Positioning for Transition

An Abductive Study on Resource-Based Market Entry into the European Hydrogen Pipeline Coatings Sector

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Positioning for Transition: Strategic Market Entry of Coatings Firms into Emerging Hydrogen Markets

An Abductive Study on Resource-Based Market Entry into the European Hydrogen Pipeline Coatings Sector

By

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Preface

This thesis was written between January and June 2025 as part of the MSc programme in Complex Systems Engineering and Management at Delft University of Technology. The research was conducted in collaboration with Hempel A/S and focuses on the strategic entry of protective coatings into emerging hydrogen pipeline markets.

The project was carried out remotely from Barcelona, where Hempel's regional office is located. While this created some challenges, such as reduced access to in-person academic exchange, it also allowed for a close working relationship with the company's internal stakeholders. I am grateful for the opportunity to work on a topic I initially had little familiarity with, and to engage deeply with a complex and fast-evolving field.

I would like to express my sincere gratitude to my academic supervisors, Dr. Jan Anne Annema and Dr. Milad Kolagar, for their thoughtful guidance, critical feedback, and flexibility throughout the process. I also want to thank Lucia Torres at Hempel for facilitating this collaboration and for her continued support in aligning the research with strategic priorities. Special appreciation goes to Ruben Paloma for his continuous help, insights into the market, and for reviewing parts of the thesis. I am also thankful to Lars Schrade for his enthusiasm and for sharing valuable resources and expertise on hydrogen pipeline infrastructure. Furthermore, I am grateful to all interviewees who generously contributed their time and perspectives. Their openness and promptness helped ground the framework in practical realities. Finally, I want to thank the classmates and peers who sparred with me along the way, their feedback helped sharpen both the argument and the structure of this work.

I feel lucky to have worked on a topic that stretched both my thinking and my confidence, and to have done so with such supportive people around me. This thesis marks the end of my time as a student and also the end of my year abroad in Barcelona, and I look back on this period with gratitude, growth, and more than a few good lessons learned.

Barcelona, June 2025
Noor Broersen

Executive Summary

Hydrogen infrastructure is a multi-billion-euro opportunity, but most coatings companies are unsure how, where, or when to engage. This thesis investigates how protective coatings firms can strategically position themselves for entry into Europe's emerging hydrogen pipeline market. As Europe accelerates its transition to net-zero, hydrogen is gaining political, financial, and technical momentum. It is seen as a crucial enabler of decarbonisation across hard-to-electrify sectors such as energy storage, heavy industry and long-haul transport. In response, the European Commission's REPowerEU plan targets 20 million tonnes of hydrogen production and imports by 2030. However, existing pipeline infrastructure is largely unfit for hydrogen transport, and adaptations will require specialised internal coatings that address permeability, embrittlement, and safety under new operating conditions. Protective coatings, traditionally used for corrosion and flow efficiency, must now meet unprecedented performance demands. Yet despite their strategic importance, coatings firms have not developed consistent approaches to entering this fast-evolving market.

This thesis addresses that gap by exploring how firms such as Hempel A/S (the industry collaborator) can formulate structured market entry strategies for hydrogen infrastructure. The sector presents a paradox. Early investment is necessary to capture long-term opportunities. Yet uncertainty about performance standards, policy developments, and market readiness makes strategic timing difficult. The lack of harmonised regulations and fragmented infrastructure development across European regions further complicates decision-making. In such environments, firms without a deliberate market entry strategy risk misallocating resources, missing first-mover advantages, or failing to meet emergent qualification criteria. A structured approach enables companies to balance agility with focus, aligning internal capabilities with external developments in a timely and targeted manner. In this context, applying Resource-Based Theory (RBT) means identifying and leveraging technical capabilities, certifications, and cross-functional expertise that competitors cannot easily imitate, a key to gaining early access to specifications and shaping market standards. Firms that understand and apply this theory can build advantage not only through innovation, but through capabilities others cannot easily replicate.

The central objective of the study was to develop a strategic market entry framework tailored to coatings firms navigating the hydrogen transition. This objective was guided by the main research question: *What strategic market entry framework can support protective coatings companies for entry into uncertain and evolving hydrogen pipeline coating markets?* The study explored how firm-specific capabilities could be mobilised to support structured entry in a context of technological complexity and institutional ambiguity. Supporting sub-questions focused on capability development, market trajectories, entry barriers, stakeholder perspectives, and sector-specific strategy components.

To answer these questions, the research adopted a qualitative abductive methodology. Initial insights from literature and market data informed the development of an early conceptual model, which was then refined through expert interviews. This iterative approach enabled a continuous interplay between theory and empirical observations, allowing the framework to evolve as new insights emerged. A total of 19 academic papers, online market data and two internal datasets were used to create a foundation for the Market Entry Framework. Nine expert interviews were conducted with stakeholders across product management, R&D, compliance, and strategic planning. Interview data was analysed using a hybrid deductive–inductive coding strategy in Atlas.ti, allowing the discovery of both expected patterns and novel themes. Together, these steps ensured that the resulting framework is not only grounded in academic theory, but also tailored to the decision-making realities faced by firms like Hempel navigating early-stage hydrogen markets.

The literature analysis, grounded in Resource-Based Theory (RBT), identified three key internal capabilities critical for strategic market entry in uncertain sectors: technological innovation, regulatory adaptability, and relational positioning. These dimensions, validated across multiple studies, formed the initial structure of the framework and were later expanded through empirical input. In addition, it revealed sector-specific challenges such as hydrogen-induced material degradation, fragmented regulation, and limited testing standards, alongside opportunities like first-mover advantage, policy-driven infrastructure investment, and demand for safety-enhancing innovation. The analysis of the market data confirmed that hydrogen-compatible internal coatings represent a high-growth segment, with market demand increasing more than sixfold in volume and over sevenfold in value between 2022 and 2029 (projected). Activity is regionally concentrated, with Germany, France, and the Benelux countries emerging as early hubs of infrastructure development. Firms that establish technical credibility and regulatory alignment early are more likely to gain access to specification processes and preferred supplier status. These combined insights were synthesised into a preliminary framework that guided the next research phase.

The qualitative results refined the preliminary framework by validating key themes and revealing overlooked dynamics. For example, relational positioning and regulatory engagement, initially treated as subcomponents, emerged as standalone strategic enablers. Interviewees confirmed that early visibility and regulatory involvement are critical to accessing specifications and building credibility. Internal capability gaps, particularly the absence of hydrogen-specific strategies and weak coordination between technical and commercial units, emerged as significant barriers.

A novel insight, developed abductively from the interviews, was the concept of "narrative pre-positioning": shaping stakeholder expectations before full technical validation to establish early legitimacy. Firms that combined technical credibility with trust-based engagement were consistently seen as better positioned for long-term success. These insights directly informed the final market entry framework by embedding early visibility, relational credibility, and stakeholder signalling as core strategic levers for market entry.

The outcome of this research is a sector-specific Market Entry Framework that synthesises firm capabilities, contextual constraints, and stakeholder perspectives into a structured tool for strategic analysis. While the framework is fully presented in Figure 1, its logic and application are best understood in combination with the detailed explanation provided in the chapters that follow. The framework consists of six interconnected dimensions (*Motives, Entry Barriers, Contextual Factors, Firm Capabilities, Strategic Entry, and Outcomes*) which together reflect how coatings firms navigate market timing, regulatory complexity, and internal readiness. Each dimension provides a practical lens: for example, firms can use the Motives dimension to clarify whether their drivers are innovation, regulation, or policy opportunity; Entry Barriers to identify gaps in readiness or access; and Contextual Factors to map infrastructure and policy landscapes. The Firm Capabilities dimension guides internal assessment across technical, regulatory, and commercial domains, while Strategic Entry supports choice of mode, scope, and pacing. Finally, Outcomes such as early specification access or stakeholder credibility help firms evaluate and adapt their strategy over time.

Crucially, the framework incorporates feedback loops, recognising that strategic positioning in hydrogen markets is not a one-off decision, but a continuous process of learning and adaptation. By translating abstract challenges into concrete strategic levers, the framework offers coatings firms a diagnostic and planning tool to structure entry into complex, evolving infrastructure markets. For companies like Hempel, it supports investment prioritisation, internal capability development, and early positioning in a market where timing and credibility are critical.

The result of this thesis is a sector-specific Market Entry Framework that helps protective coatings firms assess their strategic readiness to enter the hydrogen pipeline market. The framework offers a structured lens through which companies can align internal capabilities with external developments such as policy trends, infrastructure planning, and specification procedures. By translating both abstract uncertainties and practical constraints into six integrated dimensions, it supports firms in navigating the timing, targeting, and tactics of market entry under conditions of high volatility and institutional change.

The framework is best used as a strategic assessment tool: firms can map their current capabilities, assess external conditions, and identify the most viable entry pathways based on their position. Each dimension offers guiding questions to structure internal discussion and investment planning.
Key practical takeaways include:

1. Early regulatory engagement and visibility are essential for accessing specification processes.
2. Strategic coordination between technical and commercial teams is a critical internal success factor.
3. Narrative positioning, communicating future value credibly before full technical validation, can create early legitimacy in uncertain markets.
4. Entry strategies should be treated as iterative: firms need to test early moves, learn from setbacks, and adapt quickly: fail fast, course-correct, and continue.

These insights offer practical guidance for firms actively positioning themselves in the hydrogen infrastructure value chain. For companies like Hempel, the framework serves as a diagnostic and planning tool to support strategic decision-making, capability allocation, and stakeholder engagement in hydrogen infrastructure markets.

Beyond its practical application, the framework contributes to the broader field of strategic management by showing how Resource-Based Theory can be operationalised in emerging, uncertain, and highly institutionalised markets. The findings highlight that early market influence is not only a function of technical innovation, but of coordinated internal mobilisation, credible signalling, and proactive regulatory engagement. Ultimately, the framework enables coatings firms to shift from reactive adaptation to proactive positioning, turning hydrogen uncertainty into a source of long-term strategic advantage.

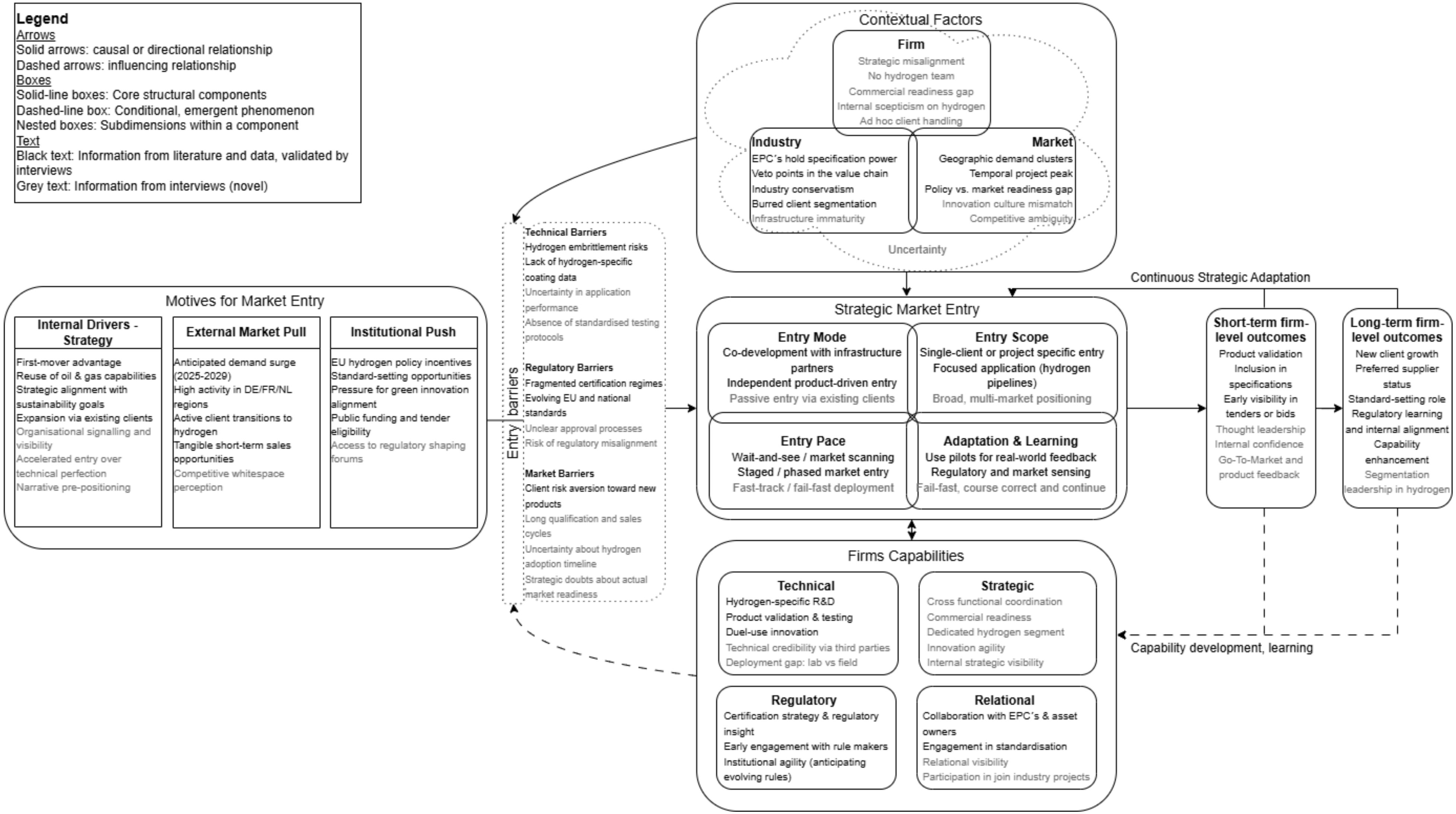

Figure 1: Sector-Specific Market Entry Framework

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List of Abbreviations

Abbreviation	Full Form
CoSEM	Complex Systems Engineering and Management
R&D	Research and Development
RBT	Resource-Based Theory
VRIN	Valuable, Rare, Inimitable, and Non-substitutable (resources)
SME	Small and Medium-sized Enterprises
EPC	Engineering, Procurement, and Construction
JIP	Joint Industry Project
ESG	Environmental, Social, and Governance
VOC	Volatile Organic Compound
IEA	International Energy Agency
DNV	Det Norske Veritas
EU	European Union
KPI	Key Performance Indicator
TUD	Delft University of Technology

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1 Introduction

1.1 Background

The future mix of renewable energy remains highly uncertain, shaped by fluctuating policy environments, technological advances, and divergent regional priorities (Ram et al., 2022). These developments impact a range of industrial sectors, including the protective coatings industry (Energy Business Review Europe, 2024). Protective coatings are specialised materials applied to infrastructure, such as pipelines, tanks, and valves, to prevent corrosion, enhance durability, and improve flow efficiency under harsh operating conditions (Hempel, 2014). As energy systems are reconfigured, such coatings play an increasingly vital role in ensuring the performance and reliability of new infrastructure technologies (Firoozi et al., 2025).

Hydrogen, in particular, is expected to play a pivotal role in Europe's decarbonisation strategy, enabling applications in heavy industry, long-haul transport, and energy storage (Abid et al., 2025; Otsubo, 2025; Vergara et al., 2024). To meet REPowerEU's target of 20 million tonnes of hydrogen production and imports by 2030, the EU must rapidly develop new infrastructure for hydrogen transport, storage, and distribution (ENTSOG, GIE, CEDEC, Eurogas, GEODE, GD4S, 2025). This infrastructure push has mobilised actors across the value chain, from transmission and distribution operators to private consortia, highlighting the scale and complexity of the transition (Offutt, 2023). Such expansion demands not only new engineering solutions, but also sector-specific strategies to guide firms entering this uncertain and rapidly evolving market space (Shan & Kittner, 2025). However, existing pipeline infrastructure is largely unsuitable for hydrogen transport due to material compatibility issues such as embrittlement, permeability, and pressure-induced fatigue (Wang, 2025). Protective coatings companies are thus positioned as critical actors in enabling hydrogen-ready infrastructure, as they contribute directly to the material performance and lifespan of pipeline systems (Li et al., 2024).

In response, some early-moving firms have begun adapting their product portfolios to meet hydrogen-specific demands (DENSO Group, n.d.). These adaptations include performance characteristics such as low hydrogen permeability, thermal adhesion stability, and resistance to hydrogen-induced embrittlement (DENSO Group, 2020). Such requirements underscore the increasingly specialised role coatings must play in supporting the safe and efficient operation of hydrogen pipelines (Wetegrove et al., 2023). Despite these emerging signals, the broader protective coatings sector, including firms like Hempel A/S, has not yet established a clear strategic position (Hempel Group, 2024). As a global coatings provider with deep involvement in pipeline infrastructure, Hempel faces increasing pressure to define its role in the hydrogen transition (Hempel Group, 2021). Strategic decisions around capability development, market timing, and positioning remain constrained by the sector's technical complexity and regulatory uncertainty (Hasankhani et al., 2024).

This strategic ambiguity is reinforced by the fragmented and fast-evolving nature of Europe's hydrogen infrastructure. As visualised in Figure 2, based on the H2 Infrastructure Map (ENTSOG, GIE, CEDEC, Eurogas, GEODE, GD4S, 2025), the hydrogen network is very complicated and uncertain. This underscore the urgent need for structured market entry strategies tailored to emerging sectors like hydrogen pipeline coatings.

Successfully entering emerging markets requires well-defined strategies to navigate uncertainties, seize growth opportunities, and achieve competitive advantage (Cho, 2024). Companies that fail to adopt structured market entry strategies risk losing market share to more agile competitors (Meyer et al., 2009). Structured market entry strategies enable firms to assess expansion pathways, through direct investment, partnerships, or staged entry, leveraging firm-specific resources and capabilities (Meyer & Tran, 2006). Studies on wind energy expansion and compressed natural gas retail show that structured entry strategies provide early brand recognition, stakeholder trust, and long-term market stability (Pavan et al., 2020; Zwarteveen et al., 2021). Internationalisation can strengthen firm capabilities and innovation performance, potentially enhancing resilience through expanded operations and revenue opportunities (Baier-Fuentes et al., 2020). Collaboration between industry, government, and academia, highlighted by the Triple Helix model, further supports successful market entry (Kolagar et al., 2022; Thakur-Wernz & Samant, 2015).

This research builds on the Resource-Based Theory (RBT), which posits that sustained competitive advantage arises from the strategic deployment of valuable, rare, inimitable, and non-substitutable (VRIN) resources (Zhang et al., 2021). According to Kero and Bogale, internal firm resources, such as technological expertise, process know-how, and organisational capabilities, play a crucial role in shaping market entry decisions and long-term performance (Kero & Bogale, 2023).

While RBT provides a useful lens for analysing the role of internal assets, it often assumes relatively stable environments (Burisch & Wohlgemuth, 2016). To better account for strategic action under uncertainty, this study integrates insights from the dynamic capabilities perspective. Dynamic capabilities refer to a firm's ability to purposefully adapt, reshape, and combine internal and external competences in response to changing environmental conditions (Wilden et al., 2013). Deng et al. (2018) argue that such capabilities, particularly opportunity recognition, resource reconfiguration, and strategic adaptation, are essential for firms navigating emerging and institutionally diverse markets.

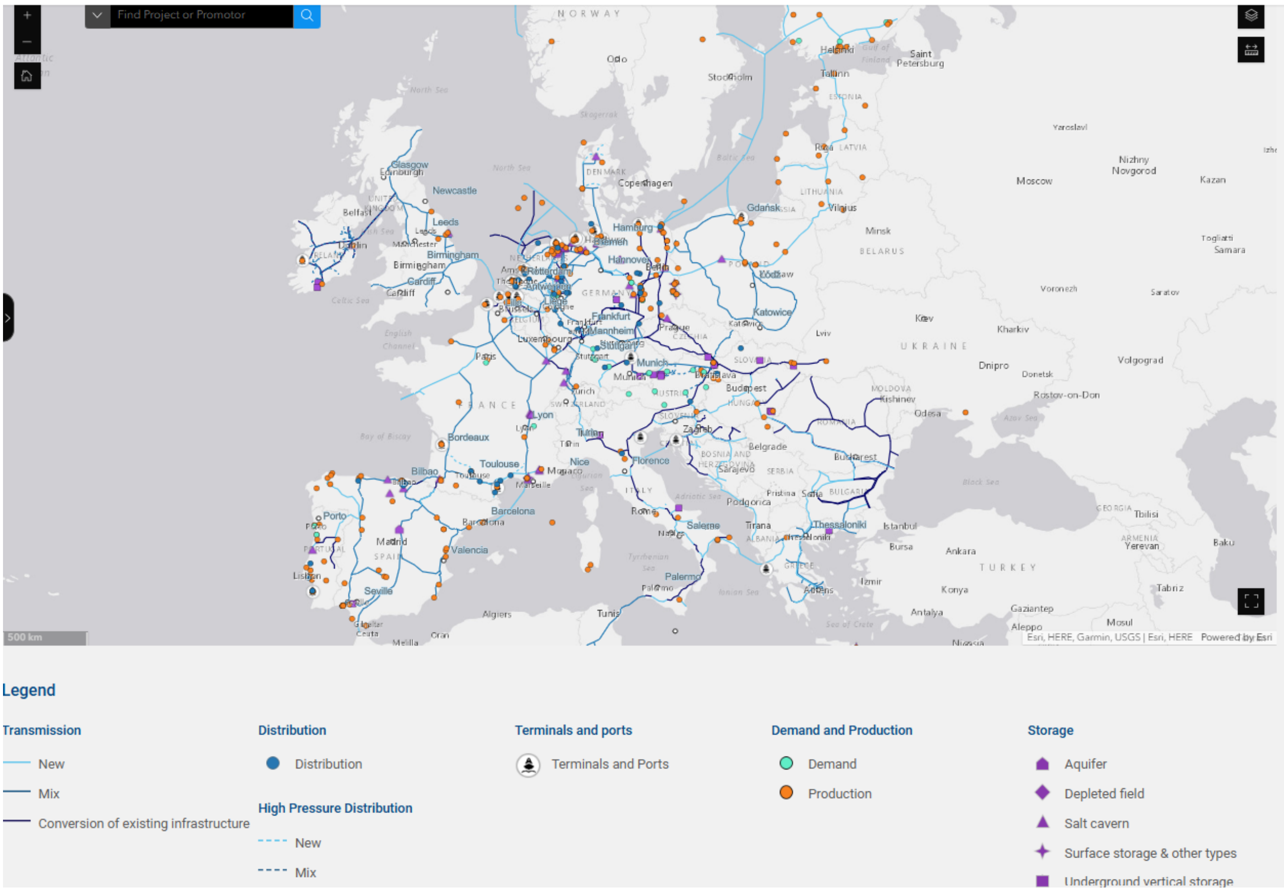


Figure 2: European Hydrogen Infrastructure Projects illustrating key pipeline routes, storage sites, and demand hubs. **Source:** H2 Infrastructure Map (ENTSOG, GIE, CEDEC, Eurogas, GEODE, GD4S, 2025) Disclaimer: *the map and its content are intended for informative and indicative purposes only and do not reflect a true-to-scale representation of infrastructure.*

A critical gap remains in the literature. As Kero and Bogale (2023) note in their systematic review, RBT and dynamic capabilities frameworks are often applied in separately, with limited integration when analysing market entry processes. This split application limits our understanding of how firms can strategically respond to volatile and emergent market conditions. Evers (2011) further emphasises that in emerging sectors, resource-based strategies must be continuously reconfigured in response to shifting contextual demands. In line with this, Deng et al. (2018) argue that dynamic capabilities are essential for firms navigating institutional complexity and uncertainty during international expansion, particularly in frontier markets such as hydrogen infrastructure.

