regime's silence on equipment

The certification framework does not regulate, record or observe equipment origin – a finding Chapter 4 established across the delegated acts, the greenhouse-gas system boundary, and the verification regime, down to the certificate's sole origin field marked "not applicable" (Annex B; the chain and its silences are set out at Exhibit 5). What is new is why the silence exists, and what the industry makes of it.

[199] (Energy-Storage.News / ESS-News, 2024)
[200] (International Energy Agency, 2026b)
[201] Author's background correspondence; non-attributable by agreement; recorded at Annex D.

Industry's own submissions confirm the boundary, and its association states: "the delegated acts... are to describe sustainability criteria, they are not meant for industrial policies", with origin belonging, on that account, to the funding instruments instead.[202] Equipment origin appears nowhere in the sector's regulatory asks, in either direction. The omission is shared across the corridor because no instrument makes it anyone's variable.

The silence is not an oversight in drafting. Equipment origin is absent because the regime's object is the fuel's environmental integrity, not the provenance of the plant that makes it. An equipment-origin condition on imported fuel would also be self-defeating, choking the very imports REPowerEU's 10 Mt target depends on by excluding the cheapest hardware. More fundamentally it would run against the trade-law position of a regime whose defensibility rests on regulating product characteristics rather than producers' nationality. The WTO panels on the EU's palm-oil measures confirm this on both counts. The RED II palm-oil measures were held to be technical regulations within the TBT Agreement's discipline, and the EU was found wanting not for setting them but for administering them, including failures of timely review and of the design of its low-ILUC exemption.[203] A nationality test on the product would surrender exactly that defence.

The claim is therefore not that the EU overlooked equipment origin in the rules; it is that the design places it outside them by necessity. As §6.3 shows, equipment origin remains a live concern for the EU – one it pursues through the instruments it operates for itself.

6.3 The domestic contrast: origin regulated at home

Outside the certification regime, the EU regulates equipment origin with increasing specificity across the Net-Zero Industry Act,[204] the Critical Raw Materials Act,[205] the

[202] (T. Block, personal communication, 7 July 2026; eFuel Alliance, 2026)
[203] Panel Report, EU – Palm Oil (Malaysia), WT/DS600/R, adopted 26 April 2024; Panel Report, EU – Palm Oil (Indonesia), WT/DS593/R, adopted 24 February 2025
[204] Regulation (EU) 2024/1735 (Net-Zero Industry Act); Implementing Regulation (EU) 2025/1176
[205] Regulation (EU) 2024/1252 (Critical Raw Materials Act), Art 5(1)(b)

Hydrogen Bank's IF24/IF25 auctions[206] and the proposed Industrial Accelerator Act.[207] Union manufacturing benchmarks, resilience triggers and funding conditions steer sourcing and capacity away from single-country dependence, and Annex F.1 sets out the instruments and thresholds in full.

The Hydrogen Bank goes furthest, capping Chinese electrolyser-stack capacity at a quarter, on an explicit rationale of irreversible dependency. The cap is the Commission's own design, not a concession to industry. Where industry lobbied at all, it pressed for a stricter in-Europe pass/fail test.[208] The European hydrogen association's resilience proposals address public funding instruments and stop at the import boundary, saying nothing on imported fuel.[209]

Politically, an origin test on imported fuel would be self-defeating for the same reason (§6.2); institutionally, the gap is unowned. Trade-defence instruments reach goods entering the Union; the foreign-subsidies regime reaches bidders in the Union's market; neither reaches Chinese equipment embedded in a third-country plant whose certified output the Union imports. That seam between the trade, industrial and energy files currently has no Council formation responsible for it.[210]

Set side by side, the two positions form an asymmetry: on its internal funding and deployment, the EU screens, caps, and conditions equipment origin; on its imported fuel, it does not. A molecule of Chilean e-fuel thus enters certified against criteria that track every kilowatt-hour and gram of CO_2 behind it, yet nothing about the equipment that made it.

The asymmetry follows from instrument design: funding conditionality can discriminate where product regulation cannot, for the trade-law reasons §6.2 gives. But its cost falls on the exporter. The EU secures diversification for its own build-out through instruments Chile has no part in, while the corridor's Chilean end, governed only by the origin-blind certificate, has no equivalent unless it builds one. The Union does back one renewable-

[206] (European Commission, 2025; European Commission, DG CLIMA, 2024)
[207] COM(2026) 100 (Industrial Accelerator Act – proposal)
[208] (European Commission, DG CLIMA, 2024; Hydrogen Europe, 2024b, 2024a)
[209] (Hydrogen Europe, 2024b)
[210] Author's background communication with an EU official; non-attributable, recorded at Annex D

hydrogen facility for Chile, with the EIB and KfW, of up to €216.5m,[211] but this funds production for export, not manufacturing capability. Chile's own instruments point the other way: CORFO's manufacturing support co-finances Chinese entry.[212] Neither government has yet named the dependence, and the term-level review below finds the vocabulary missing on both sides.[213]

6.4 Implications for Chilean industrial development: the supply-chain face of agency

§5.5 gave the first face of Chile's agency: it does not set the rules its sector produces under, though Brazil shows it could. This section explores the second – agency over the supply chain. The two are one finding: a latecomer governing neither the rules nor the industrial base of its flagship sector. That §6.3 imbalance keeps the second face closed.

The section is read against the three criteria Chapter 3 set. On standard-setting agency, none is exercised: the single-track position documented at §5.5, with the rules named in national planning only in passing. On capability formation, nothing provides for it – no instrument on either side attaches capability to certified production, and procurement runs on cost. On linkage creation, none is built in – the strategy's local-value pillar is aspirational, without any instrument to enact it. On all three, the instruments of the promoting state organise around hosting and compliance rather than capability, and thus H3 is supported.

That silence carries a capability cost, and the development literature says why: local capability does not follow resource endowment automatically. Chile has run resource-linked industrial policy before, and the evidence from its extractive sectors shows that local capability follows deliberate linkage policy, and even then unevenly.[214] The sector-specific evidence agrees: the principal Chilean linkage study, on Antofagasta, finds hydrogen's linkage potential real but policy-dependent,[215] and the development-strategy

[211] (European Investment Bank, 2025)
[212] (CORFO, 2025)
[213] (Buffi & Motola, 2026; Ministerio de Energía, 2026)
[214] (Lebdioui, 2019, 2020)
[215] (Scholvin, 2023)

literature for hydrogen in emerging economies reaches the same conclusion for the current wave.[216]

Three facts bound what is currently possible in green hydrogen. First, there is no mandatory local-content rule in Chile's framework, and the strategy's local-value pillar operates through aspiration and support programmes rather than requirements.[217] Second, the external rule-set through which the export market is constituted contains, as §6.2 established, no provision that rewards, records, or even renders visible any local-capability contribution: a project scoring identically on every certified criterion may source globally or locally, build capability or not. Third, WTO law disciplines the space for hard local-content requirements.[218]

Two counter-readings deserve their strongest form before the implication is drawn. The first holds that origin-blindness is a virtue: a nationality-blind product rule survives trade-law scrutiny and keeps compliance costs down (§6.2). But the virtue justifies the absence of origin conditions, not of origin visibility, and it says nothing about the EU's parallel instruments. The asymmetry stands on the most charitable reading.

The second holds that capability is Chile's own business, with policy space available through its instruments and its trade agreements. Here the record answers. The binding instrument, the EU–Chile Interim Trade Agreement (ITA) in force since 1 February 2025, disciplines export pricing in its energy and raw-materials chapter and performance requirements in its investment chapter while leaving linkage promotion to soft cooperation provisions; the fuller Advanced Framework Agreement is not yet in force.[219] Chile's own instruments, as this chapter shows, currently co-finance the concentration rather than counter it. Policy space exists; nothing in the corridor's architecture prompts its use.

The developer's perspective closes the loop empirically. Asked what drives equipment selection, HIF's regional commercial lead lists capital and operating cost, product

[216] (Bacil et al., 2025)
[217] (Ministerio de Energía, 2026)
[218] (de Lima Figueiredo, 2022; X. Li & Du, 2025)
[219] (Dünhaupt et al., 2025; ISPI, 2025); EU–Chile Interim Trade Agreement, Ch 8 (Energy and Raw Materials) and Ch 10 (Investment Liberalisation)

quality, reliability and financial strength, with partnerships a further influence. Certification does not enter the list, because it has nothing to say at that node.[220] Generalised across many projects buying in a concentrated market, that is the pattern §6.1 documented, and the window implication follows (Exhibit 10): hosting certified projects, however successfully, does not of itself move Chile along any capability dimension the green-windows literature treats as decisive, and the years in which hosting proceeds are the years in which manufacturing returns accumulate elsewhere.[221]

The strategy documents on both sides share a blindness, and it is measurable at term level across three governing documents. In the Commission's technology observatory report on RFNBOs, dependence appears only as dependence on imported fossil fuel, China appears only as a production rival, equipment provenance is never analysed, and Chile, third countries, and strategic autonomy receive zero mentions; the trade section records that "So far, no trade has been recorded beyond demo-activities", in a document whose subject-matter name contains the word origin.[222] The Commission's acceleration communication uses import exclusively for fossil energy and locates new strategic dependencies in EU manufacturing capacity rather than in the supply chains of the projects its rules certify abroad.[223] Chile's Action Plan mirrors the pattern, naming the EU's regime only obliquely, as "the import requirements being discussed in Europe" – the closest its planning documents come to naming the rules its export sector is built against.[224]

An official with a view of the region locates certification's arrival late in the policy sequence, at implementation and export rather than in early dialogue.[225] That is consistent with the documentary pattern. The question is not anyone's assigned business at either end of the corridor, and the instruments reflect that absence.

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[220] (A. Pedinian Mohr, personal communication, 1 July 2026)
[221] (Lema et al., 2020; Orihuela et al., 2025)
[222] (Buffi & Motola, 2026)
[223] COM(2026) 370 final (AccelerateEU)
[224] (Ministerio de Energía, 2024, p. 190)
[225] Author's background communication with an official of the EU's external service; non-attributable, recorded at Annex D

6.5 Attribution

H4 can now be assessed in full. The hypothesis predicted amplification rather than causation, and the evidence supports precisely that division.

The rules do not cause Chinese supplier selection. Origin is decided by cost, in a market whose concentration predates and exceeds anything the hydrogen rulebook touches, and the certification framework is inert at the selection node. Exhibit 9 sets the rulebook against the other causal factors and ranks it third, behind China's cost and scale advantage and the demand slump.

The rules do amplify, through three channels the case makes concrete (Exhibit 7). The engineering channel inflates and shapes the hardware bill, projecting existing concentration onto a larger, rule-configured demand (§6.1). The silence channel leaves no countervailing provision – no disclosure, no diversification incentive, no capability linkage – and the certificate, alone among the instruments that could have carried one, reaches every EU-bound project and carries none (§6.2–6.3). The cost channel raises project cost and, in a weak market, the viability threshold, sharpening the pressure toward cost-optimal, concentrated procurement (§6.1). The §5.4 counterfactuals map onto the three, one to one.

The formative-phase rider can now be closed. At the pilot, shelter bought diversity – European core equipment, on a German grant and with German partners – consistent with the prediction but unable to confirm it (§2.2, §5.7). At the regulated tier the record is procurement-adjacent, short of firm purchase orders (the Chapter 2 confidentiality limit), but its elements point one way: commercial-scale buying meets the alkaline price curve, the segment Chinese supply dominates, state co-finance is pulling Chinese suppliers in rather than out, and the storage layer is already contracted to Chinese firms at the flagship projects (§6.1). The developer's stated drivers are non-regulatory (§6.4).

Shelter bought diversity; cost pressure buys concentration. The divergence the rider predicted is what the record shows, on the side where the evidence can bear weight, and the mechanism survives its built-in test in that qualified form. The conjunction is the thesis's answer to RQ3, and H4 is confirmed in the split form it predicted: the regime amplifies a dependence it did not create, while withholding the visibility that would be the minimum condition for anyone to govern it.

This sizes the claim: amplification sits between the race-to-the-top reading of EU standards and the strong-dependency reading, and the case supports it in that form and no stronger. §7.2 develops the placement.[226]

[226] (cf. Altenburg & Strohmaier, 2025; Weber, 2025)

Chapter 7 – Conclusions

7.1 Findings

The thesis asked what the EU's RFNBO rules govern in practice in Chile, and what falls outside their scope. The answer has three parts.

First, the rules govern early and specifically. Their operational consequences are visible in project engineering – oversized generation, storage, direct connection, siting, and carbon-sourcing strategy – and some were visible before the delegated acts were adopted, because a first-mover project built to the acts' anticipated requirements.

Second, the rules' scope has a definite edge. Certification examines electricity, carbon and emissions intensity. It does not examine equipment provenance or capability contribution, so the same Union that caps Chinese content in its domestically funded electrolysers imports certified fuel with no record of the hardware it embodies.

Third, attribution divides three ways. Supplier concentration is cost-caused; configuration and scale are rule-caused; and project viability is demand-driven and rule-amplified. The regime amplifies a dependence it did not create and does not observe.

Set against the questions: RQ1 is answered by the two-axis mechanism and its anticipatory operation (H1, H2); RQ2 and RQ3 by one finding with two faces (H3, H4). Chile governs neither the rules under which its flagship sector produces – Brazil's benchmark shows a national strategy was available – nor the supply chain it builds with, where the rules amplify a hardware demand that cost, not regulation, ultimately sources.

Beneath the findings sits the market fact the thesis has carried throughout. The demand side of this regime remains largely unrealised – 6% of announced global e-fuels projects at final investment decision, transposition incomplete, targets under review.[227] The effects documented here are therefore not those of trade. They are the effects of rules

[227] (eFuel Alliance, 2026; International Energy Agency, 2026a)

operating through anticipation, certification and design, which makes their scope – what they govern and what they leave ungoverned – the central object of evaluation.

7.2 Theoretical implications

For the Brussels Effect literature, the case supplies a scope condition with documentary precision. Where the accounting rules that constitute a product's regulatory identity make compliance divisible, the strong effect's conversion mechanism is unavailable, and what remains is conduct governance over the compliant stream.[228] Mass balance does exactly that, by design (Annex B).[229] Divisibility here is not a market accident but is written into the regime's machinery, which is why the condition can be assessed before the trade it would govern has occurred.

Bradford's own examples are market variants and separate production locations,[230] and Bastos Lima and Schilling-Vacaflor place the sorting at sector level;[231] hydrogen, as §5.7 shows, has no such intermediary tier, so the sorting moves upstream into the firm's own portfolio. Where an industry lacks that layer, non-divisibility does not follow.

For Market Power Europe and territorial extension, the case shows the mechanism operating through anticipation. Market Power Europe carries no non-divisibility condition, which is why it survives exactly where the strong Brussels Effect fails: it needs only market access as leverage, without a globalising standard. It transmits requirements, not capabilities.

For the green-windows literature, the case adds the externally set institutional window as a distinct analytical object. When the constitutive rules of a green market are written outside the latecomer's polity, the window's terms are exogenous and the latecomer's agency is narrowed on both faces – over the rules and over the capability the sector could build. On all three criteria Chapter 3 set, the Chilean record returns the narrow verdict documented by Chapter 6.[232] Against a strong-dependency reading, the case shows no necessity: Brazil's segmentation and Uruguay's carbon geography mark

[228] (Bradford, 2012; cf. Weber, 2025)
[229] Implementing Regulation (EU) 2022/996, Art 19(2)(f)
[230] (Bradford, 2020, pp. 54, 62–63)
[231] (Bastos Lima & Schilling-Vacaflor, 2024)
[232] (Lema et al., 2020; Orihuela et al., 2025)

margins of manoeuvre, and Chile's position is a choice, not a fate. The window constrains that agency; it does not extinguish it.

The finding also holds a mirror to the weaponised-interdependence literature. Where that work studies powers exploiting network chokepoints deliberately, this case shows a regulatory design channelling dependence towards a third country's supply chains inadvertently – influence and vulnerability produced by the same instrument.[233]

The sequence behind the regime makes the same point in historical form. REPowerEU, the Union's exit from Russian energy dependence, set the import ambition under which these rules operate,[234] and the import channel those rules now certify runs on hardware whose manufacture concentrated in China. One dependence was exited by way of another, and the second, unlike the first, accumulates without record.

The combination travels on a stateable condition. Wherever regulatory authority and manufacturing capacity are geographically misaligned and the regulated activity is hardware-intensive, the same amplification structure should appear. That is why certified-commodity corridors – sustainable aviation fuel, low-carbon steel, and, prospectively, carbon-accounted imports generally – are the predicted next cases.

7.3 Policy directions

Full recommendations are developed in the addendum. Four directions follow from the findings, each disciplined by Chapter 6's trade-law limits.

First, sequence demand before stringency. The review now under way concerns the criteria's strictness. The findings locate the binding failure in the market those criteria assume – transposition, target credibility and offtake – so a revision that relaxes production rules without completing demand-side implementation treats the wrong constraint.[235]

Second, make origin visible without conditioning on it. A disclosure line recording equipment make and origin would breach no product-regulation principle, add trivially

[233] (Farrell & Newman, 2019)
[234] COM(2022) 230 final (REPowerEU Plan)
[235] (Bellona Europa, 2026; H2 View, 2026; International Energy Agency, 2026a)

to audit cost, and give the EU's observatory and the exporter's ministries the data both lack.[236]

Third, point existing finance at capability. Conditioning the EU–EIB–KfW facility's tranches[237] on capability, not than offtake alone is the WTO-robust route to the linkage the certificate cannot carry,[238] and where trade-policy thinking is heading as the case grows for treating climate-critical industrialisation permissively.[239]

Fourth, give exporters a seat in reviews. Article 10's mid-2028 report excludes supply chains and third-country implementation, and no standing channel brings exporter evidence into the review cycle, so a standing exporter-evidence track is the procedural version of the rest.[240]

7.4 Limitations and further work

The limits stated in Chapter 2 hold: commercial confidentiality around procurement, a single corridor, a thin operating base, rules under revision, and counterfactual inference disciplined but not eliminated by design.