To address these gaps, this research proposes a preliminary conceptual framework (Figure 3), inspired by Deng et al. (2018), that captures the interplay between firms' entry motives, internal capabilities, and external environmental conditions. By combining RBT with a dynamic capabilities lens, the study contributes to a more nuanced understanding of how firms mobilise and adapt their resource base in response to the evolving demands of internationalisation.

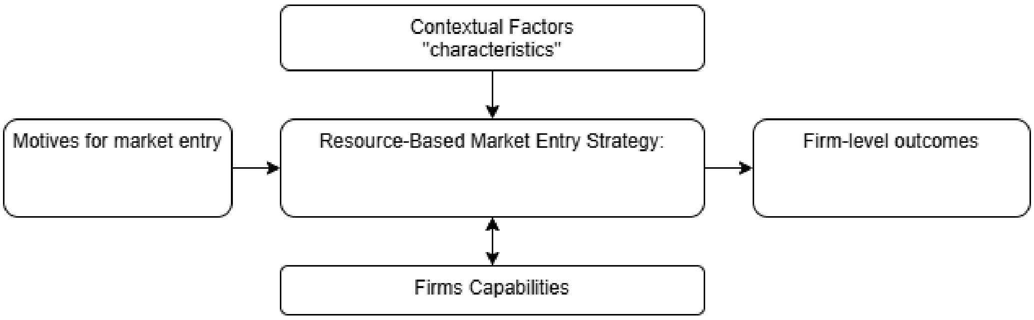


Figure 3: Preliminary conceptual model inspired by Resource-Based Theory and market entry theory, providing an initial framing for the research approach.

1.2 Problem Statement

Protective coatings have long been essential in maintaining the integrity, efficiency, and safety of energy infrastructure. Flow efficiency coatings, in particular, reduce frictional losses and improve transport performance in pipeline systems (Hempel, 2014). As the renewable energy sector expands, hydrogen infrastructure introduces distinct challenges for protective coatings, including hydrogen-induced embrittlement, leakage prevention, and durability under extreme conditions (Li et al., 2024; Otsubo, 2025). Although hydrogen infrastructure is expanding across Europe, driven by governmental policies and investment support, significant uncertainty remains regarding the scale, timing, and regional deployment of projects (Abid et al., 2025; Forum, 2021; Li et al., 2024). This uncertainty complicates strategic market entry planning for adjacent industries such as protective coatings, which must anticipate evolving technical requirements and market dynamics (Li et al., 2024).

Currently, a comprehensive understanding of how protective coatings companies should strategically approach this evolving market is lacking in the academic literature. While structured internationalisation strategies are well-researched across sectors such as wind energy and gas retail (Matějková & Dohnal, 2024; Meyer et al., 2009; Pavan et al., 2020; Zwarteveen et al., 2021), few studies examine their applicability within the fragmented and rapidly evolving hydrogen economy (Abid et al., 2025). Moreover, although the value of early market entry, innovation-led expansion, and cross-sector collaboration is acknowledged in broader strategic management literature (Baier-Fuentes et al., 2020; Thakur-Wernz & Samant, 2015), the coatings industry lacks sector-specific models that integrate hydrogen's distinct challenges, such as material compatibility, regulatory flux, and uncertain infrastructure deployment timelines (Li et al., 2024). This gap limits the ability of coatings firms to formulate proactive, adaptive entry strategies in a high-stakes industrial transition. Referring back to Figure 3, the problem can be understood as a misalignment between firms' internal capabilities, the fragmented hydrogen infrastructure landscape, and evolving entry motives. While each of these elements is discussed in isolation in existing literature, few studies integrate them into a coherent strategic framework. Figure 3 serves not only as a theoretical starting point but also as a diagnostic lens for analysing how coatings firms might respond to these overlapping uncertainties. Figure 4 summarises the main categories of challenges that must be addressed to enable successful market entry: technical, regulatory, and strategic.

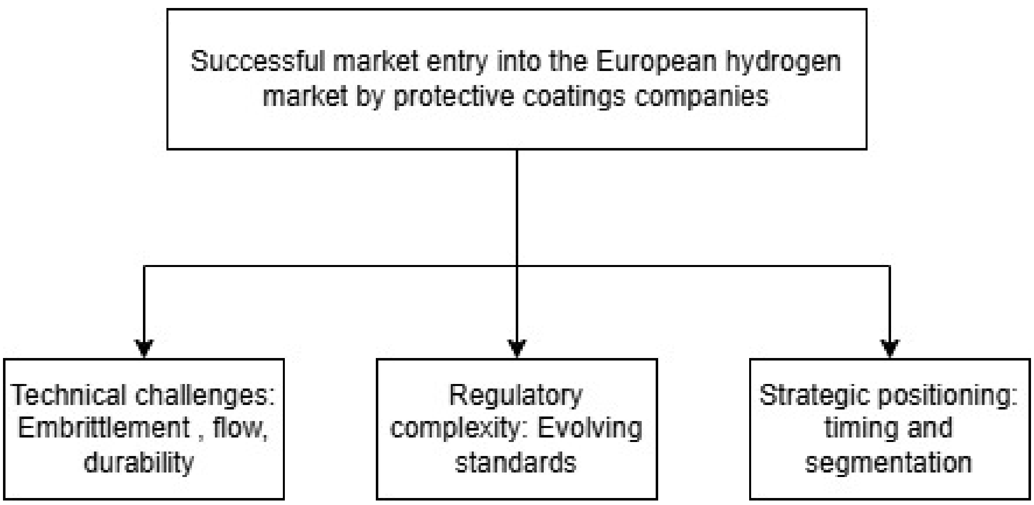


Figure 4: Key challenges shaping market entry for protective coatings in the European hydrogen sector

This research addresses the gap by integrating technical, regulatory, and strategic considerations to support market entry strategies in uncertain and evolving hydrogen markets. This research is particularly relevant for Hempel, the industrial partner behind this study. As the hydrogen infrastructure landscape evolves, Hempel faces strategic uncertainty around when and how to position its protective coatings portfolio in this market. By offering a structured market entry framework tailored to the specific challenges of hydrogen pipeline coatings, this research supports Hempel in aligning internal capabilities with external developments, guiding strategic timing, investment priorities, and potential collaboration pathways.

1.3 Research Objective

The objective of this research is to develop a strategic market entry framework for protective coatings companies targeting the hydrogen sector, with specific focus on European pipeline infrastructure. It aims to understand how firms can leverage internal capabilities, such as technological expertise, regulatory adaptability, and strategic positioning, to respond to the evolving demands, risks, and opportunities within hydrogen pipeline development.

To achieve this objective, the main research question is formulated as follows: *What strategic market entry framework can support protective coatings companies for entry into uncertain and evolving hydrogen pipeline coating markets?*

This question is broken down into the following sub-questions:

1. *What are the theoretical aspects of a successful resource-based market entry strategy?*
   Methods: Literature analysis, desk research, expert consultation.
   Data: Academic journals, industry reports, regulatory documents.

2. *What are the key challenges and opportunities for protective coatings companies entering hydrogen markets?*
   Methods: Literature analysis, desk research, expert consultation.
   Data: Academic journals, industry reports, regulatory documents.

3. *What are the growth trajectories and segmentation opportunities within the hydrogen sector for protective coatings?*
   Method: Market analysis, data analytics.
   Data: Open industry reports, internal datasets.

4. *What are the perceptions and expectations of industry stakeholders regarding the challenges and opportunities for market entry in the hydrogen sector?*
   Methods: Primary data from interviews with industry leaders and technical experts.
   Data: Primary interview data.

5. *What components should a strategy for protective coatings companies entering hydrogen markets include?*
   Methods: Synthesis of findings from previous sub-questions, additional literature analysis, and expert consultation.
   Data: Synthesised insights.

1.4 Relevance to the CoSEM Program

This thesis aligns strongly with the objectives of the Complex Systems Engineering and Management (CoSEM) program by addressing a complex socio-technical challenge: the strategic entry of protective coatings companies into the emerging hydrogen sector. Hydrogen infrastructure development in Europe represents a dynamic and uncertain system shaped by rapidly evolving technologies, multi-level regulatory frameworks, strategic market forces, and long-term sustainability goals (Zabanova, 2024). Within this system, internal pipeline coatings, both protective and flow efficiency solutions, play a critical yet underexplored role in enabling safe, efficient, and scalable hydrogen transport (Zhang & Wang, 2024).

The thesis exemplifies CoSEM's interdisciplinary approach by combining systems engineering principles with institutional economics and strategic management. It integrates technological considerations such as hydrogen embrittlement and flow performance with regulatory uncertainty and strategic market positioning. The hydrogen pipeline coating industry is highly dependent on hydrogen development, thus the multi-disciplinary perspective of this study can contribute to the coating industry proactively enter the market, instead of reactively, which aligns with the CoSEM goals. By adopting a resource-based market entry perspective, the research highlights how firm-level capabilities interact with systemic developments in hydrogen infrastructure.

This contributes to CoSEM's emphasis on developing actionable, system-aware strategies that balance technical feasibility with institutional alignment. Furthermore, the study uses data-driven analysis and stakeholder consultation to support informed decision-making in an emerging domain marked by high complexity and interdependence. It reflects the CoSEM mission by demonstrating how cross-domain collaboration, empirical insight, and strategic foresight can support real-world transitions toward sustainable and low-carbon energy systems.

1.5 Scope

This research focuses exclusively on the European market for internal protective and flow efficiency coatings used in hydrogen pipeline infrastructure. The geographical and technological delineation is reinforced by visual references such as the H2 Infrastructure Map, which clearly marks active and planned infrastructure projects that are critical for hydrogen integration across Europe (ENTSOG, GIE, CEDEC, Eurogas, GEODE, GD4S, 2025).The scope is limited to internal applications because external pipeline coatings largely follow existing standards and practices, whereas internal coatings face new and distinct performance requirements due to the unique properties of hydrogen as a transported medium (Li et al., 2024). Key areas of interest include corrosion resistance, hydrogen embrittlement mitigation, flow optimisation, and potentially sensor-compatible or insulation-enhancing coatings. Other hydrogen infrastructure applications, such as storage tanks, compressors, or transport via ammonia or liquefied hydrogen, are explicitly excluded from this study.

The research targets protective coatings manufacturers, such as Hempel, that already possess relevant technological, operational, or market resources. By focusing on pipeline-specific challenges and opportunities within Europe, the study adopts a resource-based market entry perspective to examine how internal firm capabilities can be leveraged to support strategic positioning. While the primary focus is on strategy, the analysis also considers how technical development, Research and Development (R&D) capacity, and cost structures influence market entry decisions. This defined scope enables a deep and focused exploration of how coatings companies can navigate and respond to the emerging hydrogen economy through capability-aligned strategies.

1.6 Report Structure

This thesis is structured to reflect the iterative and abductive research approach taken to explore strategic market entry into the hydrogen sector. Chapter 2 outlines the research methodology, including the data sources, analysis techniques, and design logic. Chapter 3 presents the literature and data analyses that inform the conceptual model. Chapter 4 contains the empirical findings from semi-structured interviews with industry stakeholders. Chapter 5 synthesises these insights into a strategic market entry framework. Finally, Chapter 6 provides the conclusions, theoretical contributions, practical implications, limitations, and recommendations for future research. Supplementary data and methodological details are included in the appendices.

2 Methodology

This chapter outlines the methodology employed in the development of a strategic market entry framework for protective coatings firms. Section 2.1 describes the qualitative abductive research approach, combining insights from academic literature, market data, and expert interviews. Section 2.2 details the data collection process, including the development of interview questions and the use of internal datasets. Section 2.3 explains the data analysis techniques, including the hybrid deductive–inductive coding strategy employed to identify key themes and insights. Lastly section 2.4 discusses the limitations and ethical considerations of the research methodology.

2.1 Research Approach

This study adopted a qualitative, abductive research approach, which, as Hulst and Visser (2024) explain, involves an iterative interplay between theoretical concepts and empirical observations, and is particularly well-suited for studying complex and uncertain markets where predefined models may fall short. Abductive reasoning allowed iterative movement between existing theoretical concepts and empirical findings, enabling the development of a context-sensitive and practically applicable strategic framework (Bryman, 2016). Rather than test predefined hypotheses or build theory purely from data, this approach integrated literature and data insights on market entry strategies with empirical findings gathered through interviews with industry stakeholders, in line with abductive research practices, which emphasize iterative interaction between theory and data (Flick, 2009; Hulst & Visser, 2024).

The abductive structure of the research is illustrated in Figure 5, showing how deductive elements (such as background research, literature review, and market analysis) were combined with inductive insights from interviews to co-develop a conceptual model and ultimately produce a strategic market entry framework. Each phase contributed to answering different dimensions of the main research question, collectively supporting the development of a robust and grounded strategy.

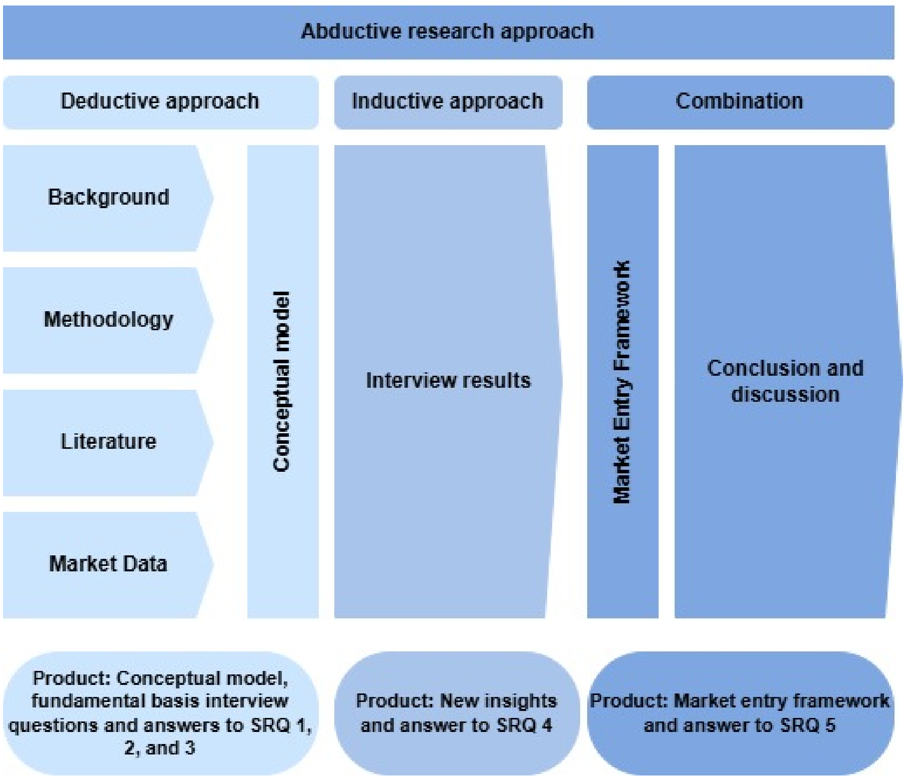


Figure 5: Abductive research structure combining deductive and inductive phases.

2.2 Data Collection

The research process integrated three primary data sources: literature, market data, and semi-structured interviews.

The literature analysis addressed sub-research questions 1 and 2, which focus on understanding the theoretical aspects of successful market entry strategies and identifying the key challenges and opportunities for protective coatings companies entering hydrogen pipeline markets. This foundational phase involved a comprehensive examination of existing academic and industry literature to establish a theoretical framework for the study. By analysing sources that explore strategic market entry frameworks, the complexities of the hydrogen market, and regional market dynamics, this phase ensured that the research was grounded in a well-established body of knowledge. It identified key themes related to market entry while it highlighted industry-specific challenges and areas where further research is required. This set the stage for the next research phases by providing essential context and structure. Certain challenges in data collection, such as access to proprietary datasets or limited stakeholder engagement, have been mitigated through the use of publicly available resources and collaboration with a protective coatings company to access relevant data and insights.

The data analysis in this research supports sub-research question 3 by assessing hydrogen growth trajectories, market segmentation opportunities, and energy transition trends. Rather than processing raw data, the analysis focused on synthesising insights from existing industry reports and internal datasets. Key external sources include the International Energy Agency (IEA) Global Hydrogen Review and Det Norske Veritas (DNV)'s Energy Transition Outlook 2024, which provided projections on hydrogen demand, infrastructure development, and future energy mix trends in Europe (DNV, 2024; International Energy Agency, 2024). Two internal datasets complemented this analysis: one containing and forecasting demand for hydrogen pipeline coatings in volume and value (2022–2029), and another detailing over 250 planned hydrogen infrastructure projects across Europe from 2025 until 2045, including timelines, investment values, and locations. While informative, these project data represent planned and not executed initiatives, and are subject to change, introducing a key limitation. To complement internal datasets and ensure robustness in data validation, publicly available external sources were also integrated into the analysis. Among these, the H2 Infrastructure Map was notably valuable, providing detailed, regularly updated visualizations and project-specific insights into Europe's hydrogen infrastructure landscape (ENTSOG, GIE, CEDEC, Eurogas, GEODE, GD4S, 2025). Descriptive statistics and trend analysis were used to interpret these sources, enabling a practical, data-driven assessment of the hydrogen market's evolution (Creswell & Creswell, 2009). The detailed findings are included in Appendix A and the key conclusions are discussed in the main text to inform both the conceptual model and the qualitative research phase.

Semi-structured interviews formed the qualitative phase of this research and were designed to address sub-research question 4 (Kolagar, 2024; Scholten et al., 2024). With the study focused specifically on the hydrogen pipeline coatings sector, the interviews aimed to explore how protective coatings companies can strategically position themselves in this emerging market. A total of nine interviews have been conducted with a diverse group of experts, both internal and external to Hempel. These include product managers active in European markets, R&D specialists and senior professionals involved in strategic decision-making, all of which can be found in Table 1 and Figure 6.

Table 1: Company Profiles and Interview Roles

Company	Description	Industry	Role (no. of interviews)
Hempel	Global supplier of protective coatings and paints, delivering sustainable solutions for marine, energy, infrastructure, and industrial applications.	Paints and coatings industry	Director of Solution Management Head of Product Management Chief Scientist R&D Segment Development Manager Product Manager Head of Sustainability Business Development Manager Specification Manager
Alpha	Global leader in paints and coatings, delivering sustainable solutions across decorative, marine, automotive, and industrial sectors.	Paints and coatings industry	Chief Marketing Officer

This variety ensured a broad yet in-depth perspective on both operational and strategic dimensions of market entry (Patton, 2002; Silverman, 2011). Originally, the plan was to conduct five interviews, but early findings indicated that additional perspectives could yield further insights, prompting an extension to nine. Data saturation was considered reached at that point, as responses began to exhibit strong thematic convergence and a clear reduction in the emergence of new insights. Importantly, this thematic overlap was not only consistent across interviews but also reinforced by secondary data (from the literature and market analysis), suggesting that additional interviews would likely result in diminishing returns (Chase & Murtha, 2019; Hampel et al., 2020). The interview questions were developed from earlier phases of the thesis, drawing from both the literature analysis and the market analysis. However, they were formulated to allow for open-ended responses that can reveal new insights, an abductive approach intended to capture perspectives that may not emerge through data analysis alone (Hulst & Visser, 2024). Rather than only validating existing findings, the interviews were designed to surface new ideas, strategic considerations, and practical enablers or barriers across the full spectrum of hydrogen market entry, from technical product alignment and regulatory adaptation to partnership dynamics and organisational readiness. This qualitative phase therefore ensures that the strategic framework developed in later chapters is grounded in both market evidence and real-world expertise. This triangulation of data sources enhances the robustness and credibility of the findings (Carter et al., 2014). Further methodological details regarding the development of the interview questions, themes, and role-specific adaptations are provided in Appendix B.

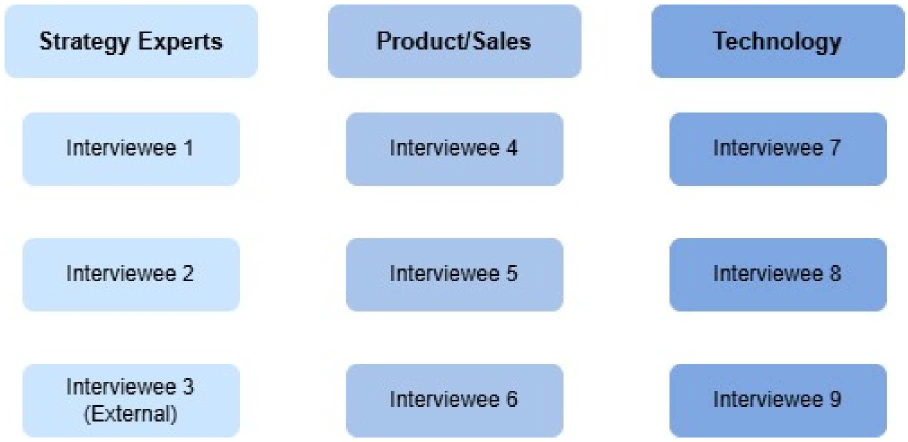


Figure 6: Overview of Interviewee Distribution by Functional Area

2.3 Data Analysis

The data analysis followed an abductive structure. First, a literature analysis was conducted to establish a theoretical foundation, focusing on market entry strategies and sector-specific challenges for hydrogen infrastructure. Next, market data analysis was performed, using internal and external datasets to explore hydrogen infrastructure growth trajectories and segmentation opportunities.

Insights from the literature and market analysis served two critical functions: (1) they informed the development of the preliminary conceptual model introduced earlier in the research, and (2) they guided the design of the interview questions by identifying key themes and knowledge gaps.

Following these phases, semi-structured interviews were conducted and analysed. The interviews served two primary purposes: (1) to validate and enrich findings from the literature and market data (deductive analysis), and (2) to uncover new strategic insights and emergent themes relevant to hydrogen pipeline coating market entry (inductive analysis). This dual approach aligns with established practice in management research, where combining inductive and deductive logics enhances both theoretical rigour and empirical depth (Woiceshyn & Daellenbach, 2018).

All participants signed informed consent forms, and the process followed TU Delft's Human Research Ethics Committee guidelines. Personal data were anonymised and stored securely on institutional infrastructure, with recordings deleted after transcription and all data erased one month post-research completion. Interviews were conducted over a four-week period via Microsoft Teams, during which all sessions were recorded with participant consent and transcribed verbatim. To ensure data integrity, each transcript was manually reviewed and corrected for accuracy. These transcripts were then imported into Atlas.ti software to facilitate systematic coding. ATLAS.ti is an advanced software tool for qualitative data analysis that enables researchers to systematically identify and code underlying themes (ATLAS.ti Scientific Software Development GmbH, 2024). Its structured workflow supports transparency and verification in qualitative research, as codes and interpretations can be easily traced and reproduced. This ensures analytical rigor and enhances the credibility of the findings.

A hybrid coding strategy was employed, combining deductive codes from the conceptual framework with inductive codes derived from the interview data. This approach is consistent with best practices in qualitative analysis where theory-informed and data-driven coding intersect (Linneberg & Korsgaard, 2019). This dual approach allowed the study to test theoretical expectations while remaining open to emergent insights. The coding process was iterative and reflexive. Initially, codes were applied manually and line-by-line, with each quotation carefully reviewed to determine relevance and interpretive fit. As novel themes emerged, additional codes were developed, documented, and retrospectively applied across the full dataset to ensure coherence. This approach enabled the coding schema to evolve over time while maintaining internal consistency. After completing first-order coding, related codes were clustered into higher-order thematic categories to reflect broader patterns in the data. These groupings were not predefined but developed inductively based on thematic density and conceptual linkage.

Analytical memos were written throughout the coding process to capture interpretive reflections, document coding decisions, and trace conceptual developments. These memos contributed to translating raw codes into analytical insight. This served as a bridge between quotations across the interviews and broader themes. Once all memos were drafted, they were analysed collectively to identify confirming, disconfirming, and novel findings relative to the study's conceptual framework. This comparative step allowed for a structured evaluation of which assumptions were upheld, challenged, or redefined through empirical evidence.

Finally, to address sub-question 5, findings from the literature analysis, market analysis, and qualitative phases were abductively synthesised into a two-stage strategic market entry framework. The first model presents the structural layout of the framework, a conceptual architecture that integrates the core themes and relationships identified through qualitative coding. It reflects the outcome of a rigorous analytical synthesis, combining deductive categories from the conceptual model with inductively generated themes emerging from the interviews. However, this version remains abstract: it outlines how key dimensions such as market conditions, internal capabilities, stakeholder dynamics, and timing considerations interact, but does not yet include illustrative data.

In contrast, the second model builds directly upon the structure of 5.1 by populating it with empirical content. Drawing on coded quotations, analytical memos, and cross-case synthesis, the framework is filled in with concrete insights derived from stakeholder narratives. This final framework therefore represents not only a theoretically coherent representation of strategic entry into the hydrogen coatings market, but also a practically validated tool grounded in real-world evidence. It supports decision-making by protective coatings firms navigating uncertainty, capturing both the complexity and specificity of market entry in this evolving sector.

2.4 Advantages and limitations of the research methods

The abductive research approach adopted in this study presented several advantages, particularly for navigating the uncertainty and complexity of strategic market entry into the hydrogen sector. By iteratively integrating existing theory, market data, and qualitative insights, the study enabled the development of a framework that was both empirically grounded and context-sensitive. One key strength of this approach is its flexibility: it allowed the researcher to move between conceptual frameworks and real-world data, making it well-suited to emerging and under-researched domains such as hydrogen. The use of literature and market data provided a solid theoretical and analytical basis for identifying market dynamics, technical requirements, and segmentation opportunities. These findings then informed the design of semi-structured interviews, which served as a primary source of in-depth insights into stakeholder perspectives, strategic priorities, and perceived challenges. This layered structure ensured that the resulting framework is not only theoretically informed but also practically validated by industry actors, enhancing its real-world applicability and relevance.

However, the abductive approach also brings certain limitations. The reliability and granularity of hydrogen market data can vary significantly, particularly given the evolving nature of the sector and differences in regional infrastructure development. Additionally, while the iterative process strengthens the validity of the framework, it can also introduce ambiguity, as new insights may require revisiting earlier assumptions or reformulating parts of the research design. The subjective nature of qualitative interviews presented another challenge: expert perspectives are shaped by specific roles, experiences, and strategic contexts, which may limit their generalisability. Moreover, the abductive process required a high degree of analytical reflexivity and interpretive rigor, as the researcher must synthesise diverse data types without rigid methodological boundaries. Finally, the time-intensive nature of conducting a multi-phase, theory-informed, stakeholder-driven study demanded careful planning and adaptability, particularly when translating findings into a coherent and usable strategic framework.

3 Conceptual Framework

This chapter combines literature and data analyses to inform the development of a conceptual strategic market entry framework. Section 3.1 presents a literature analysis of resource-based market entry strategies and sector-specific opportunities and challenges for coatings firms. Section 3.2 summarises key findings from a market data analysis of hydrogen infrastructure and coatings demand across Europe. Section 3.3 integrates both streams to support the design of the conceptual model used in subsequent research phases.

3.1 Literature Analysis

This section presents an analysis of academic and industry literature to identify theoretical foundations for strategic market entry. The analysis focused on RBT, market entry frameworks, and sector-specific opportunities and challenges relevant to protective coatings companies entering the hydrogen infrastructure sector. All searches were done using Scopus.

3.1.1 Resource Based Market Entry

This literature analysis explored how RBT can be applied to understand successful market entry strategies for protective coatings firms in the renewable energy sector.

3.1.1.1 Literature research setup

The literature analysis was conducted in four stages to develop a well-rounded understanding of strategic market entry for protective coatings firms within the evolving renewable energy landscape. Each search focused on a distinct layer of the research topic, from general internationalisation strategies to resource-based market entry frameworks, ensuring both theoretical robustness and sector-specific applicability.

Step 1: Strategic market entry in emerging economies

The first step focused on collecting studies that provide a broad perspective on how firms navigate international expansion, particularly in high-growth and emerging markets. The aim was to identify general strategic entry approaches, success factors, and positioning strategies. Search terms included combinations such as:

```
 ("market entry strategy" OR "business entry strategy" OR "strategic market entry"
OR "internationalisation strategy")
AND ("success factors" OR "key elements" OR "determinants" OR "theoretical framework")
AND ("emerging markets" OR "developing economies" OR "high-growth markets")
```

This search returned 148 results. After filtering for language (English), publication years (2020–2025), and access availability, 47 papers remained. Following a title and abstract review, seven were selected for further analysis.

Step 2: Sector-specific challenges in renewable energy market entry

The second search targeted studies related to the energy transition, with an emphasis on the challenges and opportunities of entering renewable energy markets. The search included terms linking internationalisation with sector-specific demands and performance requirements in industries like protective coatings. The following string was used:

```
 ("market entry strategy" OR "business expansion strategy")
AND ("emerging markets" OR "developing economies" OR "high-growth markets")
AND ("challenges" OR "opportunities" OR "competitive advantage")
AND ("energy sector" OR "renewable energy" OR "industrial coatings" OR "protective coatings")
```

This query returned 14 documents. After checking for accessibility and reviewing abstracts, only one was retained due to relevance and full-text availability.

Step 3: Theoretical foundations for market entry strategies

To ensure the literature analysis was grounded in established international business theory, the third search examined conceptual models of market entry. This included transaction cost economics, the Uppsala model, the OLI paradigm, and institutional theory. Keywords focused on competitive positioning and strategic advantages. The search string applied was:

```
 ("market entry theory" OR "international business strategy")
AND ("transaction cost theory" OR "Uppsala model" OR "OLI paradigm" OR "institutional theory")
AND ("competitive advantage" OR "differentiation strategy" OR "first mover advantage"
OR "barriers to entry")
```

A total of 102 documents were identified. After applying filters and reviewing abstracts, seven articles were selected for in-depth analysis.

Step 4: Resource-Based Theory and firm-specific capabilities

The final search narrowed the focus to RBT, seeking papers that explicitly address resource-based views on internationalisation and market entry. This step was critical to align the literature with the theoretical lens guiding this research. The search string used was:

```
 ("resource" AND "based" AND "market" AND "entry" AND ("strategy" OR "strategies"))
AND (LIMIT-TO (OA , "all")) AND (LIMIT-TO (EXACTKEYWORD , "Resource-based Theory")
OR LIMIT-TO (EXACTKEYWORD , "Resource-based View") OR LIMIT-TO (EXACTKEYWORD ,
"Market Entry Strategy") OR LIMIT-TO (EXACTKEYWORD , "Market Entry"))
```

This yielded 18 papers, of which seven were reviewed in detail. Five were ultimately retained due to relevance, availability, and theoretical alignment.

3.1.1.2 Inclusion and Exclusion Criteria

Articles were selected based on the following inclusion criteria:

- Published between **2016 and 2025**
- Peer-reviewed journal articles
- Written in English
- Direct relevance to strategic market entry, Resource-Based Theory (RBT), dynamic capabilities, or coatings in renewable energy contexts

Exclusion criteria were as follows:

- Conference papers or non-peer-reviewed sources
- Articles without full-text access
- Studies focused on unrelated industries (e.g., decorative or marine coatings)
- Purely conceptual articles lacking empirical grounding

3.1.1.3 Examples of Inclusion

Two examples illustrate the rationale behind the selection of included studies. The article by Beamish and Chakravarty (2021) examines the role of proprietary resources and regulatory capabilities in shaping successful foreign market entry for multinational enterprises. It was included for its relevance to how Resource-Based Theory can be operationalised under institutional complexity, which is central to the context of this thesis. Another example is the work by Meygoonpoury et al. (2024), which focuses on the role of partnerships and collaborative competition in enabling internationalisation within the renewable energy sector. This study was selected due to its empirical emphasis on relational capabilities, which were frequently cited in expert interviews as critical for coatings firms navigating hydrogen markets.

3.1.1.4 Selection Outcomes

The selection process is summarised in Figure 7, which illustrates the identification, screening, and inclusion phases conducted via Scopus. The initial search yielded four distinct keyword strings, resulting in a combined total of 282 articles. After removing duplicates and filtering for availability, language (English only), publication years (2016–2025), and peer-reviewed journal status, a total of 62 unique articles were retained for further assessment.

The screening phase involved reading titles and abstracts, after which 20 articles were selected for detailed review. Of these, 12 were found to be sufficiently relevant based on a thorough reading. Three additional articles were excluded at this stage due to limited empirical applicability or insufficient conceptual relevance to the hydrogen coatings context.

Ultimately, nine articles were included in the final literature review. These articles were selected based on their explicit contribution to theoretical or empirical aspects of market entry strategies, particularly within resource-constrained, uncertain, or highly institutionalised contexts.

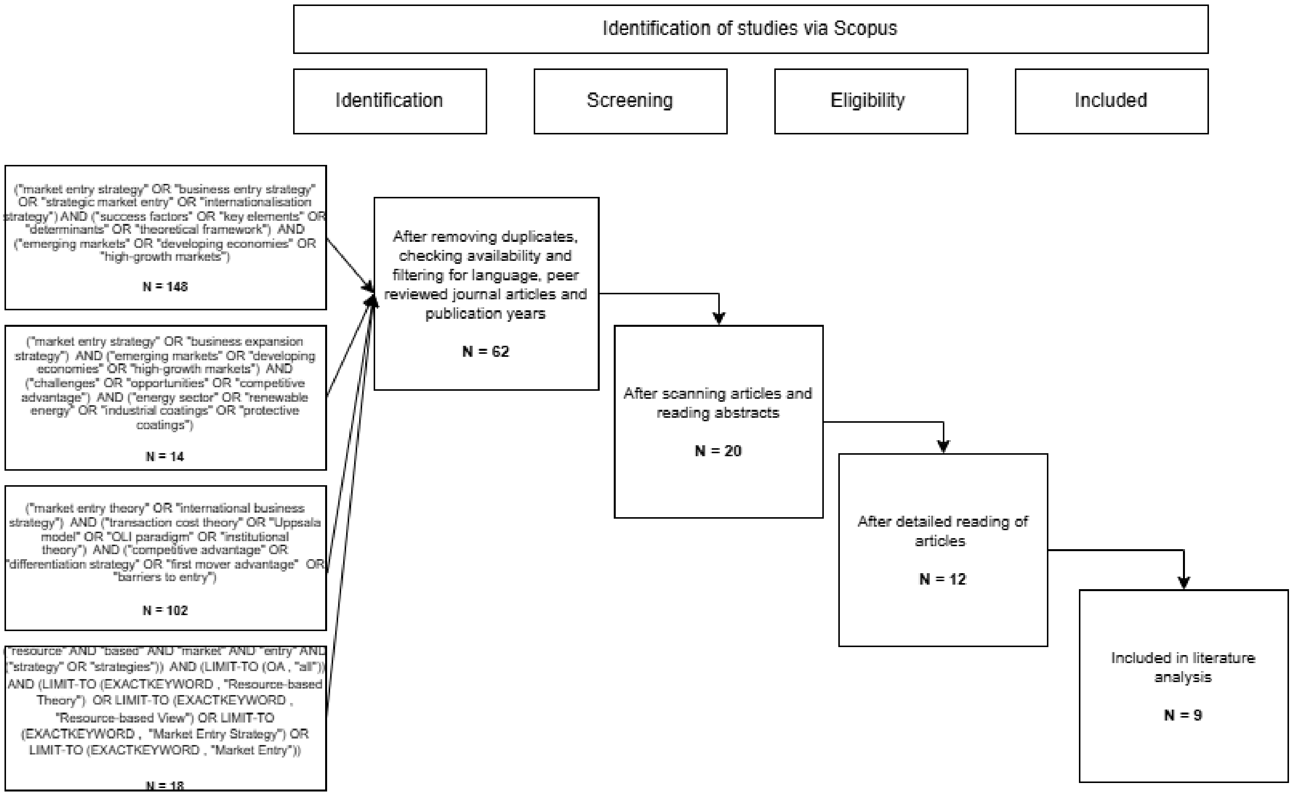


Figure 7: Identification of Relevant Studies

3.1.1.5 General Overview

The selected studies collectively provide insight into how firms leverage internal resources to overcome market entry barriers and achieve competitive advantage. They address key aspects such as risk perception, strategic orientation, institutional factors, and firm-specific capabilities. The findings highlight the importance of proprietary technology, regulatory adaptation and strategic alliances in successful market entry. The detailed breakdown of each paper's purpose, findings, and relevance to coating firms is presented in Table 3. This table provides an overview of the purpose of the papers, key findings and conclusions that underpin the analysis of market entry strategies in the renewable energy sector. The relevance to coatings companies assessments are interpretive and reflect how the insights from each study have been analytically applied to the context of protective coatings and hydrogen pipeline market entry.

Table 2: Summary of Literature on Market Entry Strategies for Protective Coatings Companies

Source	**Purpose**	**Key Findings**	**Conclusion**	**Relevance to Coatings Companies**
Stocker et al., 2022	To analyse how born-global firms perceive and manage risks in international markets.	Risk perception impacts internationalisation speed. Firms with strong networks and positioning manage entry risks better.	Entrepreneurial characteristics and firm capabilities shape international expansion.	Coatings firms can use strategic positioning and internal strengths to manage risk in renewable energy markets.
Trindade et al., 2023	To examine how strategic orientations and institutional factors influence internationalisation decisions.	Market orientation and innovation help firms succeed in new markets.	Strategic and institutional readiness are key for entry.	Highlights the need for coatings firms to leverage R&D and adapt to regulation in renewables.

Ahmadova et al., 2022	To explore how MNEs align firm-specific and country-specific advantages for better market performance.	Combining internal innovation and supply chains with external institutions enhances entry success.	Strategic alignment of internal and external factors is crucial.	Coatings firms should align tech expertise with renewable regulations.
Rahman et al., 2024	To explore how institutional and organisational factors drive SME internationalisation.	Firm-level and institutional capabilities both influence expansion.	Adaptability and leveraging firm strengths are key for entry.	Firms need proprietary tech and institutional insight for entry into renewables.
Rahman et al., 2017	To analyse barriers SMEs face when entering foreign markets.	Regulations, finances, and fragmented markets are challenges. Networks help overcome them.	SMEs must address both institutional and resource constraints.	Coatings firms should use internal resources to overcome regulatory and market barriers.
Donnelly et al., 2023	To examine how institutional distance and slack resources affect foreign market entry.	Firms with extra resources are better at managing regulatory differences.	Adaptation and resource use are critical for internationalisation.	Firms must allocate capital and talent to meet renewable energy market rules.
Meygoonpoury et al., 2024	To assess the role of networking and collaborative competition in energy market internationalisation.	Partnerships and government engagement improve market success.	Strategic alliances and knowledge-sharing are vital.	Coatings firms should build alliances with renewable developers and institutions.
Chang et al., 2022	To analyse the effect of bottleneck resources on firm growth and entry strategies.	Regulatory knowledge and strategic focus act as bottlenecks.	Overcoming resource constraints enhances success.	Coatings firms should identify and invest in critical resources for market access.
Beamish and Chakravarty, 2021	To evaluate the application of RBT in multinational enterprise strategies.	Proprietary resources and regulatory capabilities drive entry success.	RBT alone is not enough; institutional factors matter.	Coatings firms should integrate R&D, IP, and compliance to enter renewable markets.

3.1.1.6 Capabilities for a successfull resource-based market entry

According to the analysed literature, firms that successfully enter renewable energy markets rely on a combination of technological innovation, institutional knowledge and strategic alliances. Each of these factors plays a distinct role in shaping competitive advantage and ensuring a strong market position and the following paragraphs describe these different capabilities.

A. Technological Capabilities

Technological capabilities are foundational within RBT, as they represent knowledge-intensive and often proprietary resources that enable product differentiation and operational performance (Beamish & Chakravarty, 2021; Kero & Bogale, 2023). Firms that invest in innovation and R&D, particularly when these efforts result in process or product advantages, are better positioned to enter new markets with a compelling value proposition (Ahmadova et al., 2022; Trindade et al., 2023). These capabilities not only improve competitiveness but also create entry barriers for rivals, especially when embedded in specialised technical knowledge or patented processes (Beamish & Chakravarty, 2021). The literature also identified technological expertise as a frequent bottleneck resource, suggesting that access to such capabilities can determine the pace and success of internationalisation (Chang et al., 2022). As firms expand, those able to continuously align their technological development with evolving market demands retain strategic flexibility and long-term relevance.

B. Regulatory and Institutional Capabilities

The ability to navigate regulatory environments is equally central to a resource-based market entry strategy (Beamish & Chakravarty, 2021; Rahman et al., 2024). Unlike physical or financial assets, institutional knowledge and compliance capabilities are intangible resources that evolve with experience and learning (Rahman et al., 2017, 2024). Firms that can interpret and adapt to institutional conditions such as certifications, legal frameworks, and policy regimes, gain a significant advantage over less prepared competitors (Chang et al., 2022; Donnelly et al., 2023; Rahman et al., 2024). This institutional agility is especially important in markets where entry is shaped by policy, risk, and regulatory fragmentation (Donnelly et al., 2023). In line with RBT, these capabilities are difficult to imitate, as they rely on firm-specific learning curves, embedded routines, and external stakeholder relationships (Beamish & Chakravarty, 2021; Donnelly et al., 2023). The literature consistently highlights that firms combining regulatory insight with resource commitment are more likely to overcome entry barriers and secure a long-term position (Beamish & Chakravarty, 2021).