Three developments will test the findings in the near term, and the dated addendum will record them: the expected revision of the delegated acts, whose treatment of the demand side and of origin will test the policy analysis; the exchanges still open across the certification chain, recorded as pending in Annex D; and Haru Oni's first certificate period with certified output – as of submission, the audit record shows none yet.

The research programme the thesis opens is comparative and prescriptive in turn. Comparatively, the same framework applied to Brazil's segmented position, Namibia's corridor,[241] Morocco's – where Chinese package-building is already visible[242] – and the adjacent certified-commodity regimes identified in §7.2, would establish whether the

[236] (Buffi & Motola, 2026); see §6.2
[237] (European Investment Bank, 2025)
[238] (de Lima Figueiredo, 2022)
[239] (J. A. Mathews, 2017; J. A. Mathews & Reinert, 2014)
[240] (ERGaR et al., 2026; H2 View, 2026)
[241] (Altenburg & Kantel, 2024)
[242] (International Energy Agency, 2026a, p. 223)

amplification pattern and the origin silence are general properties of Europe's external climate regulation, as the analysis predicts.

Prescriptively, the diplomatic layer is the natural sequel. Certification cannot carry development bargains; partnership instruments can. What a jointly governed framework between the EU and RED-adapting partner countries would look like, with capability finance and exporter voice designed in, is the follow-up study the addendum begins to scope.

The direction is not speculative. The RED framework is already being copied and amended into other jurisdictions' rules, and a practitioner inside the certification machine identifies cross-compliance between such frameworks as a change that would materially reduce project risk.[243] Hydrogen diplomacy is becoming a standard fixture of economic diplomacy in several countries;[244] the finding here is that the corridor's most consequential instrument has been running without it.

[243] (S. Rößler, personal communication, 17 July 2026)
[244] (IRENA, 2022)

Bibliography

ADME. (2025). *Informe Anual 2024* [Informe anual]. Administración del Mercado Eléctrico (ADME), Uruguay. https://adme.com.uy/db-docs/Docs_secciones/nid_526/Informe_Anual_2024.pdf

Altenburg, T., & Kantel, A. (2024). *Green hydrogen in Namibia: Opportunities and risks* (IDOS Discussion Paper 6/2024). German Institute of Development and Sustainability (IDOS). https://www.idos-research.de/fileadmin/user_upload/pdfs/publikationen/discussion_paper/2024/DP__6.2024.pdf

Altenburg, T., & Strohmaier, R. (2025). Low-emission hydrogen: Global value chain opportunities for latecomers and industrial policy challenges. *Journal of International Business Policy*, *8*(3), 319–340. https://doi.org/10.1057/s42214-025-00217-7

ALUR, HIF Global, & ANCAP. (2024, December). *ALUR y HIF Global firman Acuerdo de Implementación para suministro de CO2 biogénico (Paysandú)*. ANCAP. https://www.ancap.com.uy/20546/6/alur-y-hif-global-firman-acuerdo-de-implementacion-para-avanzar-en-planta-de-e-combustibles-en-uruguay.html

ALUR & HIF Uruguay S.A. (2024, December 23). *Acuerdo de Implementación entre HIF Uruguay S.A. y Alcoholes del Uruguay S.A. (versión de firma)*. https://www.ancap.com.uy/innovaportal/file/20546/1/hif-alur---acuerdo-de-implementacion-version-de-firma---signed.pdf

Amsden, A. H. (1989). *Asia's Next Giant: South Korea and Late Industrialization*. Oxford University Press.

Antunes de Oliveira, F., & Kvangraven, I. H. (2023). Back to Dakar: Decolonizing International Political Economy through Dependency Theory. *Review of International Political Economy*, *30*(5), 1676–1700. https://doi.org/10.1080/09692290.2023.2169322

Bacil, F., Black, A., Domingues, M., Jin, J., Lema, R., Robbins, G., & Scholvin, S. (2025). *Development strategies for the green hydrogen economy in emerging economies*. UNU-MERIT. https://doi.org/10.53330/LGYE5230

Bacil, F., Black, A., Domingues, M., Jin, J., Lema, R., Robbins, G., & Scholvin, S. (2026). Seizing the green hydrogen opportunity? Comparing strategies for industrial transformation in latecomer countries. *Energy Policy*, *211*, 115111. https://doi.org/10.1016/j.enpol.2026.115111

Backhouse, M., Graf, A., & Landherr, A. (2025). The coloniality of green transformation: Green hydrogen and lithium value chains in South America. *The Sociological Review*. https://doi.org/10.1177/00380261251391002

Bastos Lima, M. G., & Schilling-Vacaflor, A. (2024). Supply chain divergence challenges a 'Brussels effect' from Europe's sustainability regulations. *Global Policy*, *15*(2), 260–275. https://doi.org/10.1111/1758-5899.13326

Beach, D., & Pedersen, R. B. (2019). *Process-Tracing Methods: Foundations and Guidelines* (2nd edn). University of Michigan Press.

Bell, M., & Pavitt, K. (1993). Technological Accumulation and Industrial Growth: Contrasts Between Developed and Developing Countries. *Industrial and Corporate Change*, *2*(2), 157–210. https://doi.org/10.1093/icc/2.2.157

Bellona Europa. (2026, July 3). *Joint publication: Evidence for an effective RFNBO review*. Bellona Europa. https://eu.bellona.org/2026/07/03/joint-publication-evidence-for-an-effective-rfnbo-review/

Bennett, A., & Checkel, J. T. (2015). *Process Tracing: From Metaphor to Analytic Tool*. Cambridge University Press. https://doi.org/10.1017/CBO9781139858472

BMWi. (2020). *Zuwendungsbescheid—Förderung Projekt Haru Oni (Siemens Energy), GBER Art. 36*. BMWi (via FragDenStaat FOI #274741). https://fragdenstaat.de/en/request/vereinbarung-ueber-foerderung-von-projekt-haru-oni-zwischen-ihrem-ministerium-und-siemens-energy/

BNDES. (2022). *Hidrogênio de baixo carbono: Oportunidades para o protagonismo brasileiro na produção de energia limpa*. BNDES. https://web.bndes.gov.br/bib/jspui/handle/1408/22665

Bolard, J., Dolci, F., Gryc, K., Eynard, U., Georgakaki, A., Letout, S., & European Commission, Joint Research Centre. (2024). *Clean Energy Technology Observatory: Water Electrolysis and Hydrogen in the European Union—2024 Status Report on Technology Development, Trends, Value Chains and Markets* (EUR 40075; JRC139364). Publications Office of the European Union, Luxembourg. https://doi.org/10.2760/0461008

Bradford, A. (2012). The Brussels effect. *Northwestern University Law Review*, *107*(1), 1–67.

Bradford, A. (2020). *The Brussels effect: How the European Union rules the world*. Oxford University Press. https://doi.org/10.1093/oso/9780190088583.001.0001

Braunstein, J., & Chuchko, M. (2025). Resource curse in the age of critical minerals: Geopolitical forces and market maturity. *Energy Research & Social Science*, *127*, 104247. https://doi.org/10.1016/j.erss.2025.104247

Buffi, M., & Motola, V. (2026). *Clean Energy Technology Observatory: Renewable Fuels of Non-Biological Origin in the EU — 2025 Status Report* (No. JRC144471). Publications Office of the European Union. https://doi.org/10.2760/3760952

Cardoso, F. H., & Faletto, E. (1979). *Dependency and Development in Latin America*. University of California Press.

Carrasco, S., Flores, C., Maillet, A., Tapia, D., Cariaga, V., & Muñoz, C. (2026). A trapped green industrial policy? The challenges to lithium and green hydrogen development in Chile. *World Development*, *204*, 107409. https://doi.org/10.1016/j.worlddev.2026.107409

CertifHy. (2025). *CertifHy Assessment on Bidding-Zone Equivalence: Brazil (V2)*. CertifHy / Hinicio. https://www.certifhy.eu/wp-content/uploads/2025/11/CertifHy-Decision-on-Brazil_V2.pdf

Cherp, A., & Jewell, J. (2014). The concept of energy security: Beyond the four As. *Energy Policy*, *75*, 415–421. https://doi.org/10.1016/j.enpol.2014.09.005

Chilean Ministry of Economy, Development and Tourism. (2025, December 3). *Cámara de Diputados aprueba proyecto de Ley de Fomento a la Industria del Hidrógeno Verde y pasa al Senado*. Ministerio de Economía, Fomento y Turismo. https://www.economia.gob.cl/2025/12/03/camara-de-diputados-aprueba-proyecto-de-ley-de-fomento-a-la-industria-del-hidrogeno-verde-y-pasa-al-senado.htm

Chilean Ministry of Energy. (2020). *National Green Hydrogen Strategy: Chile, a clean energy provider for a carbon neutral planet*. Government of Chile. https://energia.gob.cl/sites/default/files/national_green_hydrogen_strategy_-_chile.pdf

Chilean Ministry of Energy. (2021). *Identificación de Potenciales Renovables: Caso Eólico. Hidrógeno Verde en la Región de Magallanes y de la Antártica Chilena*. Ministerio de Energía. https://exploradores.minenergia.cl/portal-ernc/websites/Magallanes_White_Paper_Edicion_Feb20.pdf

Chilean National Energy Commission. (2025). *Reporte Mensual del Sector Energético—Diciembre 2025*. Comisión Nacional de Energía. https://www.cne.cl/wp-content/uploads/2025/12/RMensual_v202512.pdf

Collier, D. (2011). Understanding Process Tracing. *PS: Political Science & Politics*, *44*(4), 823–830. https://doi.org/10.1017/S1049096511001429

Cooperativa.cl. (2024, July 25). Proyecto de amoniaco verde invertirá histórica cifra de US$11.000 millones en Magallanes. *Cooperativa.cl*. https://www.cooperativa.cl/noticias/economia/sectores-productivos/proyecto-de-amoniaco-verde-invertira-historica-cifra-de-us-11-000/2024-07-24/232153.html

CORFO. (2021a). *First Call for the Financing of Green Hydrogen Projects in Chile*. Corfo.

CORFO. (2021b, December 27). *CORFO adjudica el primer llamado de financiamiento de hidrógeno verde (US$50M; 6 proyectos)*. CORFO. https://www.corfo.gob.cl/sites/cpp/nacional/27_12_2021_ganadores_hidrogeno_verde

CORFO. (2023, June 19). *CORFO lanza Facility de US$1.000 millones para el hidrógeno verde*. CORFO. https://corfo.cl/sites/cpp/sala_de_prensa/nacional/19_06_2023_fondo_hidrogeno_verde

CORFO. (2025, March 18). *CORFO adjudica fabricación y/o ensamblaje de electrolizadores en Chile (US$25.6M; 3 consorcios)*. CORFO. https://www.corfo.gob.cl/sites/cpp/nacional/18_03_2025_electrolizadores

Damro, C. (2012). Market power Europe. *Journal of European Public Policy*, *19*(5), 682–699. https://doi.org/10.1080/13501763.2011.646779

Damro, C. (2015). Market Power Europe: Exploring a dynamic conceptual framework. *Journal of European Public Policy*, *22*(9), 1336–1354. https://doi.org/10.1080/13501763.2015.1046903

de Lima Figueiredo, N. (2022). *Local Content Requirements in WTO Law: Between Free Trade and the Right to Development* [Doctoral Thesis, Maastricht University & Universidade de São Paulo]. https://doi.org/10.26481/dis.20220914nf

Dejonghe, M., & Van de Graaf, T. (2025). Green colonialism or green transformation? The equity implications of clean hydrogen trade. *Political Geography*, *120*, 103338. https://doi.org/10.1016/j.polgeo.2025.103338

DINACEA. (2025a). *Certificado de Clasificación de Proyecto y Declaración de Viabilidad Ambiental de Localización—Planta de e-Combustibles HIF Paysandú*. DINACEA, Ministerio de Ambiente (Uruguay). https://www.ambiente.gub.uy/oan/wp-content/uploads/2025/09/Certificado-de-CdP-y-VAL.pdf

DINACEA. (2025b). *Informe de Clasificación y VAL — Planta de e-Combustibles HIF Paysandú (Exp. EM2025/36001/011700)*. DINACEA, Ministerio de Ambiente

(Uruguay). https://www.ambiente.gub.uy/oan/wp-content/uploads/2025/09/Inf.-de-Clasificacion-y-VAL.pdf

Dos Santos, T. (1970). The Structure of Dependence. *American Economic Review*, *60*(2), 231–236.

Dünhaupt, P., Gräf, H., Jiménez, V., & Jungmann, B. (2025). *Industrial Policy Space in Emerging Economies: The Case of Chile's Lithium Industry and the Energy and Raw Materials Chapter in the EU-Chile Free Trade Agreement* (No. 251/2025; IPE Working Paper). Institute for International Political Economy (IPE), Berlin School of Economics and Law (HWR Berlin). https://ideas.repec.org/p/zbw/ipewps/313641.html

Eder, J., & Rammer, J. (2025). *Greening the European economy at the expense of other world regions? Tracing the EU's quest for green hydrogen in Chile* (ICAE Working Paper Series No. 168). Johannes Kepler University Linz, Institute for Comprehensive Analysis of the Economy (ICAE). https://www.econstor.eu/bitstream/10419/330252/1/1937955273.pdf

eFuel Alliance. (2026). *Revision of the Renewable Energy Framework: Aligning RFNBO Production Criteria with Industry Realities and Additional Measures* [Position paper]. eFuel Alliance. https://www.efuel-alliance.eu/fileadmin/Downloads/Positionspapiere/260625_eFuel_Alliance_new_position_RFNBO_DAs.pdf

Eke, V., Sahu, T., Ghuman, K. K., Freire-Gormaly, M., & O'Brien, P. G. (2025). A comprehensive review of life cycle assessments of direct air capture and carbon dioxide storage. *Sustainable Production and Consumption*, *55*, 217–241. https://doi.org/10.1016/j.spc.2025.02.017

El Mercurio / Emol. (2025, September 23). *Empresa de US$16 mil millones suspende proyecto de hidrógeno en Magallanes*. El Mercurio / Emol. https://www.emol.com/noticias/Economia/2025/09/23/1178537/empresa-us16-mil-millones-proyectomagallanes.html

Emol. (2026, March 4). *Gremio del hidrógeno verde en Magallanes paraliza sus actividades por la 'inexistencia de un mercado consolidado'*. Emol. https://www.emol.com/noticias/Economia/2026/03/04/1193279/hidrogeno-verde-megallanes-chile.html

Enaex. (2022, June 17). *HyEx—Green Hydrogen and Green Ammonia (Engie–Enaex project page)*. Enaex. https://www.enaex.com/cl/us/hyex/

Enerdata. (2024). *Wind turbines manufacturers market share (Executive Briefing)*. Enerdata. https://www.enerdata.net/publications/executive-briefing/wind-turbines-manufacturers-market-share.pdf

Energy-Storage.News / ESS-News. (2024). *Grenergy's Oasis de Atacama (Chile): Chinese BESS supply—BYD (~3+ GWh) and CATL (1.25 GWh)*. Energy-Storage.News. https://www.energy-storage.news/catl-to-supply-grenergy-1-25gwh-bess-for-worlds-largest-energy-storage-project-in-chile/

EnergyWatch. (2024, January 22). *Chinese turbines sell 20% below rivals' prices in export markets*. EnergyWatch. https://energywatch.com/EnergyNews/Renewables/article16779228.ece

ERGaR, CO2 Value Europe, eFuel Alliance, eNG Coalition, Eurogas, Hydrogen Europe, Methanol Institute, & VDMA. (2026, July 7). *Joint industry letter calling for the targeted revision of the RFNBO production criteria (Delegated Regulation (EU)*

2023/1184). ERGaR. https://www.ergar.org/2026/07/ergar-co-signs-a-joint-letter-calling-for-the-targeted-revision-of-rfnbo-production-criteria/

European Commission. (2025). *Innovation Fund IF25 Hydrogen Auction—Terms and Conditions*. European Commission. https://climate.ec.europa.eu/eu-action/eu-funding-climate-action/innovation-fund/calls-proposals/if25-hydrogen-auction_en

European Commission, DG CLIMA. (2024). *Terms and Conditions for IF24 Auction (European Hydrogen Bank, Second Auction)*. European Commission. https://climate.ec.europa.eu/document/download/b996825e-cd36-44c1-895d-a780062f626d_en?filename=2024+09+25+Final+TC_2nd+Round+RFNBO+H2_IF_TCforPUBLICATION_Clean.pdf

European Commission, Directorate-General for Energy. (2022). *Technical Assistance to Assess the Potential of RFNBOs and RCFs in the Transport Sector—Final Report, Task 3: Develop a Framework on Additionality in the EU Transport Sector (2020 to 2050)* (No. MJ0922381ENN). Publications Office of the European Union.