C. Strategic Positioning and Relational Capabilities

Strategic and relational capabilities concern how firms position themselves within broader market ecosystems. This includes the ability to form alliances, access knowledge networks, and engage with key actors such as policymakers, partners, and end-users (Meygoonpoury et al., 2024). RBT recognises these network-based relationships as firm-specific assets when they enable unique access to information, opportunities, and channels that others cannot easily replicate. Born-global firms, for example, often rely on such relational capital to mitigate risk and accelerate international expansion (Stocker et al., 2022). The literature also pointed to the importance of aligning internal capabilities with external market expectations through proactive strategy, positioning the firm not only as a supplier but as a credible and adaptive market participant (Ahmadova et al., 2022).

3.1.1.7 Conclusions

The application of RBT to market entry strategies in the renewable energy sector underscores the necessity of firm-specific capabilities in achieving competitive advantage. Protective coatings firms seeking to enter these markets must leverage proprietary technological innovations, develop institutional and regulatory expertise, and cultivate strategic partnerships to strengthen their market positioning.

Market entry success is closely tied to a firm's ability to mobilise its internal resources while responding to external industry dynamics. Technological capabilities provide the foundation for differentiation from competitors, while regulatory insight allows firms to overcome institutional barriers. Strategic alliances further enhance market presence by granting access to networks, project opportunities, and shared learning. Together, these capabilities form the basis for a resilient and adaptable entry strategy.

In response to the sub-research question, "What are the theoretical aspects of a successful resource-based market entry strategy?", the literature reveals that success depends on the effective deployment of internal capabilities that are valuable, rare, and hard to imitate. Firms that align their core strengths with evolving sector demands and institutional complexities are more likely not only to enter but to shape the markets they engage with.

The synthesis of these findings forms the conceptual basis for the "Firms' Capabilities" component in the conceptual model presented in Figure 8. Informed by the RBT, three distinct but interdependent categories of internal capabilities were identified: (1) Technological capabilities, (2) Regulatory and institutional capabilities, and (3) Strategic and relational capabilities. These served as critical enablers for effective market entry in complex sectors like hydrogen and are explicitly visualised in the framework to reflect their theoretical origins.

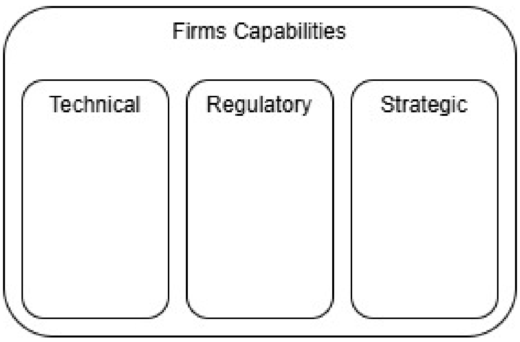


Figure 8: Conceptual model - Firm Capabilities

3.1.2 Key Challenges and Opportunities for Protective Coating Companies

This literature analysis explored the key challenges and opportunities that protective coatings companies face when entering hydrogen pipeline markets.

3.1.2.1 Literature research setup

The literature analysis was conducted in three stages to build a comprehensive understanding of the key strategic and technical aspects of protective coatings companies entering hydrogen markets. Each search was focused on a distinct layer of the research problem, ranging from general strategic barriers to technological innovation and sector-specific application.

Step 1: General market entry challenges and opportunities

The first search aimed to explore broad-level barriers to market entry and strategic opportunities for companies active in the energy transition. The focus was on understanding the structural, regulatory, and competitive dynamics that affect companies' ability to enter renewable energy markets. Key search terms included:

```
("market entry challenges" OR "barriers to entry" OR "entry obstacles")
AND ("market opportunities" OR "growth potential" OR "competitive advantage")
AND ("renewable energy" OR "energy transition" OR "clean energy sector")
```

This search returned 15 results, of which 7 were open access and 6 were selected after filtering for recent years and title/abstract relevance.

Step 2: Technological challenges and innovations in coatings

The second search aimed at literature on technological development, innovation, and R&D in the protective coatings sector. This included technical barriers related to the performance of coatings in renewable energy infrastructure, such as corrosion resistance, durability, and integration with modern systems. The search string used was:

```
("protective coatings" OR "industrial coatings")
AND ("innovation" OR "technology adoption" OR "R&D investment")
AND ("renewable energy" OR "carbon capture" OR "hydrogen pipelines" OR "biofuel pipelines")
```

This yielded 25 results, from which 6 papers were selected after full-text screening for content relevant to renewable energy applications.

Step 3: Sector-specific applications – hydrogen

The third search focused on protective coatings used specifically in pipelines and infrastructure for hydrogen. The following search string was used:

```
(("challenges" OR "opportunities")
AND ("protective" AND "coatings")
AND ("pipelines")
AND ("hydrogen")
```

This returned 4 relevant publications, with papers selected based on relevance to the renewable energy transition and coatings performance requirements.

3.1.2.2 Inclusion and Exclusion Criteria

Articles were selected based on the following inclusion criteria:

- Published between **2016 and 2025**
- Peer-reviewed journal articles
- Written in English
- Direct relevance to technical, strategic, or socio-economic challenges and opportunities for protective coatings in renewable or hydrogen infrastructure

Exclusion criteria were as follows:

- Conference proceedings or non-peer-reviewed sources
- Articles without full-text access
- Studies focused on non-industrial coating sectors (e.g., decorative, architectural, or marine coatings)

- Articles that discussed hydrogen infrastructure in general terms without reference to materials or component-level barriers

3.1.2.3 Examples of Inclusion

Two examples illustrate the rationale for selecting articles included in the final literature review. The study by Virah-Sawmy and Sturmberg (2025) reviews the socio-economic and environmental implications of renewable energy deployments. It was included for its relevance to external conditions—such as public perception, supply chain complexity, and community economics—that influence the adoption and development of sustainable coatings in emerging infrastructure projects. These themes align with this thesis' analysis of contextual factors shaping market entry.

A second example is Sharma et al. (2023), which synthesises 50 years of socio-economic research on hydrogen. It was included because it draws attention to under explored stakeholder perspectives, policy frameworks, and market conditions that are essential for understanding how coatings firms might align innovations with infrastructure development in hydrogen markets. This study also contributes empirical support for narrative pre-positioning and legitimacy-building as emerging strategic tools.

3.1.2.4 Selection Outcomes

The selection process for this stream of literature is visualised in Figure 9. The search strategy focused on three targeted keyword combinations addressing (1) market entry challenges and growth potential in the renewable energy sector, (2) technological innovation and R&D in protective coatings, and (3) hydrogen-specific applications. These searches returned a total of 52 unique results from Scopus.

Following the removal of duplicate articles and filtering based on language, publication year, and peer-review status, 32 articles were retained for initial screening. Abstracts were read to assess relevance to the research questions, resulting in 25 articles selected for detailed evaluation. After full-text reading, 13 articles remained. Of these, 3 were excluded due to insufficient relevance to hydrogen-specific coating challenges or overly generalised analysis. This process resulted in a final selection of **10 articles** that formed the analytical basis for the challenges and opportunities component of the conceptual model.

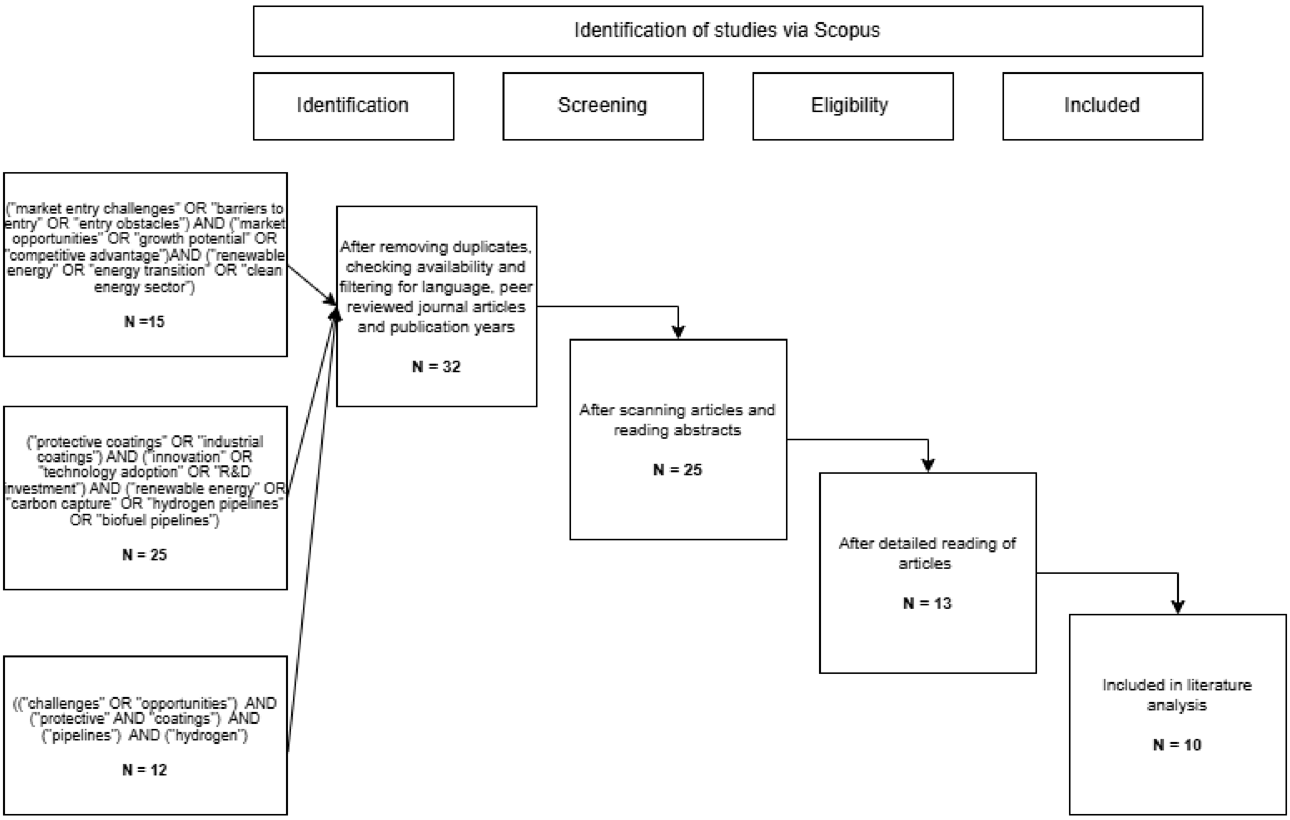


Figure 9: Identification of Literature on Challenges and Opportunities

3.1.2.5 General Overview

The selected studies collectively offer a general and hydrogen-focused view of the challenges and opportunities that protective coatings companies encounter when entering emerging energy infrastructure markets.

These sources spanned both technical and strategic domains, highlighting the need for coatings to withstand hydrogen-specific stressors such as embrittlement, leakage, and stress corrosion, while also navigating complex regulatory frameworks and international market dynamics. The literature further emphasised the importance of Quantitative Risk Assessment (QRA), digital readiness, and collaborative strategies in securing a foothold in this evolving sector. Recurring themes include pipeline material integrity, risk mitigation, sustainable innovation, and strategic internationalisation. Together, these insights illustrated how coatings firms must align technical capabilities with institutional awareness and policy trends to succeed in the hydrogen economy. Table 3 summarises each paper's purpose, findings, conclusions, and relevance, providing a consolidated academic foundation for this literature analysis. The relevance column reflects an interpretive assessment, applying each study's insights to the context of protective coatings and hydrogen market entry.

Table 3: Summary of Literature on Market Entry Challenges and Opportunities for Protective Coatings Companies

Source	**Purpose**	**Key Findings**	**Conclusion**	**Relevance to Protective Coatings Companies**
Corsatea and Giaccaria, 2018	Analyses regulatory effects on environmental productivity in EU energy.	Liberalisation increases efficiency but demands regulatory adaptation.	Regulatory insight is vital for competitive advantage.	Regulatory navigation is both a barrier and strategic opportunity.
Virah-Sawmy and Sturmberg, 2025	Reviews the socio-economic and environmental impact of renewables.	Public perception, supply chains, and local economics are central.	Balanced strategies are needed for sustainable growth.	Eco-friendly coatings must align with both durability and green objectives.
Gurtaran et al., 2024	Studies CrSi coatings for thermoelectric degradation prevention.	CrSi coatings greatly improve oxidation resistance.	Supports component longevity in extreme environments.	Technology can be adapted to solar thermal applications.
Grimme and Braun, 2022	Estimates hydrogen demand and CO2 reduction in aviation.	Hydrogen significantly reduces emissions but needs infrastructure.	Infrastructure must evolve with technology.	Hydrogen infrastructure growth requires corrosion-resistant coatings.
Meygoonpoury et al., 2024	Explores internationalisation through networking in renewables.	Partnerships help overcome entry barriers.	Collaborative models boost market resilience.	Strategic alliances help coatings firms enter renewable sectors.
Shirazi et al., 2024	Studies corrosion and stress cracking in hydrogen pipelines.	Hydrogen embrittlement is a major threat to integrity.	Advanced coatings are needed for safety.	Hydrogen resistance is both a challenge and opportunity.
Bade et al., 2024	Reviews barriers to green hydrogen scale-up in the US.	Key barriers include high costs, unclear regulations, and weak infrastructure limit progress.	Regulatory reform and public–private coordination are essential.	Coatings firms should align innovation with infrastructure policies and join cross-sector hydrogen initiatives.
Sharma et al., 2023	To review and synthesize socio-economic research on hydrogen energy from the past 50 years.	Research is concentrated in developed countries, with key themes in policy, economics, and public perception.	Socio-economic factors are critical to hydrogen adoption; more inclusive and interdisciplinary research is needed.	Understanding policy, economics, and public attitudes helps coatings firms align innovations with hydrogen infrastructure trends.

Goren et al., 2023	Reviews environmental and economic impacts of hydrogen production.	Highlights the policy, lifecycle emissions, and scaling implications.	Emphasises the need for sustainable infrastructure support.	Encourages coatings companies to align with hydrogen value chain growth.
Amer et al., 2024	Conducts a QRA of hydrogen transport via repurposed gas pipelines.	Risk of leakage and explosion is high but manageable.	Internal coating selection is key for safety and risk mitigation.	Directly supports the design of coatings for retrofitted hydrogen pipelines.

3.1.2.6 Challenges for Protective Coating Companies

Protective coatings companies face a series of challenges when attempting to enter hydrogen infrastructure markets, many of which are rooted in technical, regulatory, and strategic complexities (Bade et al., 2024; Corsatea & Giaccaria, 2018). A central technical challenge lies in the need for coatings to function reliably under extreme environmental conditions (Gurtaran et al., 2024). Hydrogen pipelines expose materials to high pressures, embrittling environments, and significant thermal fluctuations (Shirazi et al., 2024). These stresses compromise material integrity and significantly increase the risk of stress corrosion cracking and hydrogen-induced degradation in pipeline steels (Shirazi et al., 2024), underscoring the need for advanced surface protection strategies such as specialised coatings. Developing protective coatings capable of mitigating these effects requires significant R&D investment into material science, performance validation, and field testing (Amer et al., 2024; Gurtaran et al., 2024).

A further complication arises from the incompatibility of hydrogen with some traditional pipeline materials and systems. Unlike natural gas, hydrogen's smaller molecular size and wide flammability range demand stricter safety tolerances and leakage control, especially in internal surfaces of pipes (Amer et al., 2024). However, reliable field data on hydrogen component failure rates is scarce, limiting the precision of risk assessments and delaying the design of optimal coatings (Amer et al., 2024; Grimme & Braun, 2022). This uncertainty makes it difficult for protective coatings manufacturers to anticipate performance demands and complicates the qualification process for new solutions.

Regulatory complexity also presents a significant barrier (Corsatea & Giaccaria, 2018). While retrofitting existing gas pipelines with hydrogen flow capacity is a prominent strategy in national hydrogen plans, the regulatory frameworks guiding such transformations are still evolving. Varying safety standards, leak tolerance thresholds, and infrastructure testing protocols across regions further complicate deployment (Bade et al., 2024; Corsatea & Giaccaria, 2018). For protective coatings firms, these inconsistencies make it difficult to scale validated solutions across multiple markets, particularly in the absence of harmonised qualification procedures (Bade et al., 2024; Corsatea & Giaccaria, 2018; Sharma et al., 2023). Additionally, sustainability policies increasingly require manufacturers to align their products with environmental goals, amplifying regulatory and certification burdens (Bade et al., 2024; Virah-Sawmy & Sturmberg, 2025).

At a strategic level, market fragmentation and limited cross-border coordination can deter rapid entry into hydrogen infrastructure markets. Smaller coatings firms in particular may face barriers due to limited networks and experience in navigating complex international market conditions (Meygoonpoury et al., 2024). Successfully entering these markets requires not only technical readiness but also institutional awareness, policy responsiveness, and partnership development (Bade et al., 2024).

3.1.2.7 Opportunities for Protective Coating Companies

Despite these challenges, the hydrogen economy also presents compelling opportunities for coatings companies that can adapt their products to the evolving demands of this infrastructure shift. As countries invest heavily in large-scale hydrogen transport systems, particularly via repurposed natural gas pipelines, the need for reliable and high-performing internal flow coatings has become more prominent (Amer et al., 2024). These coatings must prevent corrosion and limit hydrogen permeation, each a niche for innovation and technical leadership (Shirazi et al., 2024). While friction reduction is also a performance target in some applications, the most urgent needs lie in hydrogen compatibility and safety assurance. Opportunities are particularly strong for companies developing coatings suited for both hydrogen blending and pure hydrogen transport (Amer et al., 2024). As failure mitigation becomes central to risk management and permitting, coatings with proven performance will likely be favoured in both retrofitted and new-build pipeline projects (Amer et al., 2024; Shirazi et al., 2024). In this context, the integration of field-relevant performance data, such as ignition probability reduction and embrittlement mitigation, adds value to coatings offerings.

Hydrogen's unique properties also create demand for digital integration. Infrastructure operators are increasingly turning to real-time monitoring systems, and coatings compatible with sensor technologies or capable of facilitating condition-based maintenance stand out as high-value products (Amer et al., 2024). These systems require coatings that maintain their integrity under prolonged exposure to hydrogen, with low surface degradation and reliable performance under thermal cycling. From a policy and investment perspective, governments worldwide are actively supporting hydrogen infrastructure development. This results in public-private partnership opportunities and potential co-funding of product development efforts (Bade et al., 2024). Coatings companies that align themselves with these national strategies and engage in collaborative development projects may gain early market access and secure preferred supplier positions (Goren et al., 2023; Sharma et al., 2023; Virah-Sawmy & Sturmberg, 2025).

Strategic internationalisation presents another opportunity. Firms that pursue joint R&D initiatives or co-develop projects with energy developers and regulators may better align product development with infrastructure needs and navigate regional market complexities (Meygoonpoury et al., 2024; Sharma et al., 2023). This kind of collaborative and network-driven market entry, although still underexplored in the coatings sector, offers a viable pathway to reduce institutional and strategic barriers. Furthermore, long-term competitive advantage may lie in how coatings companies position themselves within the broader sustainability transition (Sharma et al., 2023). Engaging with national and regional hydrogen strategies, investing in environmentally responsible production, and communicating a value proposition aligned with decarbonisation goals will be critical (Goren et al., 2023).

In summary, the hydrogen sector demands a new generation of protective coatings. Companies that respond to this demand with tailored, tested, and regulation-aligned solutions will not only overcome technical barriers but also gain strategic advantages in a rapidly expanding global market.

3.1.2.8 Conclusions

Protective coatings companies aiming to enter hydrogen pipeline markets are confronted with a dual reality: on one hand, a set of sector-specific technical, regulatory, and strategic hurdles, and on the other, a rapidly expanding field of opportunities created by the global shift toward clean hydrogen transport. The infrastructure transformation, driven by blending strategies and eventual shifts to pure hydrogen, requires coatings that meet heightened standards for material protection, leakage prevention, and long-term durability.

Key challenges include the uncertainty around failure data, the heightened performance expectations for materials exposed to hydrogen, and the regulatory fragmentation that slows cross-border market access. Nonetheless, these constraints are also catalysts for innovation. Growing awareness of hydrogen's unique risks have spotlighted the need for enhanced coatings, particularly those that can withstand embrittlement, reduce surface degradation, and support sensor-based monitoring.

In response to the sub-research question, "What are the key challenges and opportunities for protective coatings companies entering renewable energy markets?", the findings indicated that the hydrogen sector presents both the steepest technical requirements and the clearest early stage market opportunities. Companies that embrace this duality with targeted R&D, regulatory awareness, and participation in multi-actor development partnerships are well-positioned to become critical enablers of the hydrogen transition.

This analysis directly informed two key constructs in the conceptual model shown in Figure 10: "Motives for Market Entry" and "Entry Barriers." Opportunities such as policy-driven infrastructure investment, demand for hydrogen-compatible coatings, and sustainability alignment represent core drivers of strategic interest. Conversely, barriers including technological uncertainty, regulatory fragmentation, and high-performance demands act as constraints. These dual forces are explicitly separated in the model to reflect the opposing yet coexisting pressures identified in the literature.

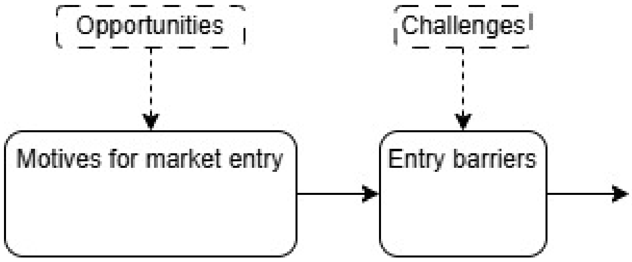
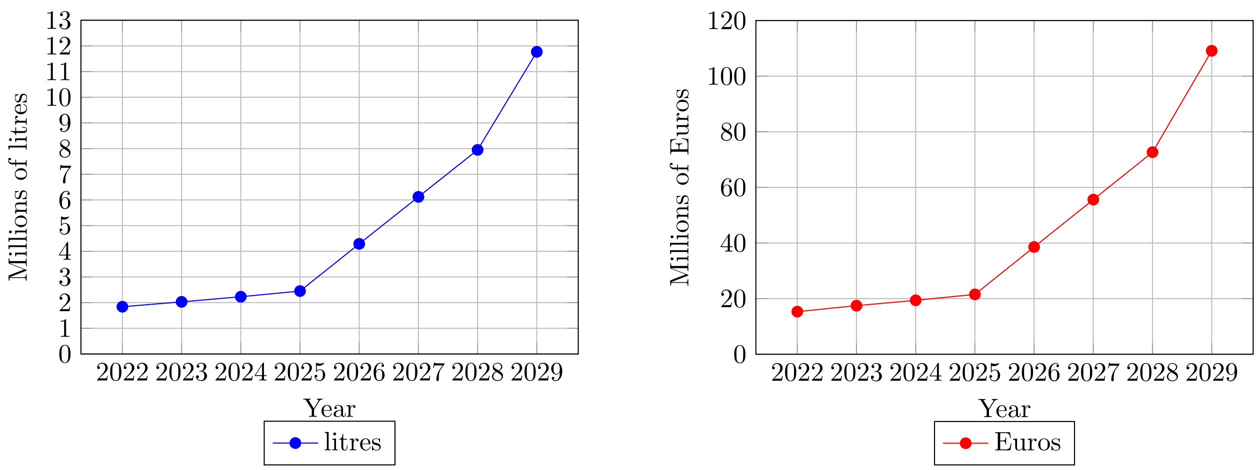


Figure 10: Conceptual model - Motives and Barriers

3.2 Market Data Analysis

To understand where and when protective coatings demand will emerge in the hydrogen sector, a market data analysis was conducted. This analysis focused on projected infrastructure development, coating demand, and regional investment patterns across Europe. Data sources included the IEA Global Hydrogen Review (Agency, 2024), DNV's Energy Transition Outlook 2024 (DNV, 2024), and two internal datasets from Hempel. This constitutes a secondary data analysis, integrating proprietary company insights with publicly available market reports to identify infrastructure trends and coating demand signals

To visualise the projected evolution of the coatings market, Figure 11 presents coating volume and market value estimates derived from the first internal dataset (see Appendix A). This dataset revealed that the European hydrogen pipeline coatings market is on track for a sixfold increase in volume and more than a sevenfold rise in value between 2022 and 2029, with stable pricing trends observed through 2025 and anticipated to continue. Demand is projected to increase from 1.84 million litres (€15.33 million) in 2022 to 11.77 million litres (€109.13 million) by 2029. The fastest growth occurs between 2025–2026, aligning with major policy-driven infrastructure rollouts. These projections reinforce the case that coatings are gaining strategic importance as enabling technologies within the hydrogen value chain. These coatings are primarily applied in the midstream and downstream phases of the hydrogen value chain, such as pipelines, storage systems, and terminals, making them critical for infrastructure durability and certification compliance.



(a) Projected coating volume

(b) Projected market value

Figure 11: Projected demand for hydrogen pipeline coatings in Europe made from internal datasets(volume and value)

Despite the detail available in the internal datasets, it is important to recognise the limitations imposed by the coatings industry's low transparency. Company-level strategies, procurement data, and specific project allocations are often commercially sensitive or restricted by non-disclosure agreements. Consequently, this analysis triangulates insights from proprietary data, public infrastructure reports, and secondary market sources to mitigate these limitations. Acknowledging this opacity is critical, as it contextualises the assumptions underlying growth projections and regional patterns.

The second internal dataset revealed that at a regional level, Germany, France, the Benelux countries lead in both project volume and investment, while countries like Romania and Portugal demonstrate high-value projects despite smaller portfolios. Overall, 253 hydrogen infrastructure projects were identified across Europe, representing a total investment of approximately $9.1 billion. Project timelines show a peak in completions around 2026, followed by sustained activity through the late 2020s.

These patterns were corroborated by the H2 Infrastructure Map (ENTSOG, GIE, CEDEC, Eurogas, GEODE, GD4S, 2025), which provides a detailed visual overview of transmission pipelines, storage sites, and production projects across Europe. The map reinforces the observed regional concentration of hydrogen activity and helps identify emerging opportunity zones for coatings firms seeking geographically targeted market entry.

This market data analysis informed the structure of the interview phase and validated assumptions regarding timing, regional demand clusters, and the strategic window for market entry, aligning with the abductive logic underpinning this research. Full data tables, project categories, and methodology details are provided in Appendix A.

In response to sub-research question 3 "When and where is demand for hydrogen-related protective coatings expected to emerge?", the data shows a concentrated demand window between 2024 and 2026, driven by project completions and operational starts across Europe. Regionally, Germany, France, and Belgium are projected to lead in both number of projects and total investment, indicating priority markets for near-term entry. The results of this market data analysis reinforced and refined three areas of the conceptual model (Figure 12). First, the identified demand growth and timing clusters directly inform the "Motives for Market Entry" by signalling when and where market opportunities emerge. Second, the incomplete and projected nature of much of the hydrogen infrastructure data highlights strategic uncertainties that strengthen the "Entry Barriers" component. Third, the regional variation in project volume and investment patterns contributes to the "Contextual Factors" category, particularly the sub-dimensions of market dynamics and infrastructure readiness across Europe. These findings provide empirical grounding to theoretical constructs derived from the literature.

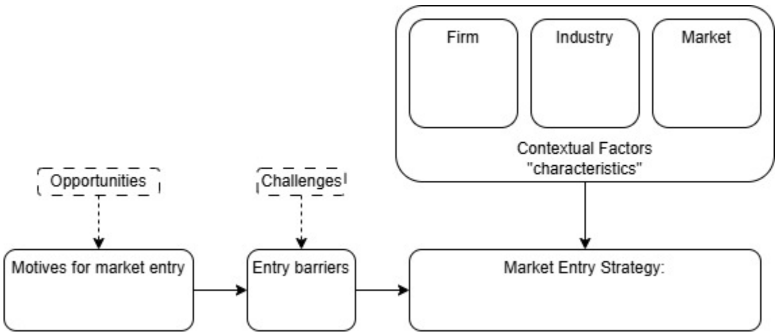


Figure 12: Conceptual model - Contextual Factors, Motives and Barriers

3.3 Conceptual Model

The conceptual model presented in Figure 13 represents the second iteration in the development of a strategic framework for market entry into hydrogen infrastructure by protective coatings companies, built on the conceptual model presentated in Figure 3. It synthesises findings from the literature analysis and hydrogen market data analysis, translating theoretical insights and empirical trends into a structured representation of the decision-making environment. Compared to the initial model shown in the introduction, this version incorporates refined constructs and interdependencies, grounded in both firm-internal dynamics and broader sectoral uncertainties. This iterative development process reflects the abductive logic underpinning the research, in which emerging empirical insights are used to revise and elaborate theoretical constructs in a continuous dialogue between data and literature.

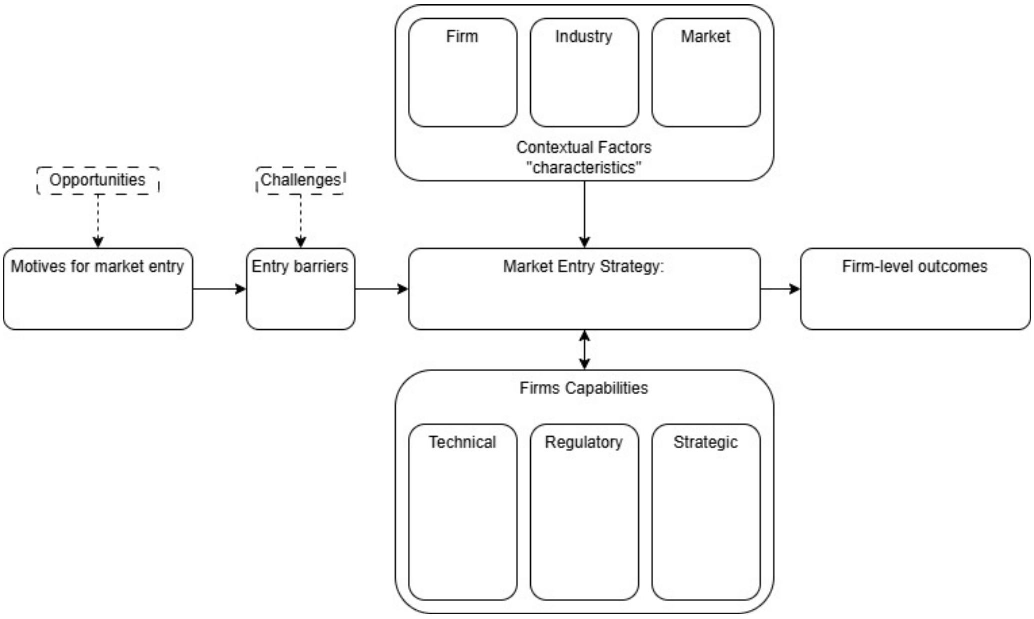


Figure 13: Conceptual model – Second iteration

The model consists of five interrelated dimensions. First, the model distinguishes between the opportunities and challenges present in the external environment and their respective influence on firm behaviour. Opportunities such as policy momentum, infrastructure investment, and potential first-mover advantages shape the strategic motives that drive coatings firms to explore entry into hydrogen markets. Conversely, challenges such as technical uncertainty, regulatory fragmentation, and uneven regional rollout manifest as entry barriers that constrain or complicate those ambitions. In this way, the model reflects that firms respond not only to external incentives, but also to constraints that shape the feasibility and design of their entry strategies. Second, it includes contextual factors that shape the feasibility and timing of entry decisions, ranging from internal readiness and capability maturity to external influences such as project timelines, geographic demand concentration, and institutional variance across jurisdictions.

In this model, firm capabilities are positioned directly beneath the market entry strategy block, reflecting their foundational role. Here, they are differentiated into three strategic domains: technological, regulatory, and strategic. Rather than serving as the core of the framework, capabilities act as the primary enablers that shape and constrain strategic options. This placement reflects the resource-based nature of the model: firms do not enter markets with generic strategies, but instead configure their approach based on the resources and competences they possess. As such, capabilities exert a direct influence on the strategy layer above, determining what entry paths are viable and under what conditions. The model thus recognises that a firm's internal capacity does not passively support market entry, but actively structures it.

At the core of the model lies the market entry strategy itself. In this model, strategy is not treated as a singular decision but as an evolving configuration of capability deployment and external alignment. Drawing on the abductive research design of the thesis, the model enables iterative movement between theoretical constructs and empirical observations, supporting both the validation of known patterns and the discovery of new strategic mechanisms. Entry strategies might take various forms, including early-stage partnerships, regional targeting, or phased market testing, and their configuration depends heavily on how firms interpret and respond to contextual signals.

Finally, the model includes firm-level outcomes as the result of the chosen market entry strategy. These outcomes reflect the consequences of how firms align their capabilities with contextual factors and strategic intent. Depending on the strategy pursued, outcomes may take the form of reputational gains, initial market access, or regulatory approval. In this version of the model, outcomes are conceptualised as end points, their role is to capture the strategic consequences of market entry.

Overall, the model served both as a conceptual consolidation of the research-to-date and as a structuring device for the qualitative phase. It provided a foundation for the interview design, which was explicitly mapped to the model's components, ensuring alignment between theoretical exploration and empirical inquiry. The model served not just as a description, but as an analytical tool to support capability-based strategy development in a complex and emerging market.

4 Interview Results

This chapter presents the results of nine semi-structured interviews conducted to validate and refine the market entry framework developed in Chapter 3. Eight of the participants were internal stakeholders from across strategic, technical, and commercial functions within Hempel and one was an external strategy expert from a competitor. The interviews aimed to assess the relevance, clarity, and completeness of the framework's dimensions, covering motives for market entry, barriers, contextual factors, capabilities, strategic approaches, and anticipated outcomes. Using thematic analysis in Atlas.ti, the data was coded through a hybrid approach that combined pre-defined codes (deductive) and emergent themes (inductive), which is explained in Section 4.1 and further examples are given in Appendix C. The results from the interviews and coding analysis are presented in two parts. Section 4.2 synthesizes validated insights that reinforce existing elements of the framework. Section 4.3 outlines novel insights that extend, nuance, or challenge theoretical assumptions and empirical expectations. Together, these findings formed the basis for the framework refinement presented in Chapter 5.

4.1 Coding Process

The analytical process began with the construction of a set of validated first-order codes, which were derived through a combination of a targeted literature review, strategic market analysis, and alignment with the conceptual framework developed in Chapter 3. In that chapter, a synthesis of academic literature and practical insights into hydrogen pipeline coatings led to the identification of recurring themes such as *R&D investment*, *speed to market*, *barriers due to lack of clarity*, and *first mover advantage*. These deductive categories were translated into codes prior to data collection to provide a structured lens for analysis. As shown in Table 4 (*Validated Coded Themes and Their Frequencies*), these initial codes were informed by prior research into strategic responses to emerging technologies, firm capabilities in complex B2B environments, and institutional pressures surrounding decarbonization and infrastructure investment. This structured coding frame served as a foundation to guide the analysis of expert interviews, ensuring consistency while remaining open to novel insights emerging from the empirical data.

During the coding of the expert interviews, the initial validated codes were supplemented by a set of inductively derived codes. These new codes emerged directly from the interview transcripts as patterns of meaning that had not been captured in the pre-existing schema. For example, quotes such as "We follow the money and market potential," or "Until two weeks ago, I wasn't sure if we were seriously interested in this market," revealed themes of organisational ambiguity and opportunistic timing, topics not explicitly captured in the original framework. These recurring patterns were first grouped into new first-order codes, each grounded in multiple data excerpts.

Once all interviews were coded, both the pre-validated codes and newly generated ones were clustered into second-order themes by identifying commonalities, causal links, or shared strategic implications. For example, codes like *Expansion of client base*, *External recognition*, and *Speed and responsiveness* were grouped under the theme *Success Criteria*. This abstraction was guided by qualitative research procedures aimed at increasing interpretive transparency and theoretical clarity (Bryman, 2016; Silverman, 2011; Linneberg & Korsgaard, 2019). The process sought to reduce complexity while preserving the empirical richness of the material.

The resulting second-order themes were then organised into broader aggregate dimensions, each representing a strategic domain in the context of hydrogen pipeline market entry. These dimensions include: **Motives and Barriers**, **Firm Capabilities**, **Market Entry Strategy**, **Firm-Level Outcomes**, and **Contextual Factors**. As shown in the mapping presented in Appendix C, these groupings served as the analytical backbone for the six key memos. For example, the memo on "Challenges and Barriers" draws on codes from Motives and Barriers, Contextual Factors, and Market Entry Strategy, illustrating the interpretive interdependence across the dataset. Figure 29 in Appendix C provides a transparent illustration of how raw quotes were transformed into first-order codes, then abstracted into second-order themes and finally linked to code groups. This layered approach enhances analytical traceability and ensures the credibility of the findings.

4.2 Validated Insights

The interviews conducted as part of this research offered strong empirical reinforcement of the analytical foundations laid in Chapter 3. Both the literature review and the market data analysis had already established a set of theoretical expectations regarding the motives, barriers, capabilities, and expected outcomes of market entry into the hydrogen pipeline coating segment. The codes that were established before the interviews, their frequency and the amount of interviews they were mentioned in can be found in Table 4. What follows is a synthesis of those insights, now validated through expert perspectives from within Hempel and across its ecosystem. These findings confirmed the relevance of the existing theoretical model, while grounding it in the practical realities faced by the firm.

Table 4: Validated Coded Themes and Their Frequencies

No.	Code	Grounded	Interviews	Code Group
1	Industry Context	52	9	Contextual Factors
2	Competitive landscape	12	5	
3	Government subsidy reliance	2	2	
4	Hydrogen maturity	9	4	
5	Internal Capabilities	124	9	Firm Capabilities
6	Cross-functional alignment	13	6	
7	Data availability and internal visibility	12	5	
8	Internal communication	5	4	
9	R&D Investment	12	7	
10	Resource allocation	34	9	
11	Speed to market / Agility	20	8	
12	Talent and expertise availability	35	9	
13	Market Opportunities	95	9	Motives and Barriers
14	Adjacent markets (methanol, CO_2)	9	3	
15	Commercial testing / Pilot projects	7	5	
16	Potential scale of hydrogen investments	17	7	
17	Partnerships	72	9	Firm Capabilities
18	Collaboration with pipeline manufacturers	8	6	
19	End-user engagement	14	8	
20	Government / institutional partnerships	6	5	
21	Joint development initiatives	12	6	
22	R&D institute cooperation	20	7	
23	Third-party testing / certification	16	7	
24	Regional Differences	32	9	Firm Capabilities
25	Exportability of European standards	6	5	
26	Fragmented regulatory environments	4	3	
27	Regulatory Challenges	46	8	Motives and Barriers
28	Anticipating future standards	17	8	
29	Barrier due to lack of clarity	12	6	
30	Third-party approval relevance	2	2	
31	Strategic Positioning	138	9	Market Entry Strategy
32	Customer-centric strategy	24	8	
33	First mover advantage	20	7	
34	Market segmentation strategy	9	6	
35	Success Criteria	77	9	Firm-Level Outcomes
36	Commercial test wins or pilots	6	4	
37	Expansion of client base	5	4	
38	External recognition	12	8	
39	Standard / Specification inclusion	14	5	
40	Technical Challenges	92	9	Motives and Barriers
41	Flow efficiency requirements	7	4	
42	Gas permeability and barrier performance	12	4	
43	High-performance coating requirements	6	4	
44	Hydrogen embrittlement	7	5	
45	Productivity and curing times	2	1	
46	VOC limitations and 100% solids coatings	9	3	

4.2.1 Motives for Market Entry

Seven interviewees reiterated the strategic logic of early entry, reinforcing the idea that first-mover advantage remains a compelling rationale in this emerging market. As established in Chapter 3.1.1, first-mover positioning through a proactive strategy, particularly in immature and fast-evolving sectors, offers firms the chance to shape standards, influence customer preferences, and build long-term relational capital. The comparison with Hempel's historical trajectory in the wind sector, done by four interviewees, is particularly telling: being seen as a trusted early supplier had direct commercial payoffs. Other interview data confirmed this parallel, with multiple references to the importance of case-building, visibility, and signalling leadership while standards and technical expectations are still fluid.

Regulatory involvement, similarly, emerged as both a motive and enabler of market entry. Chapter 3.1.1.3 identified regulatory capabilities as a form of non-imitable resource, an insight reinforced by 8 of the interviews, which frequently cited early standard-shaping activities with DNV and other regulatory bodies. The ability to anticipate and shape regulatory frameworks was described not only as a strategic advantage but as a necessary condition to avoid being locked out of future specifications. This confirms that regulatory engagement is not merely a defensive posture but a proactive lever for shaping demand and future-proofing internal technology development.

Market opportunity, while already demonstrated through forecasts in Chapter 3.2, was further validated qualitatively. Interviewees across functions referenced the anticipated infrastructure scale, particularly in Western Europe, as a key enabler of entry. Their familiarity with national project maps, specification timelines, and regional procurement trends mirrored the macro patterns discussed earlier, lending credibility to the projected sixfold increase in hydrogen pipeline volume by 2029. Importantly, this demand-side visibility was not seen as abstract; it was understood concretely in terms of near-term sales opportunities, particularly in Germany and the Netherlands.

Finally, internal commercial relationships were cited as instrumental in easing the path to entry. As noted in Chapter 3.1.1.3, strategic capabilities, particularly those that enable trust-based expansion within existing accounts, are a form of embedded advantage. This was confirmed by six interviewees who emphasized "land and expand" strategies and the ability to leverage longstanding partnerships to introduce hydrogen-specific innovations. These findings suggested that market entry in this segment will not necessarily require the creation of new channels, but rather the reactivation and deepening of existing ones.

4.2.2 Entry Barriers

The interviews also strongly reaffirmed the technical and institutional frictions outlined in Chapter 3.1.2.3. Most prominently, technical uncertainty, already identified in the literature as a core challenge, was cited extensively by all of the interviewees. The limitations of current testing infrastructure, uncertainty around permeation thresholds, and the absence of consistent degradation data all confirm the risks highlighted in the literature. What is particularly notable is the alignment between technical and regulatory ambiguity: 6 interviewees pointed to the absence of agreed-upon standards not only as a scientific bottleneck, but as a commercial one. These dual uncertainties, technical and regulatory, compound each other and were anticipated in Chapter 3.1.2.3.

Interviewees also confirmed that entering business to business markets is hard, especially because existing suppliers are deeply entrenched and change happens slowly. Literature on industrial coatings markets notes the difficulty of displacing existing suppliers in commodified segments, especially in the absence of clearly superior performance or a compelling value proposition. Five interviewees echoed this concern, adding that risk aversion among pipeline owners and applicators often prevents experimentation with unproven technologies, regardless of their theoretical benefits. This challenge was discussed in Chapter 3.1.2.3 and now gains empirical weight through qualitative input.

The final barrier, related to scaling and production readiness, further validated findings from both the literature and the market data analysis. Chapter 3.2 identified 2025–2026 as a critical inflection point in the hydrogen pipeline segment, suggesting that firms lacking validated and scalable offerings by this time risk marginalisation. Four interviews echoed this time pressure explicitly, adding that it is a now or never situation. Furthermore, eight of the interviewees pointed to the high costs of real-world testing, the absence of in-house simulation capabilities, and the lack of structured pilot lines as obstacles to timely commercialisation. These remarks not only confirm the earlier identification of manufacturing scale-up as a choke point, but add operational specificity to what had previously been presented as a strategic risk.

4.2.3 Contextual Factors

The broader context in which these dynamics are unfolding also found strong corroboration between primary and secondary data. As discussed in Chapter 3.2, hydrogen pipeline development is geographically concentrated, with Germany, France, and the Benelux countries leading in project maturity. This regional clustering was repeatedly acknowledged in six of the interviews, not only as a demand signal but as a strategic filter, guiding decisions about where to deploy testing resources, engage partners, or launch pilot projects. This confirms the contextual destiction of geography and supports the regional prioritisation logic embedded in market entry planning.