European Commission, Directorate-General for Energy. (2024). *Q&A for the certification of RFNBOs and RCF (Q&A on the implementation of the hydrogen delegated acts)* (p. 23) [Guidance document]. European Commission, Directorate-General for Energy. https://circabc.europa.eu/ui/group/8f5f9424-a7ef-4dbf-b914-1af1d12ff5d2/library/ca8efd4d-cb44-4aec-914d-3d95f95ea293/details?open=true

European Investment Bank. (2025, March 28). *EU, EIB and KfW to provide up to EUR 216.5 million to finance renewable hydrogen projects in Chile*. EIB. https://www.eib.org/en/press/all/2025-161-european-union-eib-and-kfw-to-provide-up-to-eur216-5-million-to-finance-renewable-hydrogen-projects-in-chile

Farrell, H., & Newman, A. L. (2019). Weaponized interdependence: How global economic networks shape state coercion. *International Security*, *44*(1), 42–79. https://doi.org/10.1162/isec_a_00351

Fearon, J. D. (1991). Counterfactuals and Hypothesis Testing in Political Science. *World Politics*, *43*(2), 169–195. https://doi.org/10.2307/2010470

Feld, L. (2026). Leading the Way or Crossing the Line? The Extraterritorial Dimension of the EU Directive on Corporate Sustainability Due Diligence. *Business and Human Rights Journal*, *11*(1), 23–45. https://doi.org/10.1017/bhj.2025.10038

Flores Fernández, C. (2026). The spatial politics of green hydrogen: Speculative enactments, contested dynamics and alternative pathways in southern Chile. *Political Geography*, *126*, 103498. https://doi.org/10.1016/j.polgeo.2026.103498

Fuel Cells Works. (2025, March 5). *Ignis Energy puts green ammonia and hydrogen initiatives on hold in Chile's Magallanes region*. Fuel Cells Works. https://fuelcellsworks.com/2025/03/05/green-hydrogen/ignis-energy-puts-green-ammonia-and-hydrogen-initiatives-on-hold-in-chile-s-magallanes-region

Fuel Cells Works. (2026, April 22). *EU makes it official: RFNBO green hydrogen rules will be reviewed this quarter—Hormuz crisis becomes the accelerant*. Fuel Cells Works. https://fuelcellsworks.com/2026/04/22/energy-development/eu-makes-it-official-rfnbo-green-hydrogen-rules-will-be-reviewed-this-quarter-hormuz-crisis-becomes-the-accelerant

Gabor, D. (2021). The Wall Street Consensus. *Development and Change*, *52*(3), 429–459. https://doi.org/10.1111/dech.12645

Gabor, D., & Sylla, N. S. (2023). Derisking Developmentalism: A Tale of Green Hydrogen. *Development and Change*, *54*(5), 1169–1196. https://doi.org/10.1111/dech.12779

Galimova, T., Fasihi, M., Bogdanov, D., & Breyer, C. (2023). Feasibility of green ammonia trading via pipelines and shipping: Cases of Europe, North Africa, and South America. *Journal of Cleaner Production*, *427*, 139212. https://doi.org/10.1016/j.jclepro.2023.139212

García-Herrero, A., Grabbe, H., & Kaellenius, A. (2023). *De-risking and decarbonising: A green tech partnership to reduce reliance on China*. Bruegel Policy Brief 19/2023. https://www.bruegel.org/policy-brief/de-risking-and-decarbonising-green-tech-partnership-reduce-reliance-china

George, A. L., & Bennett, A. (2005). *Case Studies and Theory Development in the Social Sciences*. MIT Press.

Gereffi, G. (1994). The Organization of Buyer-Driven Global Commodity Chains: How U.S. Retailers Shape Overseas Production Networks. In G. Gereffi & M. Korzeniewicz (Eds), *Commodity Chains and Global Capitalism* (pp. 95–122). Praeger.

Gereffi, G., Humphrey, J., & Sturgeon, T. (2005). The Governance of Global Value Chains. *Review of International Political Economy*, *12*(1), 78–104. https://doi.org/10.1080/09692290500049805

Goecke, S. (2025). *Renewable Hydrogen Imports from Chile: Challenges of Implementing EU Regulations and Addressing Environmental and Social Impacts* [Master’s thesis, Utrecht University]. https://studenttheses.uu.nl/bitstream/handle/20.500.12932/50172/2025.06.27

%20-%20Stefan%20Goecke%20Thesis%20-%20EU%20Renewable%20Hydrogen%20Imports%20from%20Chile.pdf

Goldthau, A., & Sitter, N. (2020). Power, authority and security: The EU's Russian gas dilemma. *Journal of European Integration*, *42*(1), 111–127. https://doi.org/10.1080/07036337.2019.1708341

Goodwin, D., Gale, F., Lovell, H., Beasy, K., Murphy, H., & Schoen, M. (2024). Sustainability certification for renewable hydrogen: An international survey of energy professionals. *Energy Policy*, *192*, 114231. https://doi.org/10.1016/j.enpol.2024.114231

H2 View. (2026, March). *Five EU member states push Brussels to delay key RFNBO rules (H2 View)*. H2 Energy Group. https://h2eg.com/h2-view-news-five-eu-member-states-push-brussels-to-delay-key-rfnbo-rules/

H2Global Foundation / Hintco. (2024). *The H2Global mechanism: Idea, instrument and intentions*. H2Global. https://h2-global.org/library/h2global-idea-instrument-and-intentions/

Hadjiyianni, I. (2021). The European Union as a Global Regulatory Power. *Oxford Journal of Legal Studies*, *41*(1), 243–264. https://doi.org/10.1093/ojls/gqaa042

Hansen, U. E., Nygaard, I., & Kadarusman, Y. B. (2026). Green industrial policy and latecomer catch-up: A missed green window of opportunity for domestic solar PV module manufacturers in Indonesia. *Research Policy*, *55*(2), 105369. https://doi.org/10.1016/j.respol.2025.105369

HIF Chile & Enel Green Power. (2026). *Parque Eólico Faro del Sur—Estudio de Impacto Ambiental (SEIA)* [Estudio de Impacto Ambiental (SEIA)]. Servicio de Evaluación Ambiental (SEA), Región de Magallanes. SEIA expediente 2160813317.

https://seia.sea.gob.cl/expediente/ficha/fichaPrincipal.php?modo=ficha&id_expediente=2160813317

HIF Chile 1 SpA. (2025). *Planta de Combustibles Sintéticos Cabo Negro—Estudio de Impacto Ambiental (SEIA), RCA aprobada* [Estudio de Impacto Ambiental (SEIA)]. Servicio de Evaluación Ambiental (SEA), Región de Magallanes. SEIA expediente 2160078437. https://seia.sea.gob.cl/expediente/ficha/fichaPrincipal.php?modo=ficha&id_expediente=2160078437

HIF Global. (2023, September 20). *HIF Haru Oni—ISCC PLUS certificate (2023)*. https://hifglobal.com/docs/default-source/documentos-noticias/chile/2023-09-20-iscc-certification-hif-haru-oni.pdf

HIF Global. (2024, December 26). *HIF Global and ALUR advance in e-Fuels deployment in Uruguay*. HIF Global. https://hifglobal.com/media/news-description/2024/12/26/hif-global-and-alur-advance-in-e-fuels-deployment-in-uruguay

HIF Global. (2025a). *HIF Global awarded ISCC EU RFNBO certification—First facility outside the EU*. HIF Global (press release). https://hifglobal.com/media/news-description/2025/10/01/hif-global-awarded-iscc-eu-rfnbo-certification

HIF Global. (2025b, April 3). *HIF Global and Mabanaft sign e-methanol offtake HoA*. HIF Global. https://hifglobal.com/media/news-description/2025/04/03/hif-global-and-mabanaft-sign-e-methanol-offtake-hoa

HIF Global. (2025c, May 5). *HIF, Porsche AG and Shell sign e-fuels supply agreement for Haru Oni facility*. HIF Global. https://hifglobal.com/media/news-description/2025/05/05/hif--porsche-ag--and-shell-sign-e-fuels-supply-agreement-for-haru-oni-facility

HIF Global. (2026). *HIF Haru Oni (project page)*. HIF Global. https://hifglobal.com/locations/hif-haru-oni

HIF Uruguay S.A. (2025). *Comunicación de Proyecto—Planta de e-Combustibles HIF Paysandú (Agosto de 2025)*. Ministerio de Ambiente (Uruguay). https://www.ambiente.gub.uy/bir/manifiestos/attachments/CdP_VAL.pdf

HIF Uruguay S.A. (2026). *Autorización Ambiental Previa—Tomo I, Documento de Proyecto. Planta de e-Combustibles HIF Paysandú (Marzo 2026)*. Ministerio de Ambiente (Uruguay). https://www.ambiente.gub.uy/oan/wp-content/uploads/2025/09/02-HIF-DP_Tomo-I_DP_Mar2026.pdf

Hinicio. (2021). *Advisory report on the development of a Green Hydrogen certification scheme for Chile*. Hinicio (for the World Bank). https://hinicio.com/wp-content/uploads/2022/08/Hinicio_green_hydrogen_certification_report_Chile_WB.pdf

Hinicio. (2024). *RFNBO Compliance Analysis of Products Produced from Renewable Hydrogen and Different Sources of CO2 in Uruguay and Chile with the EU's Renewable Energy Directive* (Final Report No. PCLMEA24032). Hinicio, for the Ministry of Economic Affairs and Climate Policy of the Netherlands. https://hinicio.com/wp-content/uploads/2024/09/2405-RFNBO-Compliance-Analysis-of-Products-Produced-from-H2.pdf

Hobday, M. (1995). East Asian Latecomer Firms: Learning the Technology of Electronics. *World Development*, *23*(7), 1171–1193. https://doi.org/10.1016/0305-750X(95)00035-B

Hong, F. T., Lin, H., Vazquez-Sanchez, H., Xue, X., Li, Y., Zhang, L., & Sarathy, S. M. (2024). Minimizing renewable hydrogen costs at producer's terminal gate with alkaline electrolyser, proton exchange membrane, and their co-installment: A regional case study in China. *International Journal of Hydrogen Energy*, *86*, 1051–1062. https://doi.org/10.1016/j.ijhydene.2024.08.365

Hordvei, E., Hummelen, S. E., Petersen, M., Backe, S., & Del Granado, P. C. (2025). From policy to practice: Upper bound cost estimates of Europe's green hydrogen ambitions. *Cleaner Energy Systems*, *12*, 100206. https://doi.org/10.1016/j.cles.2025.100206

Hughes, I. (2026, July 1). *2025 BESS cell and system shipments: BYD takes BESS crown, no Korean firms in top 10 cell suppliers* [Guest blog / market analysis]. Energy-Storage.News. https://www.energy-storage.news/2025-bess-cell-and-system-shipments-byd-takes-bess-crown-no-korean-firms-in-top-10-cell-suppliers/

Hydrogen Council. (2022, October 14). *Haru Oni: Fuel from Wind and Water (case study—Siemens Energy PEM electrolyser)*. Hydrogen Council — Hydrogen in Action. https://hydrogencouncil.com/en/haru-oni-fuel-from-wind-and-water/

Hydrogen Europe. (2022). *Consultation response—Draft delegated regulation supplementing Article 27 RED II (additionality)* [Consultation response]. Hydrogen Europe. https://hydrogeneurope.eu/wp-content/uploads/2022/06/220617-HE-Consultation-Response-on-DA-Art-27-additionality-Final.pdf

Hydrogen Europe. (2024a). *Public consultation feedback on the draft Terms and Conditions for the second European Hydrogen Bank auction (IF24)—Design element 1.15, resilience*. Hydrogen Europe. https://hydrogeneurope.eu/wp-content/uploads/2024/06/Public-consultation_Final_TC_-2nd-Auction-Hydrogen-Bank_Hydrogen-Europe.pdf

Hydrogen Europe. (2024b). *Resilience criteria in European public funding instruments*. Hydrogen Europe. https://hydrogeneurope.eu/wp-content/uploads/2024/05/240515-Resilicience-Criteria-for-Electrolyser-Hydrogen-Europe-position-paper-.pdf

Hydrogen Insight. (2025, March). Chinese electrolyser makers Hygreen and Guofu win government grants to build factories in Chile. *Hydrogen Insight*. https://www.hydrogeninsight.com/electrolysers/chinese-electrolyser-makers-hygreen-and-guofu-win-government-grants-to-build-factories-in-chile/2-1-1796163

industrydecarbonization.com. (2023). *Hype and E-Fuels: The Haru Oni pilot plant (DAC-to-biogenic shift)*. Industrydecarbonization.Com. https://industrydecarbonization.com/news/hype-and-e-fuels-the-haru-oni-pilot-plant.html

International Energy Agency. (2022). *Solar PV Global Supply Chains* [Special Report]. IEA, Paris. https://www.iea.org/reports/solar-pv-global-supply-chains

International Energy Agency. (2024). *Global Hydrogen Review 2024*. IEA, Paris. https://www.iea.org/reports/global-hydrogen-review-2024

International Energy Agency. (2025a). *Global Hydrogen Review 2025*. IEA, Paris. https://www.iea.org/reports/global-hydrogen-review-2025

International Energy Agency. (2025b). *Uruguay—Electricity generation by source*. IEA — Countries. https://www.iea.org/countries/uruguay/electricity

International Energy Agency. (2026a). *Global Hydrogen Review 2026*. IEA, Paris. https://www.iea.org/reports/global-hydrogen-review-2026

International Energy Agency. (2026b). *Manufacturing and Trade Model Documentation 2026*. IEA. https://iea.blob.core.windows.net/assets/275e1dc8-a410-40e3-b6d2-a6830f57a1a3/ManufacturingandTradeModelDocumentation2026.pdf

IRENA. (2022). *Geopolitics of the energy transformation: The hydrogen factor*. International Renewable Energy Agency (IRENA). https://www.irena.org/publications

ISCC System GmbH. (2024). *ISCC EU 205—Greenhouse Gas Emissions (v4.1)*. ISCC System GmbH. https://iscc-system.org/wp-content/uploads/2024/01/ISCC_EU_205_Greenhouse-Gas-Emissions_v4.1_January2024.pdf

ISPI. (2025). *Legal Certainty, Strategic Ambiguity: Leveraging the EU-Chile FTA for Critical Mineral Supply*. ISPI (Istituto per gli Studi di Politica Internazionale). https://www.ispionline.it/en/publication/legal-certainty-strategic-ambiguity-leveraging-the-eu-chile-fta-for-critical-mineral-supply-211673

Jaña Maureira, E. W. (2024). Efectos territoriales del Hidrógeno Verde en la Patagonia chilena: Lecturas a contracorriente y algunas prevenciones a futuro. *Observatorio Medioambiental*, *27*, 135–158. https://doi.org/10.5209/obmd.99724

Kalt, T., Simon, J., Tunn, J., & Hennig, J. (2023). Between green extractivism and energy justice: Competing strategies in South Africa's hydrogen transition. *Review of African Political Economy*, *50*(177–178), 302–321. https://doi.org/10.1080/03056244.2023.2260206

Kobos, P. H., Erickson, J. D., & Drennen, T. E. (2006). Technological learning and renewable energy costs: Implications for US renewable energy policy. *Energy Policy*, *34*(13), 1645–1658. https://doi.org/10.1016/j.enpol.2004.12.008

Kvangraven, I. H. (2021). Beyond the Stereotype: Restating the Relevance of the Dependency Research Programme. *Development and Change*, *52*(1), 76–112. https://doi.org/10.1111/dech.12593

Lall, S. (1992). Technological Capabilities and Industrialization. *World Development*, *20*(2), 165–186. https://doi.org/10.1016/0305-750X(92)90097-F

Langenmayr, U., & Ruppert, M. (2023). Renewable origin, additionality, temporal and geographical correlation – eFuels production in Germany under the RED II regime. *Energy Policy*, *183*, 113830. https://doi.org/10.1016/j.enpol.2023.113830

Lavenex, S. (2004). EU external governance in 'wider Europe'. *Journal of European Public Policy*, *11*(4), 680–700. https://doi.org/10.1080/1350176042000248098

Lavenex, S., & Schimmelfennig, F. (2009). EU rules beyond EU borders: Theorizing external governance in European politics. *Journal of European Public Policy*, *16*(6), 791–812. https://doi.org/10.1080/13501760903087696

Lebdioui, A. (2019). Chile's Export Diversification since 1960: A Free Market *Miracle* or *Mirage*? *Development and Change*, *50*(6), 1624–1663. https://doi.org/10.1111/dech.12545

Lebdioui, A. (2020). Local content in extractive industries: Evidence and lessons from Chile's copper sector and Malaysia's petroleum sector. *The Extractive Industries and Society*, *7*(2), 341–352. https://doi.org/10.1016/j.exis.2019.05.001

Lebdioui, A. (2025). Greening of Latin American Economies. In J. A. Mathews & A. Oqubay (Eds), *The Oxford Handbook on the Greening of Economic Development* (pp. 613–640). Oxford University Press. https://doi.org/10.1093/oxfordhb/9780198883487.013.28

Lee, K., & Malerba, F. (2017). Catch-up cycles and changes in industrial leadership: Windows of opportunity and responses of firms and countries. *Research Policy*, *46*(2), 338–351. https://doi.org/10.1016/j.respol.2016.09.006

Lema, R., Fu, X., & Rabellotti, R. (2020). Green windows of opportunity: Latecomer development in the age of transformation toward sustainability. *Industrial and Corporate Change*, *29*(5), 1193–1209. https://doi.org/10.1093/icc/dtaa044

Lema, R., Rabellotti, R., & Ambrogi, J. (2025). Seizing windows of opportunity in green global value chains: The role of industrial policies in middle-income countries. *Journal of International Business Policy*, *8*(3), 341–372. https://doi.org/10.1057/s42214-025-00219-5

León, M., Silva, J., Ortíz-Soto, R., & Carrasco, S. (2023). A Techno-Economic Study for Off-Grid Green Hydrogen Production Plants: The Case of Chile. *Energies*, *16*(14), 5327. https://doi.org/10.3390/en16145327

Li, J., Liang, H., Zheng, Z., Teng, L., Zhang, Z., Gao, Z., Luo, Y., Zhang, C., & Jiang, L. (2025). A critical review of China's hydrogen supply chain and equipment. *International Journal of Hydrogen Energy*, *180*, 151737. https://doi.org/10.1016/j.ijhydene.2025.151737

Li, X., & Du, M. (2025). China's Green Industrial Policy and World Trade Law. *East Asia*, *42*(3), 261–278. https://doi.org/10.1007/s12140-025-09447-1

Linsel, O., & Bertsch, V. (2026). Effects of the delegated act on renewable fuels of non-biological origin on production costs and distribution of hydrogen production capacities across Europe. *Energy Policy*, *212*, 115178. https://doi.org/10.1016/j.enpol.2026.115178

Lira, F., Kramer, N., & Quitzow, R. (2025). Hydrogen Policy in Brazil: Emerging Path to Green Re-Industrialization? In R. Quitzow & Y. Zabanova (Eds), *The Geopolitics of Hydrogen* (pp. 177–203). Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-84022-7_8

Majone, G. (1994). The rise of the regulatory state in Europe. *West European Politics*, *17*(3), 77–101. https://doi.org/10.1080/01402389408425031

Majone, G. (1997). From the positive to the regulatory state: Causes and consequences of changes in the mode of governance. *Journal of Public Policy*, *17*(2), 139–167. https://doi.org/10.1017/S0143814X00003524

Manners, I. (2002). Normative Power Europe: A Contradiction in Terms? *JCMS: Journal of Common Market Studies*, *40*(2), 235–258. https://doi.org/10.1111/1468-5965.00353

Martin, P. (2025, December 12). EDF cancels giant green hydrogen and ammonia project in southern Chile. *Hydrogen Insight*. https://www.hydrogeninsight.com/production/edf-cancels-giant-green-hydrogen-and-ammonia-project-in-southern-chile/2-1-1915916

Mathews, J. (2023). *A Solar-Hydrogen Economy: Driving the Green Hydrogen Industrial Revolution*. Anthem Press.

Mathews, J. A. (2017). Global trade and promotion of cleantech industry: A post-Paris agenda. *Climate Policy*, *17*(1), 102–110. https://doi.org/10.1080/14693062.2016.1215286

Mathews, J. A., & Reinert, E. S. (2014). Renewables, manufacturing and green growth: Energy strategies based on capturing increasing returns. *Futures*, *61*, 13–22. https://doi.org/10.1016/j.futures.2014.04.011

MercoPress. (2026, April 9). *Uruguay considers relocating HIF Global's green hydrogen megaplant amid Argentina tensions*. MercoPress. https://en.mercopress.com/2026/04/09/uruguay-considers-relocating-hif-global-s-green-hydrogen-megaplant-to-ease-tensions-with-argentina

Middelanis, M., Fritz, B., & de Paula, L. F. (2025). The Global South in the Energy Transition: A Framework for Industrial Policy Options to Avert 'Greening Dependency'. *Journal of Globalization and Development*, *16*(2), 159–187. https://doi.org/10.1515/jgd-2024-0092

Ministerio de Energía. (2024). *Plan de Acción de Hidrógeno Verde 2023-2030*. Gobierno de Chile. https://energia.gob.cl/sites/default/files/documentos/plan_de_accion_hidrogeno_verde_2023-2030.pdf

Ministerio de Energía. (2026). *Estrategia Nacional de Hidrógeno Verde y Derivados—Actualización 2026 (final, launched 3 Mar 2026)*. Gobierno de Chile. https://energia.gob.cl/sites/default/files/documentos/estrategia_nacional_de_hidrogeno_verde_y_derivados.pdf

Müller, F., Tunn, J., & Kalt, T. (2022). Hydrogen justice. *Environmental Research Letters*, *17*(11), 115006. https://doi.org/10.1088/1748-9326/ac991a

Nahm, J., & Steinfeld, E. S. (2014). Scale-up nation: China's specialization in innovative manufacturing. *World Development*, *54*, 288–300. https://doi.org/10.1016/j.worlddev.2013.09.003

Namazifard, N., Tahavori, M. A., Nijs, W., Vingerhoets, P., & Delarue, E. (2025). Relaxing EU hydrogen criteria: A cost and emission comparison of unrestricted and green electrolytic hydrogen in 2030. *Environmental Research: Energy*, *2*(3), 035014. https://doi.org/10.1088/2753-3751/ae07e3

Naughton, B. (2021). *The rise of China's industrial policy, 1978 to 2020*. Universidad Nacional Autónoma de México, Facultad de Economía.

Odenweller, A., & Ueckerdt, F. (2025). The green hydrogen ambition and implementation gap. *Nature Energy*, *10*, 110–123. https://doi.org/10.1038/s41560-024-01684-7

OECD. (2023). *HIF Global e-Fuels: Chile Case Study*. OECD. https://www.oecd.org/content/dam/oecd/en/about/programmes/cefim/green-hydrogen/HIF-global-case-study.pdf

OLADE. (2023). *CertHiLAC: Clean Hydrogen Certification System for Latin America and the Caribbean*. Latin American Energy Organization (OLADE). https://www.olade.org/en/certhilac-clean-hydrogen-certification-system-for-latin-america-and-the-caribbean/

Orihuela, J. C., Irarrázaval, F., & Flores, C. (2025). Chile at the Green Window of Opportunity: The Troubled Road to New Productive Capabilities. *Journal of Globalization and Development*, *16*(2), 277–304. https://doi.org/10.1515/jgd-2024-0090

Perez, C., & Soete, L. (1988). Catching-up in technology: Entry barriers and windows of opportunity. In G. Dosi, C. Freeman, R. Nelson, G. Silverberg, & L. Soete (Eds), *Technical Change and Economic Theory* (pp. 458–479). Pinter. https://www.semanticscholar.org/paper/79537185df2eab78240951ea7b879c1e703712e1

Pogorel, G., & Cappelletti, F. (2024). Revisiting the EU industrial autonomy trilemma. In F. Cappelletti & G. Pogorel (Eds), *Sustainable? Competitive? The EU's Industrial Autonomy—Facts and Fantasies* (pp. 9–15). European Liberal Forum. https://liberalforum.eu/publication/sustainable-competitive-the-eus-industrial-autonomy-facts-and-fantasies/

Prebisch, R. (1950). *The Economic Development of Latin America and its Principal Problems*. United Nations / ECLA (CEPAL). https://archivo.cepal.org/pdfs/cdPrebisch/002.pdf

pv magazine Latam. (2025, May 5). *TotalEnergies presenta para evaluación ambiental un megaproyecto de hidrógeno verde en Chile*. Pv Magazine Latam. https://www.pv-magazine-latam.com/2025/05/05/totalenergies-presenta-para-evaluacion-ambiental-un-megaproyecto-de-hidrogeno-verde-en-chile/

Quitzow, R., & Zabanova, Y. (2025). Geoeconomics of the transition to net-zero energy and industrial systems: A framework for analysis. *Renewable and Sustainable Energy Reviews*, *214*, 115492. https://doi.org/10.1016/j.rser.2025.115492

REFHYNE Project Consortium. (n.d.). *REFHYNE — Clean Refinery Hydrogen for Europe (project overview)*. REFHYNE. Retrieved 18 July 2026, from https://www.refhyne.eu/

República Oriental del Uruguay & HIF Uruguay S.A. (2025, December 18). *Memorando de Entendimiento entre la República Oriental del Uruguay y HIF (Proyecto HIF Paysandú)*. https://medios.presidencia.gub.uy/tav_portal/2025/noticias/AO_677/memorando_gobierno_hif.pdf

Ruhnau, O., & Schiele, J. (2023). Flexible green hydrogen: The effect of relaxing simultaneity requirements on project design, economics, and power sector emissions. *Energy Policy*, *182*, 113763. https://doi.org/10.1016/j.enpol.2023.113763

Schmidt, J., Wehrle, S., Turkovska, O., & Regner, P. (2024). The EU additionality rule does not guarantee additionality. *Joule*, *8*(3), 553–556. https://doi.org/10.1016/j.joule.2024.02.003

Scholvin, S. (2023). Green hydrogen and linkage-based development in Antofagasta, Chile. *Local Economy: The Journal of the Local Economy Policy Unit*, *38*(5), 506–517. https://doi.org/10.1177/02690942241230450

Scholvin, S., & Kalvelage, L. (2025). New development paths through green hydrogen?: An ex-ante assessment of structure and agency in Chile and Namibia. *Energy Research & Social Science*, *120*, 103904. https://doi.org/10.1016/j.erss.2024.103904

Schorr, B., Carrasco, S., Damonte, G., & Atria, J. (2025). Explaining Varying Green Hydrogen Ambitions: State Capacity and Business Positioning in Chile and Peru. *Journal of Globalization and Development*, *16*(2), 249–275. https://doi.org/10.1515/jgd-2025-0006

Schumm, L., Abdel-Khalek, H., Brown, T., Ueckerdt, F., Sterner, M., Parzen, M., & Fioriti, D. (2025). The impact of temporal hydrogen regulation on hydrogen exporters and their domestic energy transition. *Nature Communications*, *16*, 7486. https://doi.org/10.1038/s41467-025-62873-w

Scott, J. (2014). Extraterritoriality and territorial extension in EU law. *American Journal of Comparative Law*, *62*(1), 87–125. https://doi.org/10.5131/AJCL.2013.0009

Singer, H. W. (1950). U.S. Foreign Investment in Underdeveloped Areas: The Distribution of Gains between Investing and Borrowing Countries. *American Economic Review*, *40*(2), 473–485.

Thurbon, E., Kim, S.-Y., Mathews, J. A., & Tan, H. (2023). *Developmental environmentalism: State ambition and creative destruction in East Asia's green energy transition*. Oxford University Press. https://doi.org/10.1093/oso/9780192897794.001.0001

TotalEnergies. (2025). *H2 Magallanes—Green Hydrogen and Ammonia Production Project (Project Sheet)*. TotalEnergies.

TotalEnergies H2 Magallanes. (2025). *Estudio de Impacto Ambiental—Proyecto de Producción de Hidrógeno y Amoníaco Verde 'H2 Magallanes'* [Estudio de Impacto Ambiental (SEIA)]. Servicio de Evaluación Ambiental (SEA), Chile. SEIA expediente 2165025085. https://seia.sea.gob.cl/expediente/ficha/fichaPrincipal.php?modo=normal&id_expediente=2165025085

Tunn, J., Kalt, T., Müller, F., Simon, J., Hennig, J., Ituen, I., & Glatzer, N. (2024). Green hydrogen transitions deepen socioecological risks and extractivist patterns: Evidence from 28 prospective exporting countries in the Global South. *Energy Research & Social Science*, *117*, 103731. https://doi.org/10.1016/j.erss.2024.103731

TÜV SÜD Industrie Service GmbH. (2025). *ISCC EU RFNBO Certificate (RED III)—HIF Chile 1 SpA, Haru Oni—EU-ISCC-Cert-DE102-25060138 (first certification)*. International Sustainability & Carbon Certification (ISCC); issued by TÜV SÜD Industrie Service GmbH. https://iscc-system.org/certification/all-certificates/

TÜV SÜD Industrie Service GmbH. (2026). *ISCC EU RFNBO Certificate (RED III)—HIF Chile 1 SpA, Haru Oni—EU-ISCC-Cert-DE102-26060141 (renewal)*. International Sustainability & Carbon Certification (ISCC); issued by TÜV SÜD Industrie Service GmbH. https://iscc-system.org/certification/all-certificates/

Vogel, D. (1995). *Trading Up: Consumer and Environmental Regulation in a Global Economy*. Harvard University Press.

Weber, K. (2025). Environmental Supply Chain Regulations in a Changing Market Environment: Exploring the EU's Regulatory Power in the Cocoa Sector in Ghana. *JCMS: Journal of Common Market Studies*, *64*(2), 811–834. https://doi.org/10.1111/jcms.70031

Weko, S., & Quitzow, R. (2026). From External Governance to Energy Diplomacy: The European Pursuit of Green Hydrogen. *JCMS: Journal of Common Market Studies*, *64*(3), 1135–1159. https://doi.org/10.1111/jcms.70052

White, L. V., Fazeli, R., Beck, F. J., Baldwin, K. G. H., & Li, C. (2025). Implications for cost-competitiveness of misalignment in hydrogen certification: A case study of exports from Australia to the EU. *Energy Policy*, *204*, 114661. https://doi.org/10.1016/j.enpol.2025.114661

Wilson, C. (2012). Up-scaling, formative phases, and learning in the historical diffusion of energy technologies. *Energy Policy*, *50*, 81–94. https://doi.org/10.1016/j.enpol.2012.04.077

Xue, J., Poon, J., Yang, Y., & Ji, Q. (2024). Effect of green industrial policy on China's outward renewable energy investment. *Energy Economics*, *138*, 107830. https://doi.org/10.1016/j.eneco.2024.107830

Zabanova, Y., & Quitzow, R. (2025). Hydrogen Policy in the EU. In R. Quitzow & Y. Zabanova (Eds), *The Geopolitics of Hydrogen* (pp. 17–54). Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-84022-7_2

Annexes

Annex A — Green hydrogen: what it is, why it is pursued, and its limits

A neutral technical primer for readers approaching the thesis from law or international relations. It states the case for green hydrogen and the case against over-claiming it in the same breath; the thesis's argument does not depend on either enthusiasm or scepticism about the molecule itself.

Hydrogen is an energy carrier rather than an energy source: it stores and moves energy that was generated somewhere else. Nearly all hydrogen produced today is made from fossil fuels, principally by steam-reforming natural gas, so-called grey hydrogen, which emits carbon dioxide in production. Blue hydrogen is the same process with partial capture and storage of those emissions. Green hydrogen is different in kind: an electrolyser splits water into hydrogen and oxygen using electricity, and where that electricity is renewable the resulting hydrogen carries a very low carbon footprint. In EU law the relevant legal category is the renewable fuel of non-biological origin (RFNBO), which covers renewable hydrogen and the fuels made from it, e-methanol, e-gasoline, e-ammonia and similar derivatives, produced by combining renewable hydrogen with a carbon or nitrogen input (Directive (EU) 2018/2001 as amended; the production criteria in CDR (EU) 2023/1184 and 2023/1185).

The case for it rests on the sectors that electrification struggles to reach. Batteries and direct electrification decarbonise cars, heating and much of industry more efficiently than hydrogen can, because converting electricity into hydrogen and back loses a large share of the input energy at every step. The pursued uses are therefore the hard-to-abate remainder: feedstock hydrogen for fertiliser and refining, which is already a large grey-hydrogen market that must be replaced molecule for molecule; steelmaking via direct reduction; long-haul aviation and shipping, where energy density rules batteries out and where EU law now mandates growing RFNBO shares (ReFuelEU Aviation, Regulation (EU) 2023/2405; FuelEU Maritime, Regulation (EU) 2023/1805); and long-duration energy storage. Countries with exceptional renewable endowments, Chilean Patagonian wind among the world's best, see in this a chance to export their renewable advantage in chemical form, and the EU's REPowerEU plan set the demand-side ambition of ten million tonnes (10 Mt) of renewable-hydrogen imports by 2030.[245]

Certification exists because greenness is a credence property: a molecule of hydrogen made from wind power is physically identical to one made from lignite electricity or fossil gas. No buyer, customs officer or regulator can verify the production pathway by inspecting the product, so the entire premium for green hydrogen depends on a documentary system, criteria for the input electricity and carbon, third-party audit, and a chain of custody, that travels with the fuel. That is what the RFNBO rulebook and the recognised voluntary schemes provide, and it is why the rules reach production conditions in third countries: the thing being certified is conduct at the point of production, not a testable attribute of the product.

The honest limits belong in the same annex. Green hydrogen is currently several times more expensive than grey, and the gap closes only with cheap dedicated renewables, cheaper electrolysers and scale.[246] The efficiency penalty is physics, not teething trouble, which is why analysts warn against using hydrogen where direct electrification works. Announced supply has far outrun real demand: only around 7% of announced capacity is realised on schedule, and weak offtake, not regulation alone, has stalled projects worldwide, including in Magallanes.[247] Long-distance transport of hydrogen or ammonia remains costly enough that intercontinental trade is economic only on some routes and timescales.[248] And the geopolitics of a future hydrogen trade, who captures the value, who supplies the equipment, who writes the rules, is precisely the contested terrain this thesis examines rather than assumes.[249] Green hydrogen is, in short, a genuinely necessary

245 (European Commission, Directorate-General for Energy, 2022)
246 (International Energy Agency, 2025a)
247 (Odenweller & Ueckerdt, 2025)
248 (Galimova et al., 2023)
249 (IRENA, 2022)

instrument for a defined set of uses, carried by policy ahead of market maturity; both halves of that sentence are load-bearing for everything that follows.

Annex B — The RFNBO framework and its market

This annex sets out in full the EU regulatory framework for RFNBOs and the market it constructs, on which the case analysis (Chapter 5) and the equipment-origin analysis (Chapter 6) draw. Chapter 4 states the load-bearing rules in brief; this annex is the full account. Citations and locators are at Annex C; derived figures at Annex E; exhibits at Annex G.

This annex sets out the RFNBO rules and the market they regulate: what they provide, how certification operates, and what demand the legislation constructs.

B.1 Legal architecture

The framework begins with the three Renewable Energy Directives. The first, Directive 2009/28/EC, required 20% renewable energy across the Union by 2020. The second, Directive 2018/2001 (RED II), replaced it and set 32% by 2030. The third, Directive 2023/2413 (RED III), amends the second rather than replacing it,[250] and entered into force 20 November 2023 as the renewable-energy component of the Fit for 55 package,[251] the programme implementing the European Climate Law's target of 55% emissions reductions by 2030.[252] The Commission's 2021 recast proposal had set a 40% renewable share;[253] REPowerEU, published 18 May 2022, raised that ambition in response to Russia's invasion of Ukraine.[254] The adopted text amended Article 3(1) to a binding 42.5%, with an aspiration to 45%. Within this architecture RED III defines RFNBOs, sets the demand-side targets discussed at §B.5, and delegates the production criteria to the Commission.

Two delegated regulations of 10 February 2023 contain the operative criteria. Commission Delegated Regulation 2023/1184 sets the methodology for counting electricity as fully renewable, made under the seventh subparagraph of Article 27(3) of Directive

[250] The operative text is therefore the consolidated Directive 2018/2001 as amended, and the article numbers cited throughout are its numbers.
[251] COM(2021) 550 final ('Fit for 55')
[252] Regulation (EU) 2021/1119
[253] COM(2021) 557 final (RED recast proposal), Art 1(2)
[254] COM(2022) 230 final (REPowerEU Plan), p. 1

2018/2001;[255] Commission Delegated Regulation 2023/1185 sets the minimum greenhouse-gas-saving methodology, made under Articles 25(2) and 28(5).[256] The Commission treated the first as a technical measure: its explanatory memorandum records that neither an impact assessment nor an open public consultation was required,[257] and the regulation's fourth recital explains several of its transitional provisions by reference to the early state of the hydrogen industry.[258]

Verification is governed by Commission Implementing Regulation 2022/996, and the recognition of voluntary certification schemes derives from Article 30(4) of the Directive. A producer does not deal with the Commission directly. It certifies through a recognised scheme, which issues a proof of sustainability; that proof is entered in the Union Database, the Commission-operated register tracking consignments of certified fuel as they enter the market. Three schemes – ISCC EU, CertifHy, and REDcert-EU – were recognised on the same day, 19 December 2024, with recognition running to 21 December 2029.[259] A third-country producer meets this machinery, not the directive's targets.