Policy momentum, too, was referenced in similar terms across both data sources. As highlighted in Chapter 3.1.2.4, national initiatives offer structural support to hydrogen infrastructure but fall short of providing the level of regulatory clarity required for commercial certainty. Eight of the interviewees confirmed this dual character: regulation is seen as both a latent enabler and a current gap. The risk of misalignment between product development and emerging standards, such as future volatile Organic Compound (VOC) thresholds or coating thickness requirements, was raised multiple times, directly linking strategic risk to the evolving policy landscape.

Hydrogen's role in the energy transition, particularly for hard-to-abate sectors such as steel and chemicals, was similarly discussed in both literature and interviews. While mobility applications were regarded with scepticism, industrial use was consistently viewed as a stable and growing segment, an observation that validates the sectoral segmentation in Chapter 3.1.2.5. Relatedly, three interviewees confirmed the presence of substitution threats, particularly from battery systems, ammonia, and alternative pipeline materials. These concerns echo the competitive uncertainty mentioned in both the literature and the market data analysis.

4.2.4 Firms Capabilities

The empirical data also reinforced the capability categories identified in the literature and structured through the RBT. Technical capabilities, especially in R&D, product testing, and hydrogen-specific validation, emerged as essential enablers. Chapter 3.1.1.3 already established that in sectors marked by uncertainty and technological novelty, in-house technical competence and the ability to partner with credible third parties are among the most defensible sources of advantage. All the interviewees affirmed this, citing both internal efforts (e.g., polymer development, permeation testing) and external collaborations with universities, end-users and testing institutes as key components of their strategy.

Regulatory capabilities, similarly, were recognised as vital. The literature had previously treated these as a subset of institutional capabilities, with early engagement in rule-making offering firms a chance to lock in advantage. This was corroborated through direct reference to partnerships with DNV and others, as well as acknowledgement of the risks posed by delayed or reactive regulatory strategies. In this sense, the interview data does not just confirm the importance of regulatory capabilities, it sharpens the understanding of their timing and influence.

Strategic capabilities, in the form of ecosystem partnerships, also found strong support. Chapter 3.1.1.3 describes such partnerships as dynamic, path-dependent capabilities that confer network-based competitive advantage. All the interviewees' emphasis on collaboration with pipeline manufacturers, Engineering, Procucurement and Constructions (EPCs), and academic institutions confirms the relevance of this capability category. These relationships are not only sources of information and access; they were increasingly positioned as gateways to specification and procurement channels. Strategic capabilites in the form of organisational and commercial capabilities, especially those related to internal coordination, cross-functional engagement, and product-market alignment, were acknowledged as both enablers and bottlenecks. Literature on dynamic capabilities underscores the importance of orchestration and strategic prioritisation in uncertain environments. Six of the interviews validate this view, noting gaps in hydrogen-specific resourcing, project management discipline, and commercial tooling. These shortcomings confirm that even where technical and relational assets exist, organisational readiness remains a critical determinant of successful entry.

4.2.5 Strategic Market Entry

Each of the above capability categories was linked to strategic behaviours that are consistent with those anticipated in Chapter 3.3. First-mover advantage was widely seen as a legitimate strategy, particularly if paired with validated product performance or regulatory influence. The pursuit of customer specification, through alignment with project timelines and standardisation bodies, mirrors the strategic pathways discussed earlier. Likewise, ecosystem engagement was not seen as a peripheral tactic, but a core route to credibility and access.

The dual-use innovation strategy, developing coatings that can serve both hydrogen and CO2 pipelines, also emerged as a confirmed approach. Chapter 3.1.2.4 treated this as a practical means of de-risking investment in uncertain applicationss. Sustainability alignment, finally, was referenced not only as a compliance factor but as a differentiator, particularly in terms of downstream value such as flow efficiency and lifecycle performance. This reconfirms that sustainability is now viewed as an embedded dimension of product strategy, not merely a marketing add-on.

4.2.6 Firm-level outcomes

Lastly, the outcomes that interviewees associated with successful entry align closely with those defined in the literature. These include gaining early specification, achieving validated product status, expanding into new customers or tenders, and establishing thought leadership. Each of these was mentioned in the interviews and reflects the types of outcomes associated with strategic success in capability-constrained markets, as discussed in Chapter 3.1.1.4. and 3.1.2.5. Crucially, seven interviewees also point to a temporal logic: early wins, even in the form of specification or validation alone, can pave the way for later commercial returns.

4.3 Novel Insights

In addition to reinforcing previously established constructs, the interviews yielded several novel insights that go beyond what was anticipated in the theoretical framework and data analysis presented in Chapter 3. These findings introduce new dimensions to the understanding of strategic market entry in the hydrogen pipeline coatings segment, as well as contradict certain findings from the earlier stages. The codes that were created throughout this process, their frequency and the amount of interviews they are in can be found in Table 5. These insights refine, nuance, or extend the conceptual model by drawing attention to softer, processual, or organisational dynamics that are often overlooked in conventional literature. They also highlight under-theorised tensions between technical readiness and strategic intent, as well as the importance of perception, positioning, and internal alignment as determinants of successful entry.

Table 5: Novel Coded Themes and Their Frequencies

No.	Code	Grounded	Interviews	Code Group
1	Industry Context	44	9	Contextual Factors
2	Applicator power in value chain	8	3	
3	Customer risk aversion	10	7	
4	Industry fragmentation	3	2	
5	Pipeline ownership structure	6	4	
6	Slow market development pace	7	5	
7	Internal Capabilities	24	9	Firm Capabilities
8	IP Development and Management	4	2	
9	New product development process	15	7	
10	Organisational silos	5	5	
11	Knowledge Gaps	27	5	Motives and Barriers
12	Internal knowledge limitations	10	4	
13	Technical and regulatory understanding	23	5	
14	Market Opportunities	97	9	Motives and Barriers
15	Competitive whitespace	10	7	
16	Confusion in client needs	7	5	
17	Customer interest variability	8	3	
18	Early stage positioning	13	5	
19	Examples from wind sector	2	2	
20	Expanding existing customer relationships	9	6	
21	Experimental technologies	1	1	
22	Flow efficiency as value proposition	10	5	
23	Opportunity to define standards	10	8	
24	Pipeline repurposing projects	4	4	
25	Partnerships	23	9	Firm Capabilities
26	External validation as market enabler	11	8	
27	Lack of cross-regional partner visibility	4	3	
28	Participation in industry groups	7	4	
29	Technology licensing or acquisition	1	1	
30	Regional Differences	38	9	Firm Capabilities
31	Applicator influence on specifications	4	3	
32	Country specific client requirements	10	6	
33	Difficulty with centralised European approach	1	1	
34	Local vs. EU-level coordination	2	1	
35	National risk appetite and policy stance	4	3	
36	National vs. EU funding	1	1	

37	Regional business unit silos	1	1	
38	Varying infrastructure maturity	5	4	
39	Regulatory Challenges	20	8	Motives and Barriers
40	Changing EU legislation	2	2	
41	Compliance as competitive advantage	8	4	
42	EU regulation to other regions	3	3	
43	Risk of regulatory misalignment	7	6	
44	Strategic Positioning	123	9	Market Entry Strategy
45	Balancing short-term vs long-term priorities	13	7	
46	Differentiation for competitors	18	9	
47	Internal strategic alignment	16	8	
48	Long-term vision and planning	36	8	
49	Portfolio prioritisation	12	5	
50	Risk appetite and investment mindset	21	6	
51	Segment entry timing	7	7	
52	Success Criteria	62	9	Firm-Level Outcomes
53	Growning internal investment in segment	4	4	
54	Increase in customer adoption	7	7	
55	Internal alignment across functions	9	5	
56	Product differentiation confirmed	24	8	
57	ROI or market share growth	8	6	
58	Speed and responsiveness	10	7	
59	Technical Challenges	68	9	Motives and Barriers
60	Compatibility with applicator processes	22	5	
61	Lack of hydrogen-specific coating knowledge	19	8	
62	Lack of hydrogen-specific testing standards	13	5	
63	Unclear or inconsistent technical requirements	16	8	

4.3.1 Novel Motives for Market Entry

One of the most significant contributions from the interviews is the re-framing of uncertainties not merely as a barrier, but as a strategic window. Whereas Chapter 3 treated regulatory and technical uncertainty primarily as risks to be managed, eight of the interviewees described the current lack of standards as a rare opportunity to shape emerging regulations. This introduces the concept of "narrative pre-positioning", a form of legitimacy-building in which firms attempt to influence not just what standards are adopted, but who is seen as credible within the evolving space. The idea that a firm can become the expert before standards are finalised represents a more symbolic, reputational motive for entry than previously captured, and aligns with the aspiration to build soft power through early visibility rather than conclusive technical superiority.

This links closely to a second novel theme: that strategic acceleration may be more decisive than technical excellence. Contrary to the technology-centric logic that underpins much of the RBT literature, six interviewees repeatedly suggested that credibility, speed, and visibility might outweigh incremental technical differentiation, particularly in a context where no clear benchmarks or standards yet exist. In such settings, perception management becomes a central strategic tool. This shift from technical performance to strategic visibility represents a critical departure from the assumption that superior capabilities automatically translate into competitive advantage.

Internal capability readiness also emerged as a gatekeeper to opportunity, a notion underdeveloped in existing theory. While the RBT posits that capabilities underpin strategic advantage, it often treats them as relatively static assets. In contrast, the interview data showed that internal alignment, decision-making velocity, and the willingness to formalise strategic intent are decisive. Capability, in this context, becomes as much about commitment and coordination as about possession. This reinforces the idea that opportunity does not necessarily translate into action unless internal governance structures support it.

4.3.2 Under-explored Entry Barriers

The interviews also introduced a set of internal frictions not accounted for in the literature. Chief among these is the fragmentation of strategic intent across the organisation. Although RBT acknowledges the importance of internal capabilities, it tends to assume unified strategic action once an opportunity is recognised. However, five respondents described persistent scepticism within their firm, not about the technical feasibility of hydrogen coatings, but about their market relevance. This internal disbelief functions as a non-market barrier, impeding resource allocation and delaying critical commitments. Strategic paralysis, driven by uncertainty and ambiguity about customer readiness or doubts about whether coatings are even required for hydrogen pipelines, emerged as a distinct and under-theorised challenge.

Furthermore, the notion of "presence as a capability" was a recurring theme. Four interviewees suggested that access to the right networks, such as standards committees, joint industry projects (JIPs), and regulatory roundtables, can constitute a differentiator in its own right. This reframes early market participation not only as a function of innovation or partnership, but of social positioning. In a sense, being "first to show up" may be more consequential than being technically superior, a point largely absent in RBT literature, which prioritises resource ownership over social capital.

Another critical insight was the blurred nature of customer segmentation. In contrast to the clean categories assumed in market entry theory, clients often straddle both fossil and renewable domains, complicating sales and account management structures. This duality introduces a coordination challenge that extends beyond marketing to affect CRM systems, reporting structures, and even internal performance metrics. The lack of fit between the firm's go-to-market model and its customers' energy transition trajectories points to an organisational misalignment not addressed in standard models of segmentation or capability deployment.

Lastly, the risk of opportunity misreading surfaced repeatedly. Two interviewees voiced concern that the absence of competing coatings might reflect not a market gap, but a lack of real demand. This introduces a form of strategic doubt that literature generally neglects, the fear of being early and wrong. This hesitation is qualitatively different from conventional risk; it represents a deeper epistemic uncertainty about whether the firm understands the market better than its competitors, or is simply misreading the signals.

4.3.3 Emerging Contextual Dynamics

The interviews also revealed several contextual dynamics absent from the literature and market data. Most notably, there was a consistent emphasis from all interviewees on customer-led standards rather than regulatory edicts. While Chapter 3 focused on institutional voids and regulatory ambiguity, the interviewees made clear that specifiers, especially asset owners and EPCs, hold far more sway over product requirements than national authorities or certification bodies. This re-framing challenges conventional top-down views of regulatory influence and suggests that market access is increasingly governed by client-driven technical expectations rather than formal legislation.

A related insight was the presence of unexpected veto points in the value chain. Even when asset owners approve a coating, applicators or manufacturing constraints may prevent its deployment. This subtle production-level barrier complicates the assumption that gaining specification equates to market success. It adds a practical, executional layer to the value chain that is absent from most strategic models, which often assume linear adoption processes once key stakeholders are aligned.

Five interviewees also described the hydrogen pipeline ecosystem as socially conservative and reputationally closed, a detail that introduces important nuance to the notion of market uncertainty. While Chapter 3 discusses technological and regulatory uncertainty, it does not capture the role of cultural inertia and relational conservatism in slowing adoption. This makes the hydrogen pipeline space less like an open innovation market and more like a reputational club, in which access and influence are governed by trust and history rather than by novelty.

Finally, the interviews revealed a degree of misalignment between public discourse and private reality. While policy signals and market forecasts suggest imminent growth, three interviewees warned against overinterpreting political narratives. Their comments reflect a growing awareness that actual infrastructure development is falling behind the optimistic messaging, requiring firms to balance strategic ambition with practical caution. Notably, two interviewees expressed concern that overconfidence in existing customer relationships may limit the firm's strategic agility, suggesting that familiarity with the value chain may paradoxically breed complacency and reduce the urgency to adapt or explore new entry pathways.

4.3.4 Capability Constraints and Gaps

Beyond contextual factors, several new capability-related insights emerged from the interviews. One striking theme, named by five interviewees, was the limited capacity to simulate realistic pipeline conditions internally. While technological capability is a cornerstone of RBT, this finding introduces a practical distinction between lab competence and field applicability. The inability to test thin coatings on curved, high-pressure surfaces was cited as a core bottleneck, highlighting the deployment gap between R&D and commercialisation.

Moreover, the absence of a dedicated hydrogen team, and the failure to treat hydrogen as a discrete strategic segment, emerged as significant internal misalignments. These organisational shortfalls are rarely addressed in literature, which tends to assume strategic clarity once an opportunity is recognised. In Hempel's case, hydrogen still lacks the formal project management structures, Key Performance Indicators (KPIs), and cross-functional ownership that typically accompany strategic initiatives. This is compounded by criticisms of the firm's innovation process, with two respondents describing stage-gate models as too slow or rigid to respond to rapidly evolving opportunities such as hydrogen.

Importantly, three interviewees highlighted the role of commercial readiness, not just technical readiness, as a key enabler. While R&D efforts are substantial, the absence of sales enablement, pricing strategies, and value proposition articulation was described as a constraint. This distinction between product viability and go-to-market capacity is under explored in RBT, which often combines technological and commercial capability under a single construct.

Finally, a lack of internal visibility, both in terms of who possesses what knowledge and where relevant expertise resides, was seen as a foundational failure. This scattering of knowledge undermines coordination and impedes the formation of coherent strategic responses. Adding to this, hydrogen coatings are still not recognised as a strategic priority internally. The low intensity of internal commitment, evidenced by the absence of deadlines, resources, or a formal roadmap, suggests that internal conviction, rather than external competition, may be the more immediate constraint.

4.3.5 Strategic Misalignments in Market Entry

From a strategic perspective, several operational tensions emerged that were not captured in Chapter 3. The current approach to hydrogen customers is largely ad hoc, tailored on a case-by-case basis rather than standardised. This creates a tension between responsiveness and scalability, an execution dilemma that is rarely addressed in literature, which often assumes a stable product-market fit.

Three interviewees also pointed to missed opportunities in terms of visibility and ecosystem engagement. The failure to attend relevant industry events or contribute to key standardisation discussions was described as a strategic gap, not merely in marketing, but in legitimacy-building. These omissions suggest a need to broaden the definition of strategic capability to include external presence and symbolic engagement.

More fundamentally, the internal debate around whether to invest in hydrogen coatings reflects a deeper tension between risk aversion and opportunity capture. Three interviewees acknowledged the difficulty of justifying investment in a high-uncertainty, low-revenue segment. This hesitation illustrates the limits of RBT, which assumes resource allocation follows from opportunity identification. In practice, resource mobilisation depends on internal narratives, champions, and political support.

Notably, the "fail fast" ethos was raised by three respondents as a desirable, but absent, organisational trait. The need for iterative learning cycles, fast-track innovation, and early experimentation was contrasted with the rigidity of current decision processes. This suggests that temporal and cultural dimensions, such as agility, responsiveness, and psychological safety, should be integrated into the conceptual model.

4.3.6 Reframing Firm-Level Outcomes

Finally, several novel firm-level outcomes were articulated. First, internal confidence, manifested in team formation, project formalisation, and strategic visibility, was described as a prerequisite to external leadership. This adds a temporal layering to the outcome model, in which internal conviction must precede market credibility.

Second, the lack of structured project management was identified not merely as a capability gap, but as an outcome failure in its own right. Without deadlines, ownership, or metrics, progress cannot be evaluated, let alone achieved. Third, narrative positioning, through conferences, whitepapers, and technical publications, was seen as a non-traditional, yet potent, form of thought leadership. These soft-power mechanisms directly contribute to specification wins and brand differentiation, yet are rarely acknowledged in standard frameworks.

Finally, the interviews introduced the notion that product validation, even in the absence of field deployment, can be treated as an interim success. This reframes firm-level success as a phased, multi-stage journey in which technical credibility and customer inclusion precede revenue growth. When paired with indicators such as client base expansion and eventual segmentation leadership, this phased logic offers a more nuanced and realistic understanding of what early success might look like in emerging, high-uncertainty markets such as the hydrogen market.

4.4 Conclusion

In response to subresearch question 4 *"What are the perceptions and expectations of industry stakeholders regarding the challenges and opportunities for market entry in the hydrogen sector?"*, the interviews show a nuanced but strategically consequential outlook. Stakeholders perceived hydrogen pipeline coatings as a space defined by both high uncertainty and first-mover potential. Opportunities were seen in shaping emerging standards, aligning with decarbonisation goals, and leveraging established customer relationships. However, these are offset by significant challenges, including internal fragmentation, limited technical readiness, and a lack of regulatory clarity.

While perceptions vary across technical, strategic, and commercial roles, there was a shared recognition that early visibility, credibility in the absence of standards, and commercial agility are more decisive than purely technological differentiation. Internal scepticism remained a barrier, as some doubt the viability or relevance of hydrogen coatings altogether. Yet those most engaged with external stakeholders emphasise that proactive positioning, through early testing, partnerships, and regulatory involvement, can create long-term competitive advantage. In sum, stakeholders expected that success will go to firms that can act decisively under ambiguity, and who are willing to shape the market rather than wait for it to stabilise.

5 Market Entry Framework

5.1 Market Entry Framework (Third Iteration)

This section presents the third iteration of the Market Entry Framework, which serves as the integrative output of the research. It reflects the synthesis of the conceptual insights developed in Chapter 3 with the empirical validation and refinement conducted through interviews in Chapter 4. The framework aims to represent how protective coatings firms navigate the strategic challenge of entering hydrogen infrastructure markets under conditions of uncertainty, capability variation, and evolving institutional structures.

How to Read the Framework

Figure 14 visualises six interrelated components: *Motives for Market Entry, Entry Barriers, Contextual Factors, Firm Capabilities, Strategic Market Entry, and Firm-Level Outcomes.* Solid arrows indicate directional flows (e.g., the influence of capabilities on strategy), while dashed arrows denote feedback effects (e.g., learning loops). The reader should begin by examining the Motives for Market Entry, which represent the strategic drivers initiating the entry process. From there, the framework flows through Entry Barriers, which shape and constrain the firm's available strategic options. These lead into the Strategic Market Entry configuration, which, depending on contextual factors and firm capabilities, results in short- and long-term outcomes that feed back into the strategy and capability base through continuous learning and adaptation. However, the model is not a stepwise process, but a dynamic diagnostic tool. It reflects how firms combine internal resources with external sensing to configure strategic responses under conditions of institutional uncertainty.

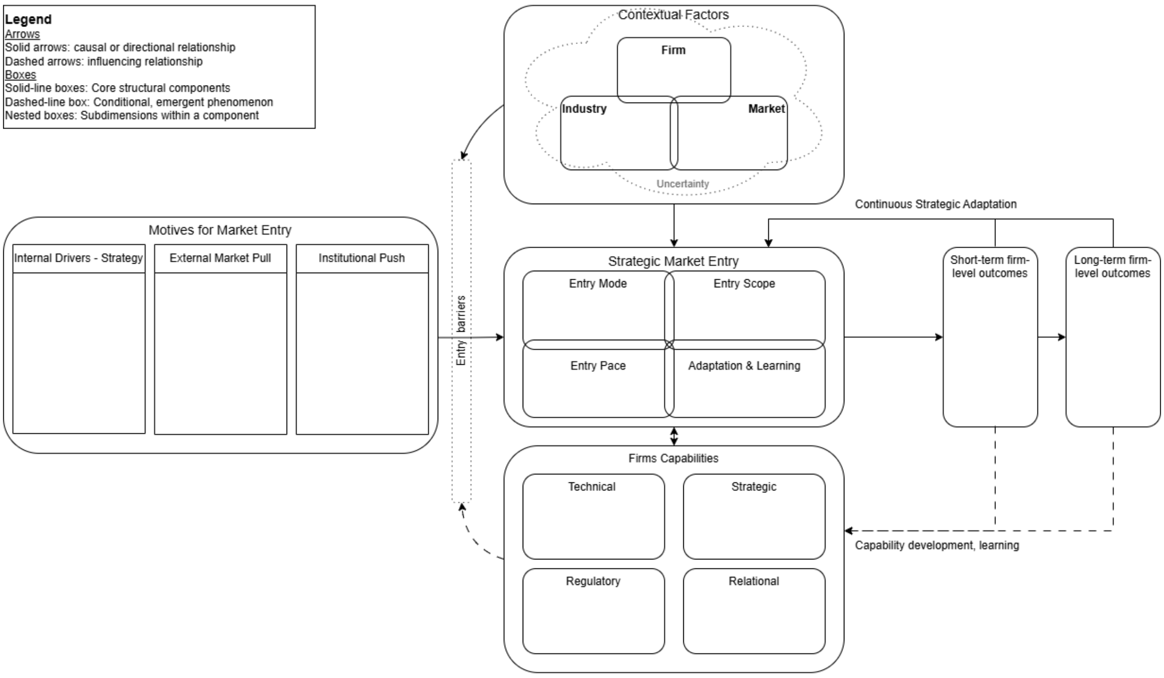


Figure 14: Market Entry Framework

Motives for Market Entry

The original concept of 'motives' has been disaggregated into three sources of strategic intent: internal drivers, external market pull, and institutional push (Figure 15). Interview data confirmed these categories. For example, seven out of nine interviewees cited early visibility and positioning as a core internal motivation, often linked to first-mover advantage and alignment with sustainability strategy (codes 13, 16, 30, 72). As one strategy expert noted, "narrative pre-positioning", which is appearing credible before performance data is fully ready, was seen as a deliberate goal.