The scheme layer translates the regulations into auditable requirements in its system documents. ISCC EU 202-6 (RFNBO requirements), 203 (traceability and chain of custody) and 205-1 (greenhouse-gas requirements) are the operative set for the certificate examined in Chapter 5,[260] and CertifHy publishes parallel documents.[261] This thesis examines those

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[255] CDR 2023/1184 cites Article 27(3), seventh subparagraph, of Directive (EU) 2018/2001 as its legal basis, that being the numbering in force at adoption. Following the amendments made by RED III, the empowerment appears in the consolidated text as Article 27(6), fourth subparagraph, and the criteria it implements as the second and third subparagraphs of that paragraph.
[256] CDR 2023/1185 cites Articles 25(2) and 28(5) of Directive (EU) 2018/2001, the numbering in force at adoption. The greenhouse-gas criteria it implements now sit at Article 29a, inserted by RED III.
[257] C(2023) 1087 final, explanatory memorandum, p. 2
[258] CDR (EU) 2023/1184, recital 4
[259] Impl. Dec. (EU) 2024/3176; 2024/3180; 2024/3194
[260] ISCC EU 202-6; ISCC EU 203; ISCC EU 205-1
[261] CertifHy GHG & Sustainability v1.6; CertifHy Traceability & Chain of Custody v1.6

two schemes: ISCC EU because it certified the case plant, and CertifHy because it published the bidding-zone determination the Brazilian comparison relies on (§B.2).[262] [263]

B.2 The electricity criteria

Delegated Regulation 2023/1184 sets out when electricity used in electrolysis may be counted as fully renewable. Which rules apply turns on a single question: does the plant take electricity from the grid?

A plant that does not is governed by Article 3. Its electricity qualifies on three conditions. The generator must be joined to the electrolyser by a direct line, or sit within the same installation. It must have come into operation no earlier than 36 months before the fuel plant. And the plant must be off the grid altogether, or metered to show that no grid electricity was used to make the fuel. This is the route the Chilean cases take.

A plant that does draw on the grid has four routes, all in Article 4. Three are location- or time-based: a bidding zone that was more than 90% renewable in the previous year, with output capped in proportion to that share (Article 4(1)); a low-emission zone below 18 grams of CO_2-equivalent per megajoule backed by an equivalent power purchase agreement (Article 4(2)); or consumption that demonstrably absorbs renewable curtailment (Article 4(3)). Where none applies, the general fourth route imposes the three correlation conditions in full (Article 4(4)).

The first is additionality. The producer must generate an equivalent amount of renewable electricity itself, or contract it under a renewables power purchase agreement – a long-term contract to buy a named generator's output. Either way the generating installation must have come into operation within the same 36 months, and must have received neither operating nor investment aid, subject to defined exceptions (Article 5).

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[262] REDcert-EU's documents are not examined; a comparison of all three schemes' interpretive choices is saved for the addendum.

[263] A separate delegated regulation, Commission Delegated Regulation (EU) 2025/2359, governs low-carbon hydrogen produced from non-renewable sources at low lifecycle emissions. This is chiefly natural gas with carbon capture or nuclear electricity, and it applies an equivalent numerical threshold to those routes. It sits outside the RFNBO framework and is noted here only to distinguish it.

The second is temporal correlation. Generation and consumption must be matched monthly until 31 December 2029, and hourly from 1 January 2030. A member state may require hourly matching from 1 July 2027. An hour counts as automatically compliant when the day-ahead price falls to or below a defined floor (Article 6).

The third is geographical correlation. Generator and electrolyser must sit in the same bidding zone, or in an interconnected zone where the day-ahead price is equal or higher, or in an offshore zone interconnected with the electrolyser's (Article 7).

Installations that entered operation before 2028 are exempt from Article 5, points (a) and (b) – the 36-month vintage and no-aid criteria – until 1 January 2038 (Article 11); the additionality obligation itself is untouched. Recital 17 grounds the deferral in the time needed to build new generation and the scarcity of unsupported capacity.

The criteria have attracted a critical secondary literature, which the analysis engages. Whether the additionality rule in fact secures system-level additionality is disputed,[264] and studies of the correlation criteria find that their effect depends heavily on the market structure they operate in.[265]

Three configurations therefore stand open to a producer: build off-grid, wired directly to its own new generation; draw on the grid, contract new capacity by power purchase agreement, and match its consumption in time and location; or site in a grid already clean enough for the criteria to relax. Only the second carries the full additionality and correlation machinery. That is why, in a system like Chile's, compliance is engineered through project configuration rather than contracting.

The loosest standard is annual matching, under which a producer needs only to balance generation and consumption across a whole year, evening out seasonal surpluses and shortfalls. EU criteria reject this approach, and it is the baseline the counterfactual at §5.4 uses. It is also the transitional standard in the United States under the section 45V rules:

[264] (Schmidt et al., 2024)
[265] (Langenmayr & Ruppert, 2023)

electricity generated before 2030 satisfies the matching requirement if generated in the same calendar year as the hydrogen, with hourly matching required thereafter.[266]

The regulation's definitions use the vocabulary of the EU electricity market, which raises a question for producers outside it. A bidding zone is defined by reference to Regulation 2019/943, "or an equivalent concept for third countries" (Article 2), and the recitals direct users to the most similar concept in the country concerned.

The Commission's interpretive guidance supplies the method. Where a location's market rules set hourly prices for a geographical area, that area is treated as the bidding zone. Where they do not, the certifier judges whether the national network is integrated, in which case the country may count as a single zone, or whether it splits into separate networks, each counting as its own.[267]

The scheme layer then allocates that judgment, and the two schemes have allocated it differently. ISCC EU 202-6 provides a guidance tree for identifying a bidding-zone equivalent outside the EU, and states that the result is not an official classification: the auditor decides, on data the system user supplies.[268] CertifHy has instead published a central assessment of bidding-zone equivalence for Brazil.[269] How these provisions operate in a nodal third-country market is examined in the case analysis.

B.3 The carbon criteria

Delegated Regulation 2023/1185 sets the greenhouse-gas methodology. The requirement itself sits in the Directive: energy from RFNBOs counts towards a member state's renewable target only if it delivers greenhouse-gas savings of at least 70% (Article 29a(1)). The delegated regulation supplies the arithmetic. Savings are the difference between the fuel's own lifecycle emissions and a fossil comparator, divided by that comparator, and the

[266] 26 CFR §1.45V-4(d)(3)(ii)(A)–(B)
[267] ISCC EU 202-6, Annex III
[268] CertifHy Assessment on Bidding-Zone Equivalence: Brazil
[269] CertifHy Assessment on Bidding-Zone Equivalence: Brazil

comparator is fixed at 94 gCO_2e/MJ (grams of carbon-dioxide equivalent per megajoule of fuel – what a conventional fossil fuel emits in delivering the same unit of energy).[270]

Two derived figures follow:[271] a 70% saving against the 94 gCO_2e/MJ comparator leaves a ceiling of 28.2 gCO_2e/MJ, or about 3.4 $kgCO_2e/kgH_2$ (kilograms of carbon-dioxide equivalent per kilogram of hydrogen) – the benchmark for Brazil's domestic threshold at §5.5. The United States reaches a comparable limit by a different route: section 45V caps eligible hydrogen at 4 $kgCO_2e/kgH_2$,[272] looser than the EU's derived 3.4 $kgCO_2e/kgH_2$.

The EU methodology counts emissions from the supply of inputs, including the capture and transport of CO_2, against the fuel. It excludes one category expressly: "Emissions from the manufacture of machinery and equipment shall not be taken into account."[273] Both recognised scheme methodologies restate the exclusion in the same terms.[274]

Point 10 of the delegated regulation's Annex defines which captured CO_2 may be counted, and five sources qualify:[275] carbon priced upstream under an emissions-trading system (point 10(a) – time-limited, and currently only the EU, Swiss, and UK systems on the Commission's interpretive guidance);[276] DAC (point 10(b)); biogenic carbon meeting the Directive's sustainability criteria (point 10(c)); carbon from combusting RFNBOs or recycled-carbon fuels (point 10(d)); and naturally occurring geological CO_2 (point 10(e)).

A producer in a country without an emissions trading system is therefore left with two practical routes: DAC and biogenic carbon. How that constraint interacts with Chilean resource geography is examined in Chapter 5.

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[270] Delegated Regulation (EU) 2023/1185, Annex, Part A, point 2
[271] See Annex E
[272] 26 U.S.C. §45V(c)(2)(A); implementing rule at 26 CFR §1.45V-4 (90 FR 2224)
[273] Delegated Regulation (EU) 2023/1185, Annex, Part A, point 1
[274] CertifHy GHG & Sustainability v1.6, §B.2, p. 10; I(ISCC System GmbH, 2024, pp. 11, 17) SCC EU 205-1
[275] Delegated Regulation (EU) 2023/1185, Annex, point 10
[276] (European Commission, Directorate-General for Energy, 2024, p. 23); Delegated Regulation (EU) 2023/1185, Annex, points 10(a) and 11 (the 2036/2041 dates and their review)

B.4 Certification mechanics and disclosure

Certification is performed by accredited certification bodies auditing against a recognised scheme's documents, annually and on site, with the scheme issuing the certificate and a summary audit report as the public record. Chain of custody runs on mass balance under Article 19 of Implementing Regulation 2022/996,[277] and two of its rules carry the analytical weight. Article 19(2)(f) requires the system to record the quantities of fuel for which no sustainability or GHG characteristics have been determined – the uncertified stream is not an omission the regime tolerates but a category its accounting anticipates. Article 19(2)(l) fixes the balancing period at three months. Mass balance lets certified and uncertified product move through shared infrastructure while paper segregation is maintained, which makes certification of fungible molecules administrable at all. A producer may sell only its compliant output into the EU as RFNBO and the rest elsewhere unlabelled, provided the bookkeeping balances within the period. The regime's definitions carry the same division: the certification body certifies the firm, the firm certifies the quantities (Articles 2(4) and 2(23)). Its analytical consequence is that regulatory identity attaches to quantities within a bounded perimeter, the "site" – defined as "a geographical location... with precise boundaries within which products can be mixed" (Article 2(22)). In the ISCC's words, mass balances "are at least site specific."[278] Compliance is therefore a property of sites and consignments, not of firms, and that is the divisibility on which Chapter 5's assessment turns.

Disclosure has a defined perimeter. The published record comprises the certificate – holder, site, certified scopes (electrolyser, methanol plant, refinery) and validity to June 2027 – and a summary audit report on the audit of 20–22 April 2026, recording the chain-of-custody method (mass balance), two minor non-conformities, both in the management system, none in traceability or greenhouse-gas accounting, and the use of actual values for the greenhouse-gas assessment. The calculated intensity itself is not published.[279] The

[277] Implementing Regulation (EU) 2022/996, Art 19
[278] ISCC EU 203, §B.2
[279] (TÜV SÜD Industrie Service GmbH, 2026)

only origin field in the published record concerns raw-material feedstock, recorded not applicable for this plant, with the notation that no materials were handled as sustainable in the previous period. The scheme documents govern what auditors collect beneath that public face; the evidence model they define – metering data, contracts, commissioning documentation, mass-balance accounts, sustainability declarations – contains no equipment-identity requirement.[280] Rößler calls this deliberate: the EU framework centres on traceability from generation to derivative rather than on technology, with equipment and metering left to national law and the auditor judging whether measurements suffice.[281] The two schemes diverge at the margins: CertifHy's documents parallel ISCC's in methodology, though they have allocated at least one interpretive task differently, as §B.2 noted for bidding-zone equivalence. The Union Database, now coming into operation, adds a transaction registry without changing the disclosure perimeter described here. These facts are used analytically in Chapter 6.

B.5 Demand-side instruments and the state of the market

REPowerEU set the ambition the framework assumes: 10 Mt of domestic renewable hydrogen production and 10 Mt of imports by 2030.[282] The European Court of Auditors (ECA) assessed that ambition in 2024 and found it driven by political will, not robust analysis, recommending a reality check on the way to 2030.[283]

Beneath the ambition sits legislated demand. RED III sets a binding industry target: 42% of the hydrogen consumed in industry must be RFNBO by 2030, rising to 60% by 2035.[284] Article 22b allows a member state to reduce the 2030 figure to 33.6%, but only if two conditions hold – its national contribution is on track, and fossil hydrogen is no higher than 23% of its hydrogen consumption in 2030 and 20% in 2035.

[280] ISCC EU 202-6
[281] (S. Rößler, personal communication, 17 July 2026)
[282] COM(2022) 230 final (REPowerEU Plan)
[283] European Court of Auditors, Special Report 11/2024: The EU's industrial policy on renewable hydrogen, para. 122, p. 63.
[284] Directive (EU) 2018/2001, Art 22a(1)

Transport is governed by Article 25. Member States must deliver either a 29% renewable share of transport energy by 2030 or a 14.5% reduction in greenhouse-gas intensity. Within whichever they choose, advanced biofuels, biogas, and RFNBOs together must reach at least 1% in 2025 and 5.5% in 2030. Of that 5.5%, at least 1 percentage point must be RFNBO. Separately, member states with maritime ports "shall endeavour" to ensure an RFNBO share of at least 1.2% in maritime energy from 2030 (Article 25(1)).

Those headline figures overstate the physical volume required, because the calculation rules apply multipliers. Qualifying fuels count at twice their energy content (Article 27(2)(c)), which makes the 5.5% basket an effective 2.75% of physical energy and the 1 percentage-point RFNBO floor an effective 0.5 percentage points. Further multipliers apply where the fuel is supplied in the aviation and maritime transport modes: 1.2 for advanced biofuels and biogas from Part A of Annex IX, and 1.5 for RFNBOs (Article 27(2)(e)).[285] The workings are at Annex E.

Two sectoral regulations add quotas of their own. ReFuelEU Aviation obliges fuel suppliers at Union airports to provide a rising share of sustainable aviation fuel, within which a further sub-share must be synthetic, meaning RFNBO-derived.[286] FuelEU Maritime sets a declining limit on the greenhouse-gas intensity of energy used on board ships calling at EU ports, and carries its own conditional RFNBO sub-target from 2034.[287]

On the funding side, the European Hydrogen Bank runs competitive auctions paying a fixed premium per kilogram of hydrogen to the lowest bidders. From IF24 the terms add a resilience criterion aimed at supply concentration, capping at 25% of capacity any stack whose surface treatment, cell production or stack assembly is carried out in China, on an explicit "irreversible dependency" rationale.[288] IF25 retained the criterion,[289] in May 2026 selected nine projects, all in Europe, and introduced auctions-as-a-service, under which a

[285] (International Council on Clean Transportation (ICCT), 2023)
[286] Regulation (EU) 2023/2405 (ReFuelEU Aviation), Art 4 and Annex I
[287] Regulation (EU) 2023/1805 (FuelEU Maritime), Art 5(3)
[288] (European Commission, DG CLIMA, 2024)
[289] (European Commission, 2025)

member state pays for additional national winners to be funded on the auction's own ranking.

The auctions matter here twice over. They are the EU's principal constructed demand. And their terms are its clearest statement of supply-diversification policy: the criterion caps content from one country rather than requiring content from the Union, which distinguishes it from a domestic-content rule. Chapter 6 examines that distinction.

Two further instruments assemble demand instead of funding production. H2Global is a German-founded mechanism, now operating with EU support, that runs a double auction: a public intermediary buys hydrogen derivatives abroad on long-term contracts at the lowest offered price, resells them to European buyers at the highest bid, and public money covers the gap.[290] Its funding windows have been extended to lots covering South America. The EU Hydrogen Mechanism is a matching platform, collecting offers from producers and expressions of demand from buyers, then pairing the two. Its first round closed in April 2026 with 265 supply-side projects offering 17.6 Mt a year.[291]

For all this architecture, the market remained thin at the cutoff. The deadline for transposing RED III was 21 May 2025,[292] and more than a year later transposition has proceeded unevenly between the two sectors the targets cover. Transport is the more advanced. By early June 2026, 13 of 27 member states, representing more than 60% of EU transport energy demand, had transposed the Directive for transport, helped by the option to count hydrogen used in refineries towards the 1% target. The IEA estimates that this triggers demand for at least 575 ktpa of hydrogen, comparable to the 630 ktpa of low-emissions hydrogen production now operational or past final investment decision. A further seven member states are in the process. Industry lags well behind: at the same date only four member states were transposing the Directive for industry.[293] The 42% industry target set by Article 22a is therefore, for most of the Union, not yet national law.

[290] (H2Global Foundation / Hintco, 2024)
[291] (International Energy Agency, 2026a, pp. 200–201)
[292] Directive (EU) 2023/2413 (RED III), Art 5(1)
[293] (International Energy Agency, 2026a, p. 202)

Investment reflects that. Where projects have reached final investment decision in Europe, they cluster in refining, roughly 70% of 2025 FID capacity, which shows an in-house buyer rather than a merchant market.[294] About 6% of announced global e-fuels projects had reached final investment decision by mid-2026, on the industry association's census.[295] Studies of announcement-to-delivery rates in hydrogen point the same way, with realisation in the single-digit percentages – a different metric from the FID census, but the same signal.[296] The IEA's 2026 review cut expected 2030 low-emissions hydrogen production by 10 Mt from its 2025 estimate, noting that most postponed or cancelled projects cite slower-than-expected market development, and recorded the global electrolysis pipeline 30% below a year earlier.[297] Chile's position within this picture is set out in the case chapters: a strategy revised from 25 GW by 2030 to 8–15 GW by 2035,[298] one operating certified plant, one suspended mega-project, and a project population in which more than half had been postponed or cancelled by 2025.[299]

B.6 Regulatory developments to the cutoff

The criteria were under review at submission, and the sequence matters to Chapter 7.

In late March 2026 senior energy officials from Germany, Spain, the Netherlands, Austria, and Poland wrote jointly to the Commission. They asked for two things: that the review of the delegated act be brought forward, and that the additionality and hourly-correlation requirements be deferred to 2035. Their ground was that the current framework does not match the market's development.[300] The review they wanted accelerated is the one Article 10 provides for – a Commission monitoring report due by mid-2028. Its mandated scope covers production costs, greenhouse-gas savings and energy-system effects. It does not extend to supply chains.

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[294] (International Energy Agency, 2026a, pp. 53, 93)
[295] (eFuel Alliance, 2026; International Energy Agency, 2026a)
[296] (eFuel Alliance, 2026, p. 1; Odenweller & Ueckerdt, 2025; Wolf & Zander, 2021)
[297] (International Energy Agency, 2026a, pp. 86, 93)
[298] (International Energy Agency, 2026a, p. 198; Ministerio de Energía, 2026)
[299] (International Energy Agency, 2025a, p. 83)
[300] (H2 View, 2026)

On 22 April 2026 the Commission confirmed it would propose a targeted review, ahead of the Article 10 schedule.[301] The interval between letter and confirmation was under a month. Trade reporting anticipates that the additionality phase-in will be deferred. No proposal had been published by 19 July 2026.

On 3 July 2026 a coalition convened by environmental organisations published an evidence compilation supporting retention of the criteria;[302] on 7 July eight industry associations jointly urged launch and completion of the amendment within the year.[303]

The review sits within a wider set of adjustments. Industry has proposed simplifying certification through omnibus instruments.[304] Joint letters have raised the Union Database's operation in third countries.[305] The proposed Industrial Accelerator Act of March 2026 would introduce Union-origin requirements for electrolysers in supported projects.[306] And the EU Hydrogen Strategy is itself under revision.[307]

Dr Stefan Rößler, lead auditor for the Haru Oni certificate, describes the same condition from inside the certification system. On his account the Commission is trying to regulate and to enable at once: "even though they want to regulate it, they still want to be an enabler for an industry", and "if you make the framework too tight, no one can breathe in there and you will just suffocate the market." The looseness is deliberate – "it is by design." So is the method of correction. After RED III was published, "it did not take even a month before the Q&A document came out": instead of reopening the text, the Commission closes gaps through guidance and writes them into the scheme documents at the next revision. He describes the result as a framework still in "a beta phase"[308]

[301] COM(2026) 370 final (AccelerateEU), p. 11
[302] (Bellona Europa, 2026)
[303] (ERGaR et al., 2026)
[304] (eFuel Alliance, 2025b)
[305] (eFuel Alliance, 2025a)
[306] COM(2026) 100 (Industrial Accelerator Act – proposal)
[307] (International Energy Agency, 2026a, p. 31)
[308] (S. Rößler, personal communication, 17 July 2026)

One feature runs through all of it. Every live proposal concerns stringency, timing or administration. None concerns the demand-side completion documented in §B.5, or the equipment questions Chapter 6 examines.

The chronology at Exhibit 1, which sets out the case's regulatory and project milestones from 2020 to the cutoff, closes with these developments. Their treatment, and that of the revision when it is published, follows the addendum protocol stated in Chapters 1 and 2.

Annex C — Legislation, primary documents and locators

*This annex is the evidentiary companion to the **Table of Legislation** (front matter). Where the Table of Legislation lists each instrument in formal citation form, **B.1 and B.2** here index the same instruments and the WTO panel reports by **what the thesis relies on each for**, down to the operative article or point — legislation is cited in footnotes rather than the bibliography, so this is where the provisions are mapped to the argument. **B.3** lists the load-bearing primary documents (filings, agreements, auction terms, state records) with locators, so the evidence base is inspectable from the document itself.*

C.1 Legislation

C.1.1 European Union — directives and regulations

Instrument	Short name	Relied on for
Directive (EU) 2018/2001, OJ L 328, 21.12.2018	RED II	The parent act. Art 2(36) defines RFNBOs; Arts 25, 27, 29a, 30 carry the targets, the RFNBO criteria and the recognition of voluntary schemes. **Cited throughout as amended**
Directive (EU) 2023/2413, OJ L, 31.10.2023	RED III	Amends 2018/2001. Art 1(1)(g) replaces the RFNBO definition, removing the transport limitation; inserts Arts 22a, 22b and 29a; sets the industry and transport targets; **Art 3(1)** raised the binding Union renewable share from the Commission's 2021 proposal of 40% to **42.5%, aspiration 45%**, on the impetus of REPowerEU (§B.1) (Directive (EU) 2023/2413 (RED III))

Directive 2009/28/EC, OJ L 140, 5.6.2009	RED I	The 20% by 2020 target, for the lineage at §B.1
Regulation (EU) 2022/2560, OJ L 330, 23.12.2022	Foreign Subsidies Regulation	Reaches bidders and concentrations in the Union's market, not a third-country producer that never bids in it – the first row of the institutional seam at §F.3
Regulation (EU) 2024/1735	Net-Zero Industry Act	40% manufacturing benchmark; >50% single-third-country resilience trigger (§6.3, Annex F)
Regulation (EU) 2024/1252	Critical Raw Materials Act	65% single-third-country benchmark — an objective, not an operative import ceiling (§6.3, Annex F)
Regulation (EU) 2019/943	Electricity Market Regulation	Art 13 redispatching, referenced by CDR 2023/1184 Art 4(3)
Regulation (EU) 2021/1119	European Climate Law	The 55% reduction target, for the Fit for 55 framing at §B.1
Regulation (EU) 2023/2405	ReFuelEU Aviation	Synthetic-fuel shares; Art 4 and Annex I (§B.5)
Regulation (EU) 2023/1805	FuelEU Maritime	Art 5(3), the 2% RFNBO trigger from 2034 (§B.5)
Regulation (EU) 2023/1115	EU Deforestation Regulation	The cross-sector parallel at §3.2 (Weber)

Regulation (EC) No 1907/2006, OJ L 396, 30.12.2006	REACH	The canonical Brussels Effect case at §3.3
Directive 2008/101/EC	Aviation ETS amendment	Territorial-extension example at §3.3

C.1.2 European Union — delegated and implementing acts

Instrument	Relied on for
Commission Delegated Regulation (EU) 2023/1184, adopted 10 Feb 2023, OJ L 157, 20.6.2023	The electricity criteria. **Art 3** direct connection (the route the Chilean cases take); Art 4 grid routes — 4(1) >90%-renewable zone (output capped in proportion to the share), 4(2) <18 gCO_2e/MJ zone with an equivalent PPA, 4(3) absorbing curtailment (redispatch under Art 13 of Reg (EU) 2019/943, on TSO evidence), 4(4) the general route (three conditions); Art 5 additionality; Art 6 temporal correlation; Art 7 geographical correlation; Art 10 review clause (report by 1 July 2028); Art 11 transitional exemption from Art 5(a)–(b); recitals 3, 4, 16, 17
Commission Delegated Regulation (EU) 2023/1185, adopted 10 Feb 2023, OJ L 157, 20.6.2023	The greenhouse-gas methodology. Annex Part A point 1 (**machinery and equipment emissions excluded**); Part A point 2 (94 gCO_2e/MJ comparator); Annex **point 10** defines the five eligible CO_2 sources — 10(a) ETS-priced carbon (time-limited: 2036 where the carbon comes from electricity generation, 2041 for other covered activities; qualifying pricing systems set by DG ENER guidance, currently EU/Swiss/UK, list stated non-exhaustive), 10(b) DAC, 10(c) biogenic meeting the sustainability criteria, 10(d)

	RFNBO/recycled-carbon combustion, 10(e) geological; point 11 subjects the phase-out dates to review (§B.3)
Commission Implementing Regulation (EU) 2022/996, OJ L 168, 27.6.2022	Verification and chain of custody. **Art 19(2)(f)** (system must book quantities with no sustainability characteristics determined); **19(2)(e)** (separate mass balances); **19(2)(j)** (sets assignable on withdrawal); **19(2)(l)** (three-month balancing period); **Art 2(22)** 'site'; Art 2(23) 'proof of sustainability'
Commission Delegated Regulation (EU) 2025/2359, adopted 8 July 2025	Low-carbon hydrogen; the adjacent category acknowledged at §B.1
Commission Implementing Regulation (EU) 2025/1176	NZIA implementing rules; resilience criteria in auctions
Commission Implementing Decision (EU) 2024/3176, 19 Dec 2024	Recognition of ISCC EU for RFNBOs, to 21 Dec 2029
Commission Implementing Decision (EU) 2024/3180, 19 Dec 2024	Recognition of CertifHy
Commission Implementing Decision	Recognition of REDcert-EU

(EU) 2024/3194, 19 Dec 2024	

Mass balance and divisibility — provisions in full (§B.4). Article 19(2)(f) of IR (EU) 2022/996 requires the system to record “information about the quantities of raw material and fuels for which no sustainability or GHG characteristics have been determined” — the uncertified stream is a category the accounting anticipates, not an omission it tolerates. The balancing period is three months (Art 19(2)(l)); regulatory identity attaches to the “site”, “a geographical location ... with precise boundaries within which products can be mixed” (Art 2(22)), with separate mass balances required wherever materials cannot be treated as mixed (Art 19(2)(e)); ISCC EU 203 restates that mass balances “are at least site specific”. *Worked illustration:* a producer making 100 t of methanol in a quarter, 40 of them under fully compliant conditions, may sell 40 t as RFNBO into the EU and 60 t elsewhere unlabelled, provided the bookkeeping balances within the period — the molecules delivered as certified need not be the molecules produced compliantly.

C.1.3 European Union — preparatory, interpretive and policy documents

Document	Relied on for
COM(2021) 550 final, 14 July 2021 — 'Fit for 55': delivering the EU's 2030 Climate Target on the way to climate neutrality	The Communication that launched and named the Fit for 55 package; relied on for the characterisation of RED III as its renewable-energy component (§B.1, §3.1.1)
COM(2021) 557 final, 14 July 2021 — proposal for the RED recast	Article 1(2) would have set a binding 40% Union renewable share by 2030, superseded by the adopted 42.5% with an aspiration to 45% (§B.1)
COM(2022) 230 final, 18 May 2022 — REPowerEU Plan	The 10 Mt renewable-hydrogen import ambition; the Russia-exit framing — “Russia’s unprovoked and unjustified military aggression against Ukraine”;

	"rapidly reducing our dependence on Russian fossil fuels by fast forwarding the clean transition" (§B.1, §7.2)
COM(2026) 370 final, 22 Apr 2026 — AccelerateEU	Commitment to a targeted review of the production criteria, p. 11 (§B.6, §7.3)
COM(2026) 100, 4 Mar 2026 — Industrial Accelerator Act	**Proposal only.** Union-origin requirements for electrolysers, pp. 33–35 (§6.3, Annex F)
C(2023) 1087 final — explanatory memorandum to the delegated acts	"Technical act", no impact assessment; §2, p. 2 (§B.1)
Commission press-corner Q&A, QANDA/23/595, 13 Feb 2023	Applicability to producers inside and outside the Union, §7
DG ENER, *Questions and answers on the implementation of the hydrogen delegated acts*, v. 14 Mar 2024	The effective-carbon-pricing list (**EU, Swiss and UK ETS**) and the bidding-zone equivalence test. Transcribed at CertifHy v1.6 Annex B, pp. 52–53; test restated at ISCC EU 202-6 Annex III, pp. 30–31.

C.1.4 Third-country legislation

Instrument	Relied on for
Brazil, Lei 14.948/2024, 2 Aug 2024	Establishes the SBCH2; Art 4(XII) sets the 7 $kgCO_2e/kg$ threshold; Art 15 §2 makes adherence voluntary (§5.5)
Brazil, Lei 14.990/2024	Creates the PHBC programme of auctioned fiscal support (§5.5)
United States, 26 U.S.C. §45V(c)(2)(A)	The 4 $kgCO_2e/kgH_2$ statutory ceiling (§B.3)

United States, 26 CFR §1.45V-4(d)(3)(ii)(A)–(B)	Hourly matching, with calendar-year matching before 1 Jan 2030 (§B.3, §5.4)
Uruguay, Decreto 349/005	Environmental authorisation regime; art. 5(c) classification and art. 22 location viability (§5.6)
EU–Chile Interim Trade Agreement, in force 1 Feb 2025	Energy and raw-materials chapter; export pricing and performance requirements (§6.4)

C.2 Dispute settlement

Report	Locator	Relied on for
Panel Report, *European Union — Palm Oil (Malaysia)*	WT/DS600/R, circulated 5 Mar 2024, adopted 26 Apr 2024	RED II sustainability criteria held to be technical regulations within the TBT Agreement; findings on administration, including failures of timely review (§6.2)
Panel Report, *European Union — Palm Oil (Indonesia)*	WT/DS593/R, circulated 10 Jan 2025, adopted 24 Feb 2025	Same discipline confirmed (§6.2)

C.3 Primary documents and locators

C.3.1 Certification file (Haru Oni)

Document	Evidences	Locator	Key
RED III certificates, EU-ISCC-Cert-	Certification against RED III; scopes, product chain and actual GHG values. Four	First issued 23 Jun 2025, valid to 22 Jun 2026 — the	TÜV SÜD Industrie Service

DE102-25060138 (first) and -26060141 (renewal)	scopes in 2025 (Energy Producer, Electrolyzer, Methanol plant, Refinery), three in 2026 — Energy Producer not carried forward. GHG option 2 (actual value) on every line of both annexes. Chronology: ISCC PLUS 2023 (no EU-recognised RFNBO scheme then existed) → ISCC EU recognised Dec 2024 → first RED III certificate 23 Jun 2025 → renewal 16 Jun 2026	certificate's own annex records issue on 18.06.2025; the face and signature date of 23.06.2025 is used here. Renewal issued 16 Jun 2026, valid 19 Jun 2026 – 18 Jun 2027	GmbH 2025; 2026
ISCC summary audit report, HIF Chile 1 SpA	Audit 20–22 Apr 2026; 0 major / 2 minor NCs; mass balance; raw-materials origin field "- not applicable -"	Report dated 8 Jun 2026	TÜV SÜD Industrie Service GmbH 2026 (attachment)
HIF certification announcement	Announcement of first certification, for the 2025/26 certificate year; "capable of producing RFNBO-compliant fuels"	1 Oct 2025 press release (announcement date, **not** the certification date)	HIF Global 2025
CertifHy GHG & Sustainability methodology v1.6	Machinery/equipment emissions excluded by design (**§B.2**, p. 10) — scheme implementation of	Scheme document	CertifHy 2025

	CDR 2023/1185 Annex A pt 1, which is the origin of the rule		
ISCC EU 203 (Traceability & CoC) v4.2	Three-month balancing period (§B.4.2, **restating IR 2022/996 Art. 19(2)(l) — see n. 50**); mass balances "at least site specific"	Scheme document	ISCC System GmbH 2025

C.3.2 Chilean environmental dockets (SEIA)

Document	Evidences	Locator	Key
H2 Magallanes EIA (descripción)	Filed design: 5 GW / 616×8 MW turbines feeding seven electrolysis centres of ~3.85 GW; **~640,000 t/yr hydrogen** for an ammonia complex **up to 10,800 t/day**; US$16bn; battery + gas backup interconnected across the site (dispersed generation, not grid-drawn)	Expediente 2165025085, filed May 2025	TotalEnergies H2 Magallanes (titular); evaluated by Servicio de Evaluación Ambiental (SEA), Chile 2025
ICSARA, H2 Magallanes	Consolidated agency observations (800+ reported)	Expediente 2165025085, 7 Aug 2025	TotalEnergies H2 Magallanes (titular); evaluated by Servicio de Evaluación Ambiental (SEA),

			Chile 2025 (attachment)
Suspension extension resolution	TotalEnergies requested suspension to 31 Mar 2027; granted only to 7 Dec 2026 (**15 months against an 18-month request**); grounds (design optimisation, archaeology/ecosystems campaigns)	Expediente 2165025085, 23 Sep 2025	TotalEnergies H2 Magallanes (titular); evaluated by Servicio de Evaluación Ambiental (SEA), Chile 2025 (attachment)
Cabo Negro RCA + EIA extracts	Approval Nov 2025; US$830m; 173,600 t/yr e-methanol	Expediente 2160078437	HIF Chile 1 SpA (titular); evaluated by Servicio de Evaluación Ambiental (SEA), Magallanes 2025
Faro del Sur RCA + EIA extracts	372 MW wind approved 6 Feb 2026 on third attempt (2156419025, 2160733311)	Expediente 2160813317	HIF Chile & Enel Green Power (titulares); evaluated by SEA, Magallanes 2026

C.3.3 Uruguayan environmental file (HIF Paysandú)

Document	Evidences	Locator	Key

Comunicación de Proyecto, HIF Uruguay S.A.	Design CO_2 requirement **1,220,550 t/yr nominal**; ALUR **50,000 t/yr**; boilers designed for **920,000 t/yr** from **951,400 t/yr** forest-residue biomass; sites ~6 km apart	Filed 17 Jul 2025; this edition Aug 2025; pp. 69–70	HIF Uruguay S.A. 2025
DINACEA, Informe de Clasificación y VAL	Ministry restatement of the mass balance; ALUR CO_2 is maize, sorghum and wheat fermentation; biomass from a ~300 km radius; biomass-supply feasibility condition (p. 19)	Exp. EM2025/36001/011700, 28 Oct 2025, pp. 6–7	Ministerio de Ambiente, DINACEA (Uruguay) 2025
Certificado de Clasificación y VAL	Category C under Decreto 349/005 art. 5(c); location viability declared; Emprendimiento de Alta Complejidad	21 Nov 2025, folios 470–473	Ministerio de Ambiente, DINACEA (Uruguay) 2025
AAP Tomo I — Documento de Proyecto	"**El principal propósito de las calderas es transformar los desechos forestales en CO_2**" (§5.2.3.2, p. 150); three boilers sized to run all four trains without	Filed 13 Mar 2026	HIF Uruguay S.A. 2026

	ALUR (p. 151); alkaline electrolysis 4 × 280 MW	
Acuerdo de Implementación, HIF Uruguay ⇔ ALUR (signed)	Fermentation CO_2 max 50,000 t/yr at **USD 80/t**; post-combustion max 100,000 t/yr at **USD 10/t** (cl. 7.5.1, p. 11); RED II/III certification required of gases **and** biomass (cl. 10.2)	23 Dec 2024
Memorando de Entendimiento, ROU ⇔ HIF	Binding siting commitment to padrones 11.950/11.951, Paysandú; USD 5,385m; 880,000 t/yr e-fuels at full phase	18 Dec 2025