External market pull was frequently mentioned in terms of anticipated demand (especially in Germany and the Netherlands), infrastructure maturity, and the relative lack of competitors (codes 24, 27). Interviewees also highlighted the importance of leveraging existing relationships, with six participants specifically mentioning “land and expand” strategies (code 32). Institutional push included the drive to engage with standard-setters like DNV or AMP, seen not just as a compliance goal but a means to future-proof the firm’s offer (code 61).

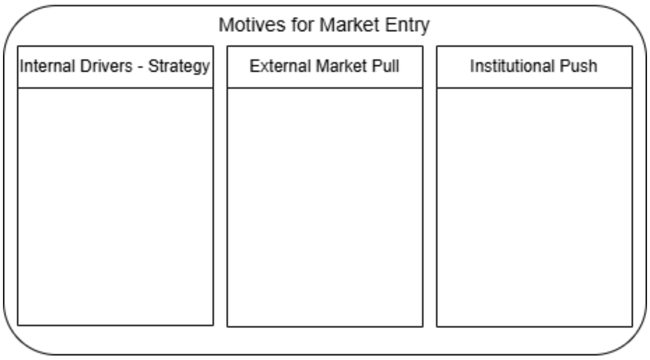


Figure 15: Motives for Market Entry

Entry Barriers

Third, the entry barriers have been reconceived not as a fixed threshold but as a conditional, firm-specific filter. Their representation in a dotted-line box indicates that they are emergent, variable, and often shaped by the firm’s own capabilities. In this model, entry barriers do not prevent action outright but instead influence which strategies are viable for which firms under specific conditions. Interview findings confirmed that such barriers are not uniform across the industry, but experienced differently depending on internal maturity and organisational framing. All nine interviewees cited challenges related to technical readiness, particularly the lack of hydrogen-specific testing standards and the absence of scalable performance validation infrastructure (codes 60, 96, 97). One technical expert put it plainly: “we don’t currently have infrastructure to simulate full-scale application,” illustrating the operational nature of this constraint. Regulatory ambiguity also emerged clearly in six interviews, with participants unsure whether compliance would ultimately be guided by DNV, national agencies, or evolving industry norms (codes 61, 62). Importantly, barriers are not only external. Several interviewees described internal doubt, particularly scepticism about whether hydrogen-specific coatings are even necessary, as a source of strategic paralysis (code 11).

These observations validate the framework’s conceptual shift: “opportunities” and “challenges” have been removed as universal categories and instead embedded contextually in motives, barriers, and capabilities. For example, a pending regulatory change may be a constraint for one firm, but a strategic advantage for another with prior exposure or technical agility. By integrating these dynamics, the framework avoids oversimplification and better accounts for how firms interpret and respond to uncertainty in a capability-dependent way. This influence is visualised in the framework through the arrows leading into the Entry Barriers component. A solid arrow from the Contextual Factors indicates that external dynamics shape the nature and relevance of barriers, while a dotted arrow from Firm Capabilities reflects that internal strengths or gaps condition how those barriers are interpreted and managed.

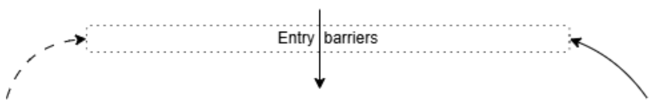


Figure 16: Entry Barriers

Contextual Factors

Second, the contextual factors have been made more explicit. The model continues to distinguish between firm-level, industry-level, and market-level contextual factors. However, these elements are no longer treated as static inputs. In this version, they are explicitly conceptualised as dynamic and interdependent, meaning that changes in one domain can influence or amplify developments in the others. For example, firm-level readiness may be shaped by evolving industry norms, while market developments can feed back into both. This interdependence was repeatedly supported in the interviews. Internally, uncertainty was reflected in knowledge gaps (code 20), organisational silos (code 16), and unclear strategic alignment (code 73), while several interviewees noted that hydrogen is still not treated as a formal strategic segment, creating tension in prioritisation and resourcing (Memo: Market Category Ambiguity). At the industry level, stakeholders described customer conservatism, the influence of EPCs, and applicator veto power as significant but under-recognised forces (codes 4, 2, 50). Market-level ambiguity, especially regarding the timing and regional concentration of hydrogen projects, compounded this sense of strategic instability. To capture this fluidity, the model introduces uncertainty as an overarching condition, visually surrounding the contextual domains. It reflects the fact that firms do not make decisions in isolation from change, but continuously interpret and respond to shifting regulatory, technical, and commercial environments.

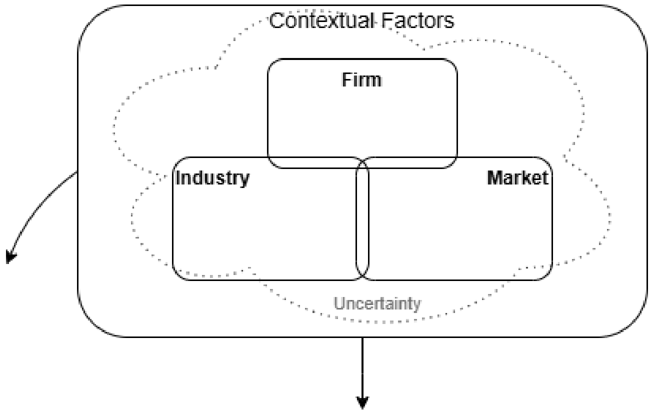


Figure 17: Contextual Factors

Firm Capabilities

Fourth, the capability component has been expanded to reflect the findings from the interviews. In the first iteration, strategic capabilities were primarily associated with relational aspects such as stakeholder engagement and external positioning. However, as the interviews progressed, a broader range of internally focused competencies emerged, including cross-functional coordination, commercial readiness, and innovation agility. These capabilities were more appropriately grouped under the strategic category, prompting a redefinition of what strategic capability entails in this context. As a result, a new and distinct category, relational capabilities, was introduced to specifically capture the outward-facing elements of ecosystem engagement, collaboration, and institutional presence. This adjustment enables the framework to better distinguish between the firm's internal operational strengths and its ability to position itself externally for influence and access.

The capability component now distinguishes between four categories: technical, regulatory, strategic, and relational (Figure 18). Interview data validated this categorisation. All interviewees emphasised the importance of technical validation, particularly the need for hydrogen-specific product testing and performance assurance (code 17), but also acknowledged a deployment gap due to lack of simulation facilities (Memo: Technical and Operational Uncertainty). Regulatory capabilities, such as early engagement with DNV or AMP, were seen not only as compliance mechanisms but as ways to influence emerging standards (code 35). Strategic capabilities were frequently discussed, including internal coordination (code 11), commercial readiness (code 18), and speed to market (code 19), especially in response to fragmented customer demands. Relational capabilities, highlighted in nearly every interview, refer to the firm's embeddedness in external networks. These include participation in JIPs, collaboration with EPCs, and alignment with third-party testing institutes (codes 26, 40, 42). One sales expert captured the strategic value of such partnerships succinctly: "collaborating with customers and independent testing institutes adds technical credibility."

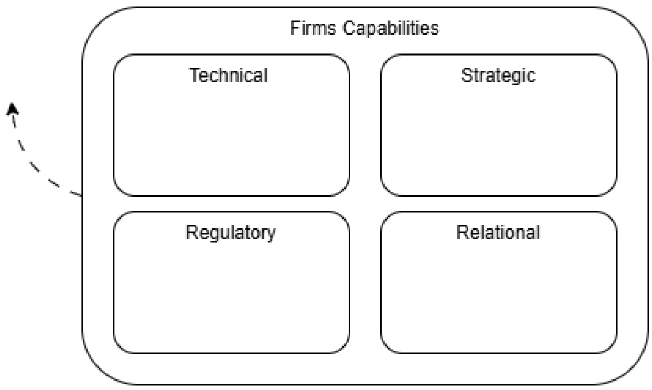


Figure 18: Firm Capabilities

Strategic Market Entry

Fifth, the central Market Entry Strategy block has been unpacked into four dimensions: entry mode, entry pace, entry scope, and adaptation and learning. This change was driven by interview findings that revealed firms do not view market entry as a single decision but as a configuration of interdependent choices. Strategy varies not only in content, but in form, speed, and timing. Some firms prioritise fast-track testing and early visibility, while others adopt a cautious, phased approach aligned with regulatory developments. The interdependency of these choices is illustrated by the overlapping within the strategic market entry box.

The new structure captures these differences through distinct yet related components. Entry mode reflects whether firms act independently, pursue co-development, or rely on existing client relationships. Pace addresses the speed of entry, from rapid iteration to wait-and-see approaches. Scope refers to the scale of engagement, ranging from narrow pilot projects to broad, multi-market positioning. Adaptation and learning, included as a cross-cutting element, acknowledges that entry is not linear but evolves through testing, feedback, and institutional sensing. By structuring strategy in this way, the framework better reflects how firms actively design their approach under uncertainty.

These four dimensions were clearly supported by interview data (Figure 19). Entry mode varied from leveraging existing client relationships (code 32) to joint development initiatives with external partners (code 43). Entry pace was also differentiated: while some interviewees supported fail-fast piloting and rapid iteration (code 45), others described a more deliberate, phased approach, closely tied to regional policy developments and client expectations. Entry scope was discussed both geographically, focusing on early mover countries such as Germany and the Netherlands, and functionally, including segment-specific targeting (e.g., transmission pipelines vs. distribution). Adaptation and learning emerged as a recurring strategic mindset. One technical stakeholder summarised this well: "we need to treat this as an experiment, test, fail, learn." This validated the inclusion of learning as a formal component of the strategy layer.

These strategic configurations are shaped by both internal capabilities and external conditions. The framework reflects this dual influence through arrows from Firm Capabilities and Contextual Factors into the Market Entry Strategy block, signalling that strategic choices are contingent upon what a firm can do internally and what the external environment demands or enables.

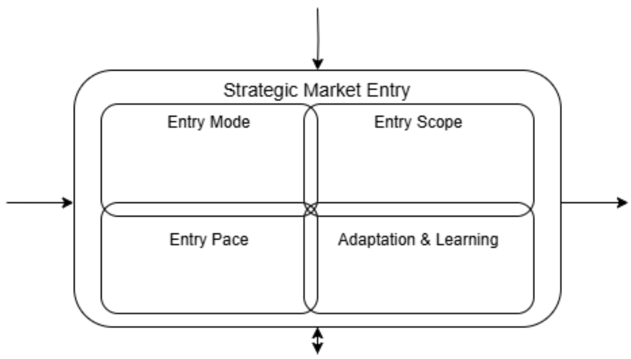


Figure 19: Strategic Market Entry

Firm-Level Outcomes and Feedback Loops

Finally, the outcome component has been refined to distinguish between short-term and long-term firm-level outcomes. This distinction was introduced to reflect that market entry is not a one-time success or failure event, but a process that unfolds over time and generates different forms of impact. Short-term outcomes may include product validation, inclusion in project specifications, or increased internal visibility, while long-term outcomes relate to positioning effects such as preferred supplier status, regulatory influence, and capability enhancement. These temporal layers are essential to understanding how firms evaluate the effectiveness of their entry approach and adjust accordingly.

Outcomes are divided accordingly in the framework (Figure 20), and this distinction was confirmed in the interviews. Short-term outcomes, such as test pilots, specification wins, and visibility in early tenders, were frequently cited as initial success criteria (codes 80, 83, 86). As one interviewee noted, even being included in a public tender process was seen as a "proof point" for internal teams. Long-term outcomes, including preferred supplier status and increased market influence, were often described as strategic aspirations, important but dependent on early execution and credibility-building (codes 82, 84, 87).

Most significantly, interviewees emphasised that these outcomes influence not only how success is measured, but also how future strategies are developed. Seven respondents described how the results of pilots or missed commercial opportunities had changed internal priorities, sometimes accelerating investment, sometimes introducing caution. This empirical pattern justifies the inclusion of two feedback loops in the model: one from outcomes to capabilities (e.g., renewed focus on testing infrastructure after failure), and one to strategy (e.g., pacing adjustments based on regulatory or customer feedback). These dual loops reflect that firms adapt not only what they do, but how they structure themselves in response to evolving entry dynamics.

The influence of outcomes is visualised through a dotted and a normal arrow feeding back into both the Firm Capabilities and Market Entry Strategy components. This emphasises that learning is not incidental, but structurally embedded in the framework. Strategic adaptation and capability development are not sequenced events, but ongoing processes triggered by what firms achieve, or fail to achieve, through their entry attempts.

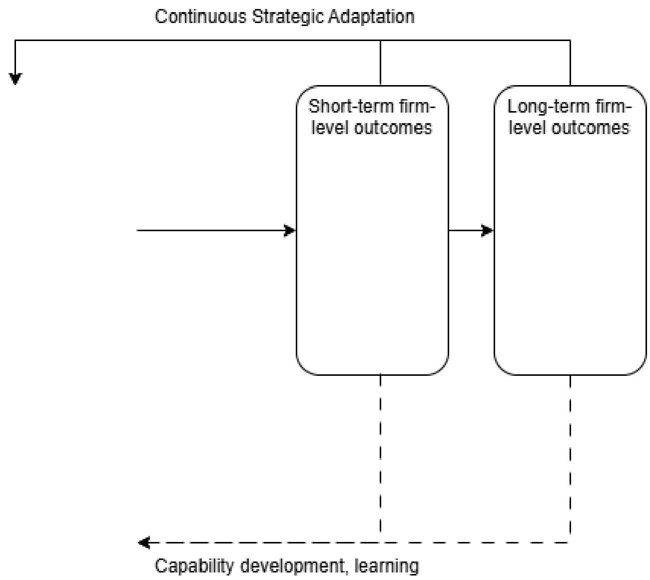


Figure 20: Firm-Level Outcomes and Feedback Loops

The third iteration of the framework serves both as a representation of the findings and as an analytical lens for interpreting future cases. It does not prescribe a specific strategy, nor does it aim to predict firm performance. Instead, it offers a structured way to analyse how different configurations of context, capability, and intent produce different strategic outcomes. The framework is therefore both explanatory and generative, providing a basis for further exploration in the next section, where the framework is applied with empirical data to identify concrete patterns of firm behaviour in the hydrogen market.

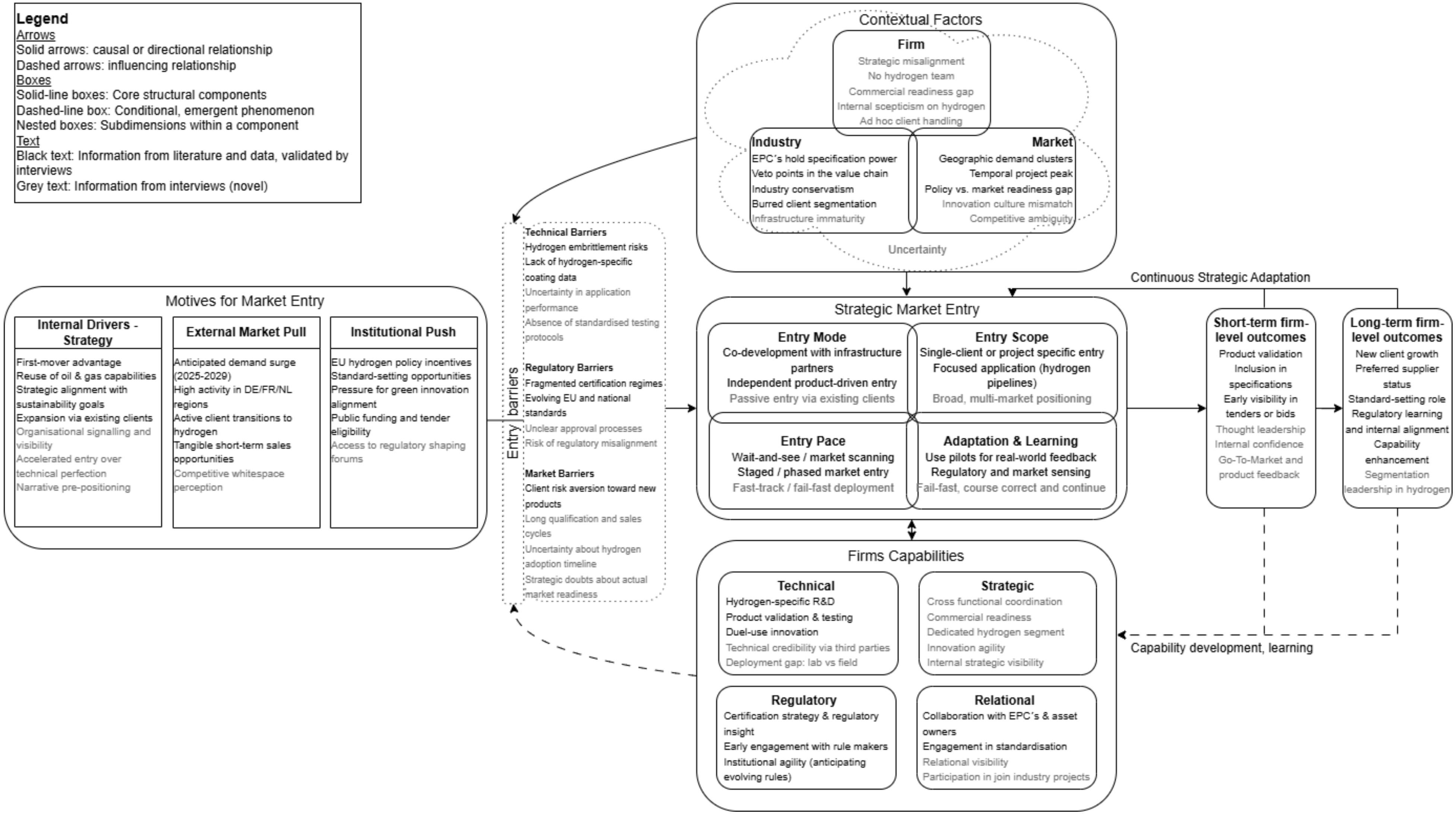


Figure 21: Application of the Market Entry Framework with Empirical Data

5.2 Application of the Market Entry Framework

This section applies the Market Entry Framework introduced in Section 5.1 by populating each of its components with empirical data gathered during the interview phase. The purpose is to demonstrate how the framework functions as an analytical tool: it allows for a structured interpretation of the factors influencing strategic market entry, while also highlighting where variation and adaptation occur. Each component of the framework is revisited below with an explanation of how it has been populated and structured. Where relevant, a distinction is made between validated insights, those supported by both literature and interview data, and novel insights, which emerged exclusively through the interviews.

Motives for Market Entry

The first component, Motives for Market Entry, is subdivided into three categories: internal drivers, external market pull, and institutional push (Figure 22). Internal drivers include validated motives such as first-mover advantage, reuse of oil and gas capabilities, strategic alignment with sustainability goals, and expansion via existing clients. These reflect proactive positioning and continuity with legacy operations. Interview data revealed several novel motivations. For instance, firms frequently referred to "organisational signalling and visibility" as a way to be part of the hydrogen narrative early, regardless of actual readiness (code 13, 16, 30). A related novel insight was the preference for accelerated entry over technical perfection, particularly among firms aiming to learn through early exposure (code 41). Lastly, "narrative pre-positioning" emerged as a distinctive strategic move, where firms deliberately shaped their perceived role in hydrogen markets before being able to demonstrate technical superiority.

External market pull is dominated by validated insights: an anticipated demand surge for hydrogen infrastructure (especially 2025–2029), concentration of project activity in Germany, France, and the Netherlands, and observable client transitions to hydrogen. Several respondents noted concrete short-term sales opportunities, often tied to pilot projects or adjacent asset types (codes 15, 26, 37). One novel insight in this domain is the notion of "competitive whitespace perception," where firms sensed a strategic window due to a lack of visible rivals, a perception that influenced their entry timing.

Institutional push also drew largely from validated inputs. EU policy incentives, standard-setting forums, and public funding mechanisms were consistently cited as motivations. Novel insight was added in the form of "access to regulatory shaping forums," where several firms engaged not for immediate commercial returns but to remain close to evolving rules (code 61, 35). This proactive stance was often taken by firms with stronger relational and regulatory capabilities.