C.3.4 Auction terms and funding instruments

Document	Evidences	Locator	Key
IF24 Terms & Conditions	25% cap on Chinese electrolyser-stack capacity, counted through surface treatment **or** cell unit production **or** stack assembly	Dec 2024	European Commission, DG CLIMA 2024
IF25 Terms & Conditions	≥75% non-Chinese electrolyser requirement retained; €1.3bn budget; three topics	Dec 2025	European Commission 2025

IF25 results	9 projects, 7 countries, €1.09bn, premia €0.44–3.49/kg	7 May 2026	European Commission 2026
EIB/KfW Chile renewable-hydrogen facility	**Up to** €216.5m (€200m EIB/KfW + €16.5m LACIF grant); CORFO implementing	28 Mar 2025	European Investment Bank 2025

Chilean, Brazilian and German state records

Document	Evidences	Locator	Key
National Green Hydrogen Strategy (2020) + Action Plan (2024)	Facilitation position; export orientation; the 1,700+ GW potential figure (2020 estimate)	Ministerio de Energía	Ministry of Energy (Chile) 2020; Ministerio de Energía 2024
Strategy update 2026–2030	Targets recast to production volumes; local-value pillar without binding content rule; Action 79 names the EU regime only as “the import requirements being discussed in Europe”	Mar 2026, outgoing administration	Ministerio de Energía 2026
CNE, Reporte Mensual del Sector Energético	Installed national capacity 37,173 MW at Nov 2025	Dec 2025 edition, §3	Comisión Nacional de Energía (Chile) 2025

CORFO 2021 production tender record	Developer/region/capacity disclosed; **no supplier or origin field**	2021 Primer Llamado	CORFO 2021
CORFO 2025 electrolyser-factory awards	US$25.6m; Hygreen, Guofu, Joltech — **origin disclosed when equipment is the funded object**	Mar 2025	CORFO 2025
Hydrogen promotion law (status)	US$2.8bn tax-credit auctions; Chamber 75–22 (3 Dec 2025); in Senate at the cutoff	Ministerio de Economía	Ministerio de Economía, Fomento y Turismo (Chile) 2025
BNDES, *Hidrogênio de baixo carbono*	Sizes national electrolyser demand off the **draft** delegated act: 48 GW at the correlation-bound 50% capacity factor against 26.7 GW at 90%, 2030, 5% scenario	Oct 2022, pp. 82, 92–93	Banco Nacional de Desenvolvimento Econômico e Social (BNDES) 2022
BMWK grant decision (Zuwendungsbescheid), obtained under FOI	Up to €8.23m to Siemens Energy; no hard content clause; soft EU-sourcing preference	27 Nov 2020	Bundesministerium für Wirtschaft und Klimaschutz (BMWi/BMWK) 2020

Annex D — Interview and correspondence record

Personal communications are cited in the text and do not appear in the reference list; this annex is their record. It also documents the access outcomes that §2.5 treats as data. Attribution bases — named, role-only or background — were agreed for each exchange in the channel of the exchange itself and are honoured as agreed. Background contributors are unnamed here by design; their identities are known to the researcher. Recordings were made for transcription only and are deleted at submission; transcripts are archived with the source record.

D.1 Exchanges informing the thesis

#	Interlocutor	Format	Date (2026)	Attribution basis	Used in
1	André Wolf, Centrum für Europäische Politik (cep)	Written answers (email)	9 June	Named personal communication; written consent, 11 June	Ch 6 §6.1 (storage-as-compliance point); informs the analytical context (§2.5)
2	Aram Pedinian Mohr, VP Commercial, HIF Global; co-chair, ISCC RFNBO Technical	Written answers to four questions	1 July	Named personal communication	Ch 1; Ch 2; Ch 5 §§5.2–5.3, 5.5, 5.7; Ch 6 §6.4

	Stakeholder Committee				
3	Dr Tobias Block, Chief Strategy Officer, eFuel Alliance	Recorded call, 27 minutes	7 July	Named interview; verbal consent given before recording; transcript archived	Ch 2; Ch 6 §6.2; Ch 7
4	Dr Stefan Rößler, TÜV SÜD, lead auditor of the Haru Oni ISCC EU RFNBO certificate	Video interview, 60 minutes	17 July	Named interview; consent recorded on tape; scope limited to general frameworks by prior agreement, audit-specific matters neither asked nor answered; transcript archived	Ch 2; Ch 4 §B.6; Ch 5 §§5.2–5.4; Ch 7 §7.4
5	Empresa de Pesquisa Energética (EPE), Brazil — federal energy planning agency	Institutional written answers via the Fala.BR platform, protocol 48008.000110/2026-75	15 July	Institutional written communication	Ch 2 §2.4; Ch 5 §5.5
6	Official of an EU institution	Call	June	Background; unattributed	Ch 6 §6.3

	working on trade and economic security				
7	Official of the EU’s external service	Written correspondence	30 June	Background; unattributed	Ch 6 §6.4
8	Staff of an international energy organisation	Written correspondence	29 June	Background; unattributed	Ch 6 §6.1

One further exchange is not used in the thesis, its contributor having declined attribution.

Eight exchanges inform the submitted text: five on a named or institutional basis, three on background.

D.2 Access record, by organisation

Organisation	Outcome
ISCC System GmbH	Interview request declined, 7 July (capacity); the scheme layer is covered instead by its published system documents, the published certificate and the stakeholder-committee vantage (§2.5)
Directorate-General for Energy (unit responsible for the production criteria)	Call offered 6 July; not schedulable before submission; carried to the addendum
EU Delegation to Chile, Santiago	Interview offered 17 July, following an EEAS introduction; falls after submission; to be recorded in the addendum

Ministerio de Energía, Chile	Written questions 26 June; procedural acknowledgment 7 July (Trámite 64191); statutory response window runs to early August, so pending at the cutoff
CORFO, Chile	Consulta CAS-120132 closed 3 July with redirection to the statutory lobby-law channel; not pursued before submission; a transparency-law request stands drafted but unfiled at the cutoff
German Institute of Development and Sustainability (IDOS)	Early correspondence (June) informed the choice of analytical lenses; no interview by the cutoff
No substantive response by the cutoff	CertifHy; MEO Carbon Solutions; JRC (CETO team); Hydrogen Europe; Hinicio; DEME (Hyport Duqm comparator); Brazil’s MME and ANP; Uruguay’s MIEM — written approaches sent 26 June – 1 July

Annex E — Derived figures and workings

Every figure this thesis derives rather than quotes is set out here, with its inputs, their sources, the working, and the sensitivity of the result. Figures quoted directly from a source are cited in the text and do not appear here. Where a working rests on an assumption rather than a cited parameter, the assumption is stated and the result is claimed only to the order of magnitude.

E.1 The greenhouse-gas ceiling: 28.2 gCO_2e/MJ

Used at: §B.3, §5.3, and as the yardstick for the Brazilian comparison at §5.5.

Inputs - Minimum greenhouse-gas saving for RFNBOs: **70 %** — Directive (EU) 2018/2001, Article 29a(1) - Fossil fuel comparator: **94 gCO_2e/MJ** — CDR (EU) 2023/1185, Annex, Part A, point 2. - Savings formula: Savings = (E_F − E) / E_F, where E is the fuel's lifecycle emissions and E_F the comparator — same point.

Working

Requiring Savings ≥ 0.70:

$(94 - E) / 94 \geq 0.70 \quad 94 - E \geq 65.8 \quad \mathbf{E \leq 28.2\ gCO_2e/MJ}$

Result: an effective ceiling of 28.2 gCO_2e/MJ on the fuel's own lifecycle intensity. Exact, not approximate: 94 × 0.30 = 28.2.

E.2 The ceiling per kilogram of hydrogen: ~3.4 $kgCO_2e/kgH_2$

Used at: §B.3, and for the EU–Brazil and EU–US threshold comparisons.

Inputs - Ceiling from D.1: **28.2 gCO_2e/MJ**. - Lower heating value of hydrogen: **≈ 120 MJ/kg** (120.0 MJ/kg; equivalently 33.3 kWh/kg).

Working

28.2 gCO_2e/MJ × 120 MJ/kg = 3,384 gCO_2e/kg = **3.384 $kgCO_2e/kgH_2$**

Result: approximately 3.4 $kgCO_2e$ per kilogram of hydrogen.

Note. The regulation states neither this figure nor the 28.2 g ceiling; both are derived here. The conversion is sensitive only to the heating value used. At an LHV of 119.96 MJ/kg the result is 3.383 kg; using the higher heating value (141.8 MJ/kg) would give 4.0 kg, which is **not** the basis used here. The lower heating value is the convention of the regulation's own methodology, which expresses intensity per MJ of fuel.

E.3 EU and US thresholds in common units

Used at: §B.3.

Regime	Stated threshold	In $kgCO_2e/kgH_2$
EU (RFNBO)	70 % saving against 94 gCO_2e/MJ	3.384 (derived, D.2)
US (section 45V)	"not greater than 4 kilograms of CO2e per kilogram of hydrogen"	4.0 (stated)

Result: the US eligibility limit is the looser of the two by roughly 0.6 $kgCO_2e/kgH_2$, or about eighteen per cent. The comparison holds only because both can be expressed per kilogram of hydrogen; the EU figure requires the D.2 conversion, the US figure does not.

E.4 CO_2 transport penalty at Magallanes distances

Used at: §5.3, to show why eligibility geography becomes siting geography.

Inputs - Road-freight emissions factor: **≈ 100 gCO_2e per tonne-kilometre** (order-of-magnitude parameter; heavy-duty lifecycle data). - Distance from Chile's biogenic CO_2

sources (Biobío region) to Magallanes: **≈ 2,000 km**. - CO_2 feed per tonne of e-methanol: **≈ 1.4 t** (stoichiometric requirement is 1.375 t; 1.4 used). - Lower heating value of methanol: **≈ 20 GJ/t** (19.9 MJ/kg).

Working

Transport emissions per tonne of CO_2 moved:

100 gCO_2e/t·km × 2,000 km = 200,000 g = **200 kg CO_2e per tonne of CO_2**

That is one fifth of the payload, before any process emissions.

Per tonne of e-methanol produced:

1.4 t CO_2 × 200 kg = **280 kg CO_2e per tonne of methanol**

Expressed against the fuel's energy content:

280,000 g ÷ 19,900 MJ = **≈ 14 gCO_2e/MJ**

Result: transport alone contributes on the order of 10–15 gCO_2e/MJ against a total ceiling of 28.2 (D.1) — roughly half the available budget, before electricity, processing or distribution.

Caveats. The freight factor is an order-of-magnitude parameter, not a Chilean measurement; road haulage over Patagonian distances may differ materially. The figure is used to establish that the constraint binds, not to price it.

E.5 Direct air capture energy penalty

Used at: §5.3, to show how the carbon axis feeds back into the electricity axis.

Inputs - DAC energy requirement: **1.5–3 MWh per tonne of CO_2** - CO_2 feed per tonne of e-methanol: **≈ 1.375 t** (stoichiometric). - Hydrogen feed per tonne of e-methanol: **≈ 0.1875 t** (stoichiometric, $CO_2 + 3H_2 \rightarrow CH_3OH + H_2O$). - Electrolyser specific energy consumption: **≈ 50 kWh per kg H_2** (assumption; system-level, current commercial range 48–55).

Working

Electrolysis demand per tonne of methanol:

187.5 kg H_2 × 50 kWh/kg = 9,375 kWh ≈ **9.4 MWh**

DAC demand per tonne of methanol:

low: 1.375 t × 1.5 MWh/t = 2.06 MWh high: 1.375 t × 3.0 MWh/t = 4.13 MWh

As a proportion of electrolysis demand:

2.06 ÷ 9.4 = **22 %** · 4.13 ÷ 9.4 = **44 %**

Result: direct air capture adds roughly 22–44 per cent to a project's electricity demand, competing with the electrolyser for the power the electricity criteria govern.

Caveat. The result is sensitive to the electrolyser efficiency assumed. At 45 kWh/kg the range rises to 24–49 per cent; at 55 kWh/kg it falls to 20–40 per cent. The stated range should be read as indicative.

E.6 Transport multipliers: nominal against physical energy

Used at: §B.5, to show that the headline transport shares overstate the physical volume required.

Inputs - Combined sub-target for advanced biofuels, biogas and RFNBOs: **5.5 % by 2030**, of which at least **1 percentage point** must be RFNBO — Directive (EU) 2018/2001, Article 25(1)(b). - Multiplier: qualifying fuels count at **twice** their energy content — Article 27(2)(c).

Working

5.5 % ÷ 2 = **2.75 %** of physical energy 1.0 pp ÷ 2 = **0.5 pp** of physical energy

Result: the nominal 5.5 per cent basket is an effective 2.75 per cent of physical transport energy, and the one-point RFNBO floor an effective half a percentage point. Further multipliers apply where the fuel is supplied in the aviation and maritime transport modes:

1.2 for advanced biofuels and biogas from Part A of Annex IX, and 1.5 for RFNBOs (Article 27(2)(e)).

E.7 Generation-to-electrolyser ratios

Used at: §5.4 and Exhibit 6.

Project	Generation	Electrolysis	Ratio
Haru Oni	3.4 MW wind	1.2 MW	3.4 ÷ 1.2 = **2.83 : 1**
H2 Magallanes	5 GW wind (616 × 8 MW = 4.93 GW)	3.85 GW	4.93 ÷ 3.85 = **1.28 : 1**

Result and warning. The ratios are not comparable as a stringency measure, and the thesis does not use them as one. The grandfathered pilot carries the *higher* ratio, which reflects demonstration-plant design margin rather than regulatory pressure. The oversizing signal the analysis relies on is storage sizing and utilisation, not nameplate ratio.

E.8 Paysandú CO_2 sourcing: the combustion share

Used at: §5.6.

Inputs — all from the Uruguayan environmental file, not from company communiqués. - Total CO_2 requirement: **1,220,550 t/yr (nominal)** — Comunicación de Proyecto, HIF Uruguay S.A., Aug 2025, pp. 69–70; restated at DINACEA, *Informe de Clasificación y VAL*, 28 Oct 2025, pp. 6–7 - From ALUR: **50,000 t/yr**, grain-fermentation CO_2 (maize, sorghum, wheat) — AAP Tomo I, Documento de Proyecto, Mar 2026, §5.2.3.1, p. 149. - From HIF's own biomass boilers: **920,000 t/yr**, from **951,400 t/yr** of forest residues sourced within a ~300 km radius — same sources.

Working

Designed supply:

50,000 + 920,000 = **970,000 t/yr**

Combustion share of designed supply:

920,000 ÷ 970,000 = **94.8 %**

ALUR share, on two denominators:

of designed supply: 50,000 ÷ 970,000 = **5.2 %** of nominal requirement: 50,000 ÷ 1,220,550 = **4.1 %**

Result: roughly **95 % of the carbon is purpose-arranged combustion and roughly 5 % is recovered from a pre-existing emitter.** Report as “about a twentieth from ALUR”, or give both denominators; do not state a single percentage without saying which.

The design intent is stated, not inferred. The Documento de Proyecto §5.2.3.2, p. 150: *“El principal propósito de las calderas es transformar los desechos forestales en CO_2”* — the principal purpose of the boilers is to transform forest waste into CO_2. Three boilers are sized to run all four production trains with no ALUR supply at all (p. 151).

Caveats. 1. **The nominal requirement (1,220,550) exceeds designed supply (970,000) and no document reconciles the gap.** Boiler nominal capacity would close it (3 × 42 t/h × 8,760 h = 1,103,760 t/yr) but no filing says so. Use the ratios, not the absolute shortfall. 2. **Three announcement figures circulate and none is a filing.** 710,000 t/yr = ANCAP, 8 Jun 2023, describing the superseded 180 kt e-gasoline concept. 150,000 t/yr from ALUR = the Dec 2024 announcements, which the signed agreement decomposes into 50,000 fermentation + 100,000 post-combustion — and **the post-combustion stream then disappears from every filing from July 2025 onward, unexplained**. 900,000 t/yr = a company round number approximating average-operation consumption (~873,000 derived from the DP’s plant factors).

Annex F — EU domestic origin and resilience instruments

This annex sets out the EU instruments that regulate equipment origin within the Union, against which Chapter 6 §6.3 draws its asymmetry with the origin-blind certification regime. It is a reference table rather than an argument; §6.3 carries the analysis. Instruments are given in the form in force or proposed at the thesis cutoff. Where an instrument is a proposal rather than law, this is stated.

F.1 The instruments

Instrument	Status at cutoff	What it does on origin	Threshold or benchmark
Net-Zero Industry Act Regulation (EU) 2024/1735	In force	Sets a manufacturing-capacity benchmark for net-zero technologies, electrolysers included; channels auctions and public procurement toward supply diversification through resilience criteria	Union manufacturing capacity to meet **40%** of annual deployment needs by 2030; resilience criteria bite where a single third country accounts for **>50%** of Union **supply** of a net-zero technology
NZIA implementing rules IR (EU) 2025/1176	In force	Operationalises the resilience and sustainability criteria for auctions and procurement	Sets the method for calculating third-country supply share and applying the criteria
Critical Raw Materials Act	In force	Sets extraction, processing and recycling benchmarks	Art. 5(1)(b) sets a benchmark (an objective, not an operative import

Regulation (EU) 2024/1252		and a single-supplier benchmark	ceiling) that no single third country supply more than **65%** of Union consumption of any strategic raw material at any relevant processing stage
Hydrogen Bank — auction IF24	Concluded	Origin condition attached to funding eligibility, on an explicit rationale of irreversible-dependency risk	No more than **25%** of electrolyser stack capacity sourced from China, counted through surface treatment **or** cell (unit) production **or** stack assembly
Hydrogen Bank — auction IF25	Concluded	Retained the IF24 origin criterion	Same 25% stack-capacity cap (retention stated in the T&C, not the results release); nine selected projects, all European, drawing **€1.09bn** at premia of **€0.44–3.49/kg**
Industrial Accelerator Act COM(2026) 100	**Proposal only**	Would generalise the approach: Union-origin requirements for electrolysers and selected components in supported projects and in public	Thresholds not settled at cutoff. The IEA flags the cost trade-off of the approach

procurement; conditions on large inbound investments from dominant-producer countries

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F.2 Industry's position, for the record

Two features of the record bear on whether the asymmetry is contested or shared.

The cap's architecture is the Commission's own. Where industry lobbied on the IF24 design, it lobbied for a *stricter* in-Europe pass-fail requirement. The Commission declined it in favour of the fractional cap that was adopted. The instrument is therefore not an industry capture of the auction terms.

Industry's resilience proposals stop at the import boundary. The European hydrogen association's resilience paper addresses public funding instruments and proposes nothing on imported fuel. Equipment origin appears nowhere in the sector's regulatory asks in either direction — a silence, not a recommendation.

F.3 The institutional seam

No single instrument or institution reaches the case the corridor produces.

Instrument family	What it reaches	What it does not reach
Trade-defence instruments	Goods entering the Union	Equipment that never enters the Union
Foreign Subsidies Regulation	Bidders and concentrations in the Union's market	A third-country producer not bidding in the Union

NZIA / CRMA resilience criteria	Union deployment and Union-supported procurement	Third-country plants whose output the Union imports
RFNBO certification	The fuel's production criteria	The apparatus that produces it (§6.2)

The residual case — Chinese equipment embedded in a third-country plant whose certified output the Union imports — falls between the trade, industrial and energy files, and no Council formation currently owns it.[309]

[309] Background communications, Annex D

Annex G — Exhibits: figures and tables

Exhibit 1 — Chronology of the case

Date	Event
2020	HIF begins Haru Oni development, designed against the anticipated RFNBO criteria for an EU-focused offtaker
May 2022	REPowerEU sets the 10 Mt renewable-hydrogen import ambition
Dec 2022	Haru Oni produces first synthetic fuel, pre-dating the adopted rules
20 Jun 2023	Both Delegated Regulations published (OJ L 157): electricity rules (2023/1184), carbon rules (2023/1185)
31 Oct 2023	RED III published; in force 20 Nov 2023
19 Dec 2024	ISCC EU, CertifHy and REDcert recognised for RFNBOs (to 21 Dec 2029)
Dec 2024	IF24 auction: 25% cap on Chinese electrolyser-stack content · HIF–ALUR biogenic-CO2 supply agreement signed, Uruguay, 23 Dec
1 Feb 2025	EU–Chile Interim Trade Agreement in force
Mar 2025	CORFO awards US$25.6m to electrolyser-factory consortia; two of three Chinese-led
May 2025	H2 Magallanes environmental study filed (5 GW, US$16bn)
23 Jun 2025	First RED III certificate issued for Haru Oni (EU-ISCC-Cert-DE102-25060138), valid to 22 Jun 2026
7 Aug 2025	Agency observations on H2 Magallanes consolidated (800+ reported)

Date	Event
23 Sep 2025	TotalEnergies requests suspension of the H2 Magallanes evaluation to 31 Mar 2027; granted to 7 Dec 2026
1 Oct 2025	Haru Oni announced as first non-EU ISCC EU RFNBO-certified facility
Nov 2025	Cabo Negro environmental approval granted · Uruguay declares location viability for HIF Paysandú, 21 Nov; Category C, full study required
3 Dec 2025	Chile's hydrogen promotion law passes the Chamber (75–22); now in Senate
Dec 2025	EDF cancels Energía Verde Austral · IF25 requires ≥75% non-Chinese electrolysers
6 Feb 2026	Faro del Sur environmental approval (372 MW wind for Cabo Negro)
Mar 2026	2026–2030 strategy update published, targets recast · Industrial Accelerator Act proposed, 4 Mar · HIF Paysandú environmental authorisation application filed, 13 Mar
20–22 Apr 2026	ISCC EU on-site audit at Haru Oni
22 Apr 2026	AccelerateEU reopens the production criteria for review
16 Jun 2026	RED III certificate issued (EU-ISCC-Cert-DE102-26060141), valid to 18 Jun 2027
3 Jul 2026	Bellona evidence compilation
7 Jul 2026	Industry joint letter urging the revision
19 Jul 2026	Factual cutoff of this thesis; later developments recorded in the dated addendum

Date	Event
Scheduled	Hourly correlation from 1 Jan 2030 · statutory review report by 1 Jul 2028 · fossil-CO2 phase-outs 2036/2041 · grandfathering ends 2038

Source: Author's compilation

Exhibit 2 — The hypotheses: predictions, observables and disconfirming evidence

Four hypotheses serve three research questions, because the rules have two axes (H1, H2) and two faces of the agency question (H3, H4). §2.2 sets out the framework; this exhibit sets out the test.

Panel A — the four hypotheses

RQ	Hypothesis	Prediction	Observed in	Fails if
RQ1 project design	**H1 — electricity axis**	Additionality and temporal/geographic correlation push developers to oversize renewable generation, add battery storage, and adopt off-grid, dispersed configurations.	Ratio of generation to electrolyser capacity; presence and sizing of storage; filed engineering decisions.	Lean designs drawing on the grid.
RQ1 project design	**H2 — carbon axis**	CO_2-eligibility rules, interacting with domestic resource geography, shape site	Carbon-sourcing strategy (biogenic where co-located feedstock exists; DAC where it does	Carbon sourcing shows no geographic pattern.

RQ	Hypothesis	Prediction	Observed in	Fails if
		selection, carbon sourcing and FIDs.	not); divergence in the same developer's sourcing across Chile and Uruguay.	
RQ2 state agency	**H3 — policy window**	The power to define compliant hydrogen sits in Brussels, not Santiago; Chile's policy is arranged around the EU standard, with no domestic standard and no equipment-origin or local-capability conditions.	Chile's adopted instruments, against the three Chapter 3 benchmarks — capability formation, standard-setting agency, linkage creation — with Brazil as the contrast.	Chile's instruments show independent standard-setting or capability conditions like Brazil's.
RQ3 supply chains	**H4 — amplification**	The rules inflate and shape the hardware a compliant project must buy; being origin-neutral and carrying no countervailing provision, they amplify dependence on Chinese hardware where	Tested outcome by outcome (Panel B).	Supplier origin is rule-driven; or a compliant project needs no more hardware than an unregulated

RQ	Hypothesis	Prediction	Observed in	Fails if
		manufacturing is concentrated there.		one; or the rules make no difference to configuration.

H1 and H2 are expected to differ in impact: at remote Chilean sites the carbon rules should bind harder than the electricity rules, since on an isolated grid additionality barely applies — an off-grid project builds its own generation regardless. §5.7 returns the verdict.

Panel B — H4 tested outcome by outcome

Counterfactual: would each outcome differ if EU demand existed but the RFNBO rules did not?

Outcome	Without the rules	Therefore
Supplier origin	Projects still buy electrolysers and turbines, and still buy on cost.	If cost explains the observed pattern, the rules make no difference.
Configuration & scale	Nothing forces oversized generation, dedicated storage or temporal correlation.	Filed engineering showing these features is evidence the rules bite.
Project viability	Weak demand exists either way.	Stalled projects count against the rules only insofar as compliance cost and regulatory uncertainty add pressure — amplifying, not causing.

Panel C — the formative-phase prediction (underlies H1 and H4)

New energy technologies pass through a sheltered early phase, when policy support makes higher-cost, varied procurement affordable, before cost pressure pushes the industry onto the cheapest supply — today, in electrolysers, China (§6.1). The Chilean cases sit on either side of that shift: the sheltered pilot (Haru Oni) could afford European equipment; a fully regulated successor, exposed to full cost pressure, would be driven toward the cheapest suppliers. The prediction is that the pilot and the regulated projects diverge in where their equipment is made. The pilot test is asymmetric, though: Haru Oni's European sourcing is confounded by an €8.23m German federal grant and German industrial partners, so it could disconfirm the mechanism but not confirm it — the decisive evidence lies with the fully regulated projects (Chapter 6).

Exhibit 3 — Novelty positioning: the nearest neighbours and what each leaves open

Study	What it does	What it leaves open
Dejonghe & Van de Graaf 2025	Typology of risks in Global-South hydrogen trade and of producer-country responses	General level; no single instrument, no single country, no certification mechanics
Weko & Quitzow 2026	EU shifting from external governance to energy diplomacy (Algeria, Morocco, Mauritania)	Sets the RFNBO rules aside as background; this thesis takes the opposite premise
Scholvin & Kalvelage 2025	Ex-ante assessment of structure and agency in Chilean and Namibian green hydrogen	Makes the latecomer's room to act its object; the foreign rule-set is not treated as the structure narrowing it
Altenburg & Strohmaier 2025	Names certification schemes among the barriers export markets in the Global North impose on latecomers	Treated as compliance cost and regulatory risk from fragmentation, not as a structure constituting the market

Study	What it does	What it leaves open
Zabanova & Quitzow 2025	Invokes a hydrogen Brussels Effect in passing	Not carried to a mechanism or to a producer country
Weber 2025	EUDR effects on Ghanaian cocoa; finds fragmentation rather than wholesale adoption	Different sector; corroborates the divisibility logic on adjacent terrain
Goodwin et al. 2024	Surveys hydrogen certification as scheme design and practitioner perception	Certification examined as such, not as an instrument of industrial consequence
Fazeli et al. 2025 · White et al. 2025 · Schumm et al. 2025	Quantify the cost of certification misalignment and hourly matching for third-country producers	Techno-economic precision without a theory of the producing state
Eder & Rammer 2025	Dependency reading of the EU–Chile hydrogen relationship	The delegated acts' mechanics stay out of frame
Goecke 2025	Doctrinal map of Chilean producers' compliance obstacles (bidding zones, correlation evidence, direct connection)	No theory of rule-export as power; no equipment or supply chains; no industrial-agency question
Orihuela, Irarrázaval & Flores 2025	Green-windows analysis of Chile's hydrogen and lithium industrial policy, on 34 interviews	EU appears as competitor and trade-agreement constraint; the certification regime does not enter
This thesis	The EU's certification regime analysed as the externally set institutional terms of Chile's green window, with equipment origin and attribution addressed explicitly	—

Source: Author's compilation.

Exhibit 4 — Bradford's five conditions stress-tested against the RFNBO regime

Condition	Holds for RFNBO?	Reasoning
1. Market size	Holds, qualified	A premium demand hub, but the import market is mandated rather than established; its scale rests on targets now under doubt, so the power is prospective and policy-made
2. Regulatory capacity	Holds	Dense delegated acts; recognised schemes, accredited auditors and the Union Database; the sanctioning lever is scheme recognition and de-recognition (RED II Art. 30(4))
3. Propensity for stringency	Holds	Additionality, hourly correlation from 2030 and a 70% greenhouse-gas threshold are among the strictest production standards on any traded energy commodity
4. Inelastic target	Strains both ways	Producers can re-route output to Asia, which is elastic; EU buyers are mandate-inelastic under RED III sub-targets, which props the demand window open
5. Non-divisibility	Fails	Certification attaches to a specific quantity (IR (EU) 2022/996, Art. 2(23)) under mass balance (Art. 19); divisibility is exercised at portfolio level
Verdict		The strong de facto Brussels Effect is unavailable. What remains is access-conditioned Market Power Europe exercised through territorial extension

Source: Author's assessment against Bradford (2012).

Exhibit 5 — The certification chain, and what it never records

Step	What happens
1. Producer	A producer in any country applies to a Commission-recognised voluntary scheme
2. Recognised scheme	ISCC EU, CertifHy or REDcert, recognised 19 Dec 2024 to 21 Dec 2029 by Commission Implementing Decisions (EU) 2024/3176, 3180 and 3194; recognition power under RED II Art. 30(4)
3. Audit	An accredited certification body audits against both axes: the electricity rules (CDR 2023/1184, Arts 5–7 and 11) and the carbon and greenhouse-gas rules (CDR 2023/1185, Annex pts 10–11; 70% saving, 28.2 gCO2e/MJ)
4. Proof of sustainability	Issued against a specific quantity of fuel (IR (EU) 2022/996, Art. 2(23)), tracked by mass-balance chain of custody (Art. 19)
5. Union Database	Registered at EU entry; the quantity then counts toward RED III targets

At no link in this chain is the make, manufacturer or origin of the equipment recorded. The certificate's only origin field concerns raw-material feedstock.

Source: Author's compilation from RED II Art. 30(4), CDR 2023/1184, CDR 2023/1185 and IR (EU) 2022/996.

Exhibit 6 — The two Chilean projects compared

	Haru Oni (pilot)	H2 Magallanes (mega-project)
Developer	HIF Global	TotalEnergies H2 (80% TotalEnergies / 20% EREN)
Status	Operating since Dec 2022; RFNBO-certified	Environmental study filed May 2025; assessment suspended to 7 Dec 2026
Scale	3.4 MW wind → 1.2 MW electrolyser	5 GW wind (616 × 8 MW) → 3.85 GW electrolysis

	Haru Oni (pilot)	H2 Magallanes (mega-project)
Output	~130,000 L e-gasoline/yr	~640 kt/yr hydrogen nameplate; ~1.9 Mt/yr ammonia expected
Investment	~US$78m, including a €8.23m German federal grant	~US$16bn
Regulatory position	Grandfathered from additionality (Art. 11) to 2038	Subject to the full criteria from entry (post-2028 commissioning)
Carbon axis	Binds: e-fuel production, interim biogenic CO2 with a DAC prototype	Does not bind: ammonia carries no carbon
Known suppliers	Siemens Energy PEM electrolyser; Siemens Gamesa turbine; Sinopec-built methanol-to-gasoline unit	Not disclosed in the filing
Certification	ISCC EU, first non-EU facility; first certified 23 Jun 2025, current certificate issued 16 Jun 2026	None
Role in the design	Process-tracing spine; least-likely case for compliance without legal obligation	The regulated contrast; the informative side of the procurement test

Wind-to-electrolyser ratios are not compared directly: the grandfathered pilot carries the higher ratio (~2.8:1 against ~1.3:1), which reflects pilot design margin rather than regulatory stringency. The oversizing signal is storage sizing and utilisation, discussed at §5.4.

Source: Author's compilation from environmental filings, the certification record and corporate disclosures.

Exhibit 7 — The causal chain the thesis traces

Stage	Content
EU rulebook	RED III with CDR 2023/1184 and CDR 2023/1185. Territorial extension: market access conditioned on conduct performed abroad
Specific provision	Axis 1 — additionality (Art. 5), temporal correlation (Art. 6). Axis 2 — CO2 eligibility (Annex pt 10), 70% greenhouse-gas threshold
Project design decision	Dedicated new-build renewables; generation oversized against electrolyser nameplate; paired battery storage; off-grid siting; direct air capture or biogenic CO2
Hardware demand	Wind turbines · electrolysers · battery storage · power electronics · capture equipment
Supplier geography	Procured from a manufacturing base concentrated in China

Attribution: the rule drives the scale and design of demand (engineering channel); the rule is silent on origin (silence channel); the rule raises compliance cost (cost channel); cost, not the rule, selects the supplier. Together these constitute amplification rather than causation.

Source: Author's analysis.

Exhibit 8 — Compliance provision, hardware category and manufacturing concentration

Provision	Design consequence	Hardware	Chinese share of the manufacturing base
Additionality, Art. 5 (CDR 2023/1184)	Dedicated new-build generation	Wind turbines	6 of the top-10 manufacturers by 2024 installations; the top four all Chinese

Provision	Design consequence	Hardware	Chinese share of the manufacturing base
Temporal correlation, Art. 6 (hourly from 2030)	Paired storage; utilisation optimisation	Lithium-ion battery storage	~85% of global cell capacity; ~91% of the top-10 storage cell market, H1 2025
Framework as a whole	Electrolysis at compliant scale	Electrolysers	~60% of manufacturing capacity, but ~85% of alkaline; PEM capacity remains substantially non-Chinese
Storage requirement	Conversion and control layer	Power electronics and integration	Sungrow second global storage integrator, 2024
Where solar applies	Hybrid generation	Solar PV	>80% across key manufacturing stages
Context	—	All clean-technology factories	~76% of global clean-technology factory investment, 2024

The electrolyser row carries the qualification developed at §6.1: concentration is uneven across technologies, and non-Chinese manufacturing retains a substantial share of proton-exchange-membrane capacity.

Source: Author's compilation.

Exhibit 9 — The five causal factors and what each explains

Factor	What it causes	Counterfactual test	Causal weight
China's cost and scale advantage (US$600–1,200/kW against US$2,000–2,600 installed non-Chinese)	Which supplier is chosen	Chinese equipment is chosen with or without the rule	Structural cause (first)

Factor	What it causes	Counterfactual test	Causal weight
Demand shortfall in the EU offtake market	Stalls, freezes and cancellations	Freezes occur under any level of stringency; compliance cost amplifies them	Proximate cause of stalls (second)
The RFNBO rulebook, both axes	Scale and design of hardware demand; origin left unmanaged; compliance cost	Oversized, storage-heavy design would not exist without the rule	Amplifier (third)
Chilean policy choice: no domestic standard; state co-finance for Chinese manufacturers	Whether the window narrows or is defended	Brazil's contrasting choice shows the space existed	Mediator
Home-country and development finance	Pilot-scale supplier choice, pulled toward European equipment at Haru Oni	The grant, not the rule, selected the Siemens PEM unit	Confound; weakest factor

Source: Author's analysis.

Exhibit 10 — The three windows after RFNBO

Window	State for Chile	Mechanism
Market / demand	Open	RED III mandates pull certified volumes; Chile captures hosting and operating value
Technological / manufacturing	Constrained	Compliance requires specific hardware before local capability exists, so capability is imported and lock-in arrives early

Window	State for Chile	Mechanism
Institutional / policy	Ceded	Exports certify directly to EU rules through EU-recognised schemes; the lever green catch-up depends on most is set in Brussels, not Santiago

Source: Author's assessment applying Lee & Malerba (2017) and Lema, Fu & Rabellotti (2020).