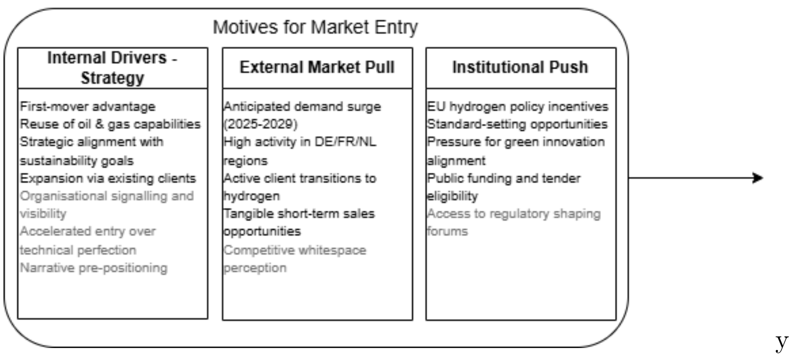


Figure 22: Populated Framework Component: Motives for Market Entry

Entry Barriers

The second component, Entry Barriers, captures the firm-specific constraints that condition whether, how, and at what pace market entry is feasible. In the updated framework (Figure 23), barriers are not treated as static thresholds, but as contingent and shaped by a firm's internal capabilities and external positioning. They are subdivided into technical, regulatory, and market barriers, and each type includes both validated and novel elements derived from the interviews.

The validated technical barriers include hydrogen embrittlement risks and a general lack of hydrogen-specific coating performance data (codes 95, 96). These gaps limit a firm's ability to make credible product claims or gain specification access. Novel technical challenges emerged as well: firms expressed concern over the absence of standardised testing protocols, especially for pipeline use cases, and uncertainty about how coatings would perform in real-world hydrogen exposure scenarios (code 97). One technical expert stated, "We know how it works in theory, but no one's tested it at scale under actual field conditions."

Regulatory barriers also included a mix of validated and novel constraints. Fragmented certification regimes, both between countries and between industrial segments, were mentioned frequently. Evolving EU and national standards, and unclear approval processes, were seen as destabilising factors (codes 62, 63). A novel and more nuanced insight was the perceived risk of regulatory misalignment (code 66), firms feared investing in solutions that might later be excluded by updated specifications or regional preferences. This made early commitment a calculated risk.

Market barriers were also present. Validated concerns included client risk aversion towards new products and long qualification cycles (code 4). Novel market challenges involved uncertainty about the actual hydrogen adoption timeline and strategic doubts about whether hydrogen pipeline coatings would ever reach mainstream specification (code 6, 9). These doubts were voiced both internally and from market-facing staff, indicating that "readiness" was not just technical or regulatory, but reputational and conceptual as well.

The influence of these barriers is shaped by both external uncertainty and internal capability. This dual dependency is reflected visually in the arrows feeding into the Entry Barriers block: a solid arrow from Contextual Factors, and a dotted one from Firm Capabilities. These connections highlight that barriers are not absolute, but relative to a firm's strategic posture and organisational maturity.

Figure 23: Populated Framework Component: Entry Barriers

Contextual Factors

The second component of the framework concerns contextual factors that shape how firms interpret the hydrogen market and develop entry strategies. These are divided across three levels, firm, industry, and market, each influenced by overarching uncertainty. This structure is reflected in Figure 24, which highlights the most frequently cited contextual dynamics.

At the firm level, all contextual insights were drawn from interviews, as these internal dynamics are not well covered in existing literature. Interviewees described multiple sources of misalignment or hesitation: strategic misalignment between business units, the absence of dedicated hydrogen teams, gaps in commercial readiness, and widespread internal scepticism about hydrogen's commercial viability (codes 11, 12, 13, 20, 73). One respondent noted that hydrogen-related activities were often "handled ad hoc" or opportunistically, which complicated long-term commitment. These insights underscore the firm-specific readiness challenges that determine whether, and how, a firm can formulate a coherent entry approach.

Industry-level factors include several validated insights. These include the central role of EPCs in shaping specification decisions and the presence of veto points throughout the value chain. Interviewees emphasised industry conservatism as a limiting force, both technically and commercially (code 4, 77). The data also revealed blurred client segmentation, many asset owners are simultaneously active in fossil and hydrogen markets, which complicates market mapping and messaging. A novel insight in this domain was the structural immaturity of the hydrogen infrastructure ecosystem itself, particularly around testing, material compatibility, and specification routines. As one interviewee stated, “There is no clear playbook, it’s like co-writing the rules while also trying to win the game.”

At the market level, several contextual dynamics were validated through both literature and interviews. These include the geographic clustering of demand in northwest Europe, particularly in Germany and the Netherlands, and the temporal project peak expected between 2025 and 2029. A consistent theme was the misalignment between policy ambition and practical readiness, including supply chain constraints and permitting delays. Two novel insights were also identified. First, many firms experienced an “innovation tempo mismatch,” where internal development speed outpaced the absorptive capacity of hydrogen clients (code 14, 17). Second, firms expressed uncertainty not only about competitors but about the existence of a competitive field at all. This sense of “competitive ambiguity” created doubt about whether the market was genuinely emerging or still speculative.

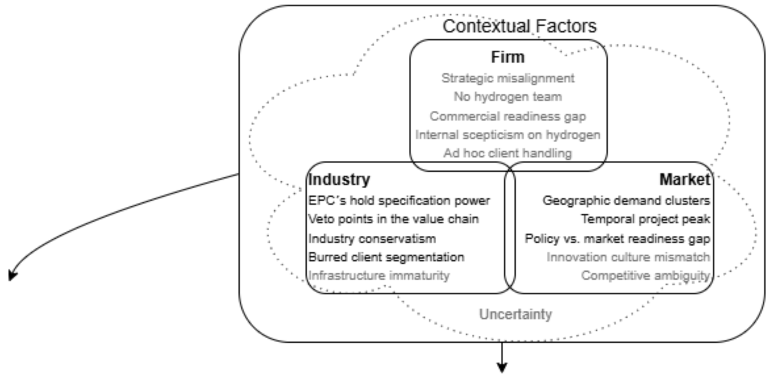


Figure 24: Populated Framework Component: Contextual Factors

Firm Capabilities

The fourth component, Firm Capabilities, is structured into four categories in the updated framework: technical, regulatory, strategic, and relational (Figure 25). These categories emerged through synthesis of literature and strong empirical validation, and they collectively describe the internal resources and organisational strengths firms leverage to engage with the hydrogen market under uncertainty.

Technical capabilities were robustly validated. These include hydrogen-specific R&D, product validation, and dual-use innovation approaches that build on oil and gas legacy knowledge (codes 17, 76). A novel capability highlighted in the interviews was the role of third-party testing institutes in enhancing technical credibility. Firms that could reference independent test data, particularly for high-risk applications, were seen as more likely to gain client trust. Additionally, a deployment gap between lab validation and field readiness was frequently mentioned. As one technical lead explained, “What works in the lab doesn’t always work at the EPC level. You need field-proven evidence.”

Regulatory capabilities were also frequently discussed. Validated elements include a clear certification strategy, early engagement with standard-setters (e.g., DNV), and institutional agility, meaning the ability to adapt quickly to evolving regulatory regimes (codes 35, 61, 64). Firms that embedded regulatory foresight into their product teams were better positioned to act ahead of new rules, rather than react defensively.

Strategic capabilities emerged exclusively from the interviews and represent a novel insight in the framework. These include cross-functional coordination, internal commercial readiness, the creation of a dedicated hydrogen segment, innovation agility, and internal strategic visibility (codes 11, 18, 19, 20). Together, these reflect the firm’s internal alignment and ability to pivot across departments. Several interviewees noted that success in early hydrogen markets was less about R&D intensity and more about aligning business units and mobilising internal decision-makers.

Relational capabilities were introduced as a new category altogether and were consistently validated. These include collaboration with EPCs and asset owners, engagement in pre-competitive standardisation forums, and participation in joint industry projects (codes 26, 40, 42, 43). These capabilities often serve as indirect enablers, helping firms gain specification access, de-risk innovation, and shape early market rules. One respondent summarised this dynamic by stating, “We don’t sell a product, we sell trust, and trust comes from being present in the room when rules are written.”

These capabilities directly influence how firms assess both barriers and strategy, which is reflected in the framework through dotted arrows from the Firm Capabilities box to the Entry Barriers and Strategic Market Entry components. This visual logic communicates that what a firm can do internally helps determine what it sees as possible externally.

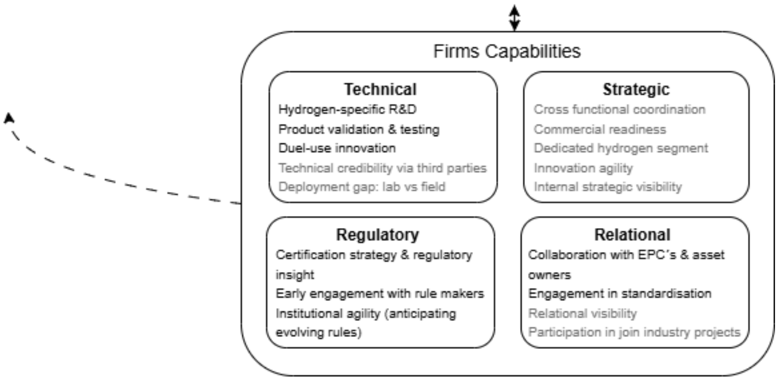


Figure 25: Populated Framework Component: Firm Capabilities

Strategic Market Entry

The fifth component, Strategic Market Entry, is structured into four interrelated dimensions: entry mode, entry pace, entry scope, and adaptation & learning (Figure 26). This disaggregation reflects the insight, strongly supported by interview data, that market entry is not a one-time decision, but a composite of strategic levers that firms configure based on capabilities, context, and perceived opportunity.

Entry mode includes both validated and novel strategies. Many firms pursued co-development with infrastructure partners or followed independent, product-driven entry routes, both of which are well-supported in literature and interviews (codes 43, 32). A novel pattern observed across multiple cases was “passive entry” via existing client relationships. This involved participating in hydrogen projects not through explicit commitment, but as an extension of existing business, without dedicated market strategy or rebranding efforts. This allowed firms to “test the waters” without internal escalation or exposure.

Entry pace also varied substantially. Validated approaches included wait-and-see strategies and phased or staged entry paths that aligned with regulatory developments or infrastructure timelines (code 78). However, a novel trend emerged in the form of “fail-fast” or accelerated entry. This was typically adopted by firms with high internal alignment and a tolerance for uncertainty. These firms used early pilots not only to gain client feedback but also to build internal momentum and demonstrate innovation leadership.

Entry scope ranged from narrow, client- or project-specific entry to ambitions for broader multi-market positioning. Validated patterns included targeted strategies, particularly around hydrogen pipelines and national flagship projects. Broader ambitions were mentioned in interviews but rarely acted on, making them more aspirational than operational. This distinction underscores how scope is often constrained not just by vision, but by capability and perceived market maturity.

Adaptation and learning was consistently cited as a core strategic principle. Validated practices include the use of pilot projects for regulatory and market feedback and the explicit integration of lessons into future product development (codes 79, 80). A novel observation was the “fail-fast, course-correct” mindset adopted by some respondents. These firms framed early market entry as a strategic experiment, with entry speed used deliberately to surface unknowns quickly, rather than to secure market share. One interviewee noted, “We treat this like R&D with commercial consequences, real clients, real learning.”

The framework represents this component as being shaped by both capabilities and contextual conditions. This is visualised through arrows entering the Strategic Market Entry box from both the Firm Capabilities and Contextual Factors components, reinforcing the view that strategy is not static, but contingent and continuously configured.

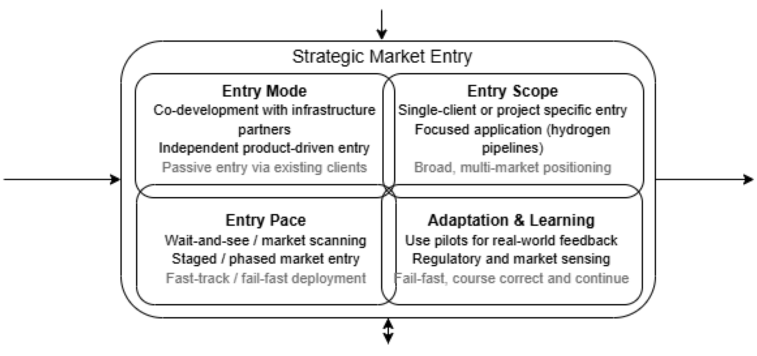


Figure 26: Populated Framework Component: Strategic Market Entry

Firm-Level Outcomes and Feedback Loops

The final component of the framework distinguishes between short-term and long-term firm-level outcomes (Figure 27). This separation reflects the understanding, validated by both literature and interviews, that market entry into hydrogen is not a binary event, but an unfolding process that produces impact over time. These outcomes not only serve as metrics of success, but also play a critical role in shaping future strategy and capability development.

Short-term outcomes were consistently validated during interviews. These include product validation, inclusion in client specifications, and early project visibility, particularly in tenders or pilot projects (codes 80, 82, 83, 86, 89). Several respondents highlighted the symbolic importance of "being seen to be active" in hydrogen as a trust signal for clients and internal stakeholders alike. Beyond these validated metrics, novel observations also surfaced. Thought leadership, increased internal confidence, and feedback loops into the go-to-market and product development processes were all named as forms of early strategic gain. One interviewee framed it as "a way to mobilise the internal machine", suggesting that external visibility generates internal momentum.

Long-term outcomes include validated effects such as client expansion, preferred supplier status, and growing influence in regulatory or standard-setting arenas (codes 81, 84, 87). Firms also described regulatory learning and capability enhancement as slow-building, but critical effects of early participation. A novel long-term ambition was also identified: becoming a segmentation leader in hydrogen coatings. Although few firms claimed to have reached this point, several saw early entry and capability-building as prerequisites for achieving this status over time.

Importantly, interviewees repeatedly emphasised that outcomes, both positive and negative, triggered internal learning and strategic recalibration. Seven respondents explicitly described how the results of pilot projects, missed tenders, or customer feedback had reshaped future decisions. These empirical insights justify the framework's dual feedback loops: one connecting outcomes to capability development, and one driving continuous strategic adaptation. This design reinforces the model's core proposition: firms do not simply act and evaluate, they learn and reconfigure.

These feedback processes are represented visually through a dashed and normal arrow looping back from the outcomes to both the Capabilities and Strategic Market Entry components. This structure highlights that learning is not a peripheral activity, but a central mechanism of strategic evolution under uncertainty.

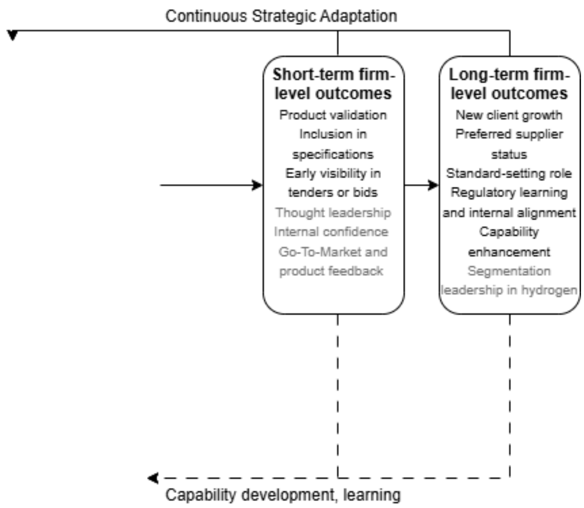


Figure 27: Populated Framework Component: Firm-Level Outcomes and Feedback Loops

5.3 Strategic Recommendation

This section translates the insights from the applied framework into a concrete strategic orientation for protective coatings firms entering the hydrogen infrastructure market. Drawing on the empirical findings and the logic of the framework components, a dynamic entry strategy is proposed, best described as *fail-fast, course-correct, and continue.* This approach reflects the reality of high uncertainty, evolving regulatory environments, and incomplete technical standards, while leveraging short feedback loops and internal learning capacity as core strategic assets.

It is important to note that this strategy is most applicable to firms that possess a certain threshold of resources, including both internal capacity and institutional positioning. Firms with established capabilities in technical validation, regulatory engagement, and relational capital are more likely to benefit from an experimental, feedback-driven approach. Conversely, firms with limited organisational alignment or strategic flexibility may first need to focus on capability development and internal readiness before adopting this posture.

The proposed strategy is also shaped by the motives, capabilities, and contextual factors identified in earlier sections. Firms that are motivated by first-mover positioning, narrative visibility, or regulatory influence may find strong alignment with a fast-paced, adaptive approach. However, success depends not only on motivation, but on a firm's ability to act within its contextual constraints. Factors such as client conservatism, vague regulatory pathways, and internal misalignment can limit what is strategically feasible. The framework emphasises that market entry must be treated as a situated decision, shaped by both ambition and constraint.

The "fail-fast" posture is not a reckless acceleration, but a deliberate tactic to surface unknowns early. Firms are advised to initiate pilot projects, seek preliminary specification access, and test assumptions in low-risk commercial environments. As highlighted in Section 5.2, several interviewees supported this approach not to gain market share, but to generate internal alignment, collect client feedback, and build credibility with ecosystem actors. In this phase, speed is a proxy for responsiveness, and technical perfection is secondary to learning velocity.

The second phase, "course-correct," is embedded in the feedback loops of the framework. Firms should use short-term outcomes, both positive and negative, as input for capability development and strategic reconfiguration. This may involve retooling product testing methods, engaging more directly with standard-setting bodies, or refining internal coordination mechanisms. The framework highlights that outcomes are not endpoints, but triggers for recalibration. One interviewee described how an early pilot failure led to a complete overhaul of their regulatory engagement strategy, a shift that ultimately unlocked access to a broader set of projects.

Finally, the "continue" phase reflects the long-term view: positioning, influence, and capability growth. Firms that persist through early friction build credibility, gain relational capital, and improve internal cohesion around hydrogen strategy. The framework's outcome component shows that these gains are cumulative and often intangible, such as being perceived as a leader, shaping regulatory debates, or becoming a preferred partner. The strategy is therefore not a linear plan, but a configuration of entry mode, pace, scope, and learning behaviour, contingent on firm-specific capabilities and evolving market signals.

As such, the framework functions as both an analytical map and a strategic compass. It does not guide firms to a fixed destination, but enables them to navigate through a dynamic and uncertain landscape in ways that are internally coherent and externally responsive.

5.4 Conclusions

In response to sub-research question 5, *"What components should a strategy for protective coatings companies entering hydrogen markets include?"*, this section outlines key strategic components grounded in empirical findings and theoretical insights. The analysis shows that successful entry into the hydrogen pipeline segment requires a multidimensional approach, combining technical validation with strategic, regulatory, and relational capabilities.

First, the strategy must include early regulatory engagement. Proactive participation in standard-setting discussions, particularly with bodies like DNV or AMP, allows firms to influence emerging requirements and align their R&D with future specifications. This reduces the risk of late-stage misalignment and strengthens credibility among asset owners and specifiers.

Second, technical readiness must go beyond lab-scale product development. Firms need to demonstrate performance under real-world pipeline conditions. This includes investment in application testing infrastructure, hydrogen-specific validation protocols, and partnerships with external testing institutes. Without these capabilities, technical claims are unlikely to translate into specification wins.

Third, strategic positioning must prioritise first-mover advantage and narrative legitimacy. In the absence of dominant standards or established leaders, perception plays a critical role. Firms that are early to test, publish, and engage in industry forums are more likely to be seen as credible, even if their technical performance is comparable to others.

Fourth, a viable strategy must be rooted in existing customer relationships. Entry pathways should emphasise expanding within known accounts and co-developing solutions with trusted partners. This reduces commercial risk, accelerates specification inclusion, and leverages relational capital that competitors may lack.

Fifth, internal strategic alignment is essential. Hydrogen should be treated as a distinct market segment, with dedicated resources, cross-functional coordination, and clear KPIs. Many of the barriers identified in this study were not technical, but organisational, they were rooted in unclear ownership, slow decision-making, or insufficient prioritisation.

Finally, sustainability integration should be built into both the product and the positioning. Customers are increasingly evaluating coatings not only on technical criteria, but on lifecycle impact and contribution to Environmental, Social and Governance (ESG) goals. Framing hydrogen coatings as enablers of system-wide decarbonisation can strengthen value propositions and justify premium pricing.

6 Conclusions and Discussion

6.1 Conclusions

The global push toward decarbonisation is accelerating investment in hydrogen as a clean energy carrier, especially within Europe's industrial and transport sectors. This shift necessitates the rapid development of hydrogen-ready infrastructure, including pipelines that must meet stringent performance and safety standards. Protective coatings firms are increasingly recognised as key enablers of this transition but they face a strategic paradox: while the opportunity is significant, the path to entry is obscured by regulatory flux, technical novelty, and an absence of established market norms. Existing strategy models offer limited guidance for firms operating in such emergent, uncertain contexts. In response to this gap, this research explored how protective coatings companies could strategically approach market entry in the hydrogen pipeline sector. Against a backdrop of policy uncertainty, technical novelty, and evolving standards, the study has adopted an abductive approach to develop and refine a market entry framework grounded in both theory and empirical insight. Drawing on literature, market data, and expert interviews, the framework highlights how internal firm capabilities interact with contextual dynamics to shape viable entry strategies.

The main research question guiding this thesis reads:

> *What strategic market entry framework can support protective coatings companies for entry into uncertain and evolving hydrogen pipeline coating markets?*

The research demonstrates that successful entry into this sector is neither a discrete event nor a uniform process. Instead, it is an evolving strategic configuration shaped by a firm's technical, regulatory, strategic, and relational capabilities. Firms that adopt adaptive approaches, characterised by early engagement, narrative positioning, and targeted learning, are better equipped to navigate market ambiguity and shape emerging opportunities.

Each sub-research question contributed to addressing this central question:

1. What are the theoretical aspects of a successful resource-based market entry strategy?
The literature has confirmed that effective market entry strategies grounded in the RBT depend on a firm's ability to mobilise internal resources that are valuable, rare, and difficult to imitate. In the context of hydrogen infrastructure, this includes proprietary technological know-how, regulatory adaptability, and the ability to build strategic alliances. These capabilities serve as the foundation for sustained competitive advantage in complex and uncertain markets.

2. What are the key challenges and opportunities for protective coatings companies entering hydrogen markets?
The analysis has revealed a dual reality. On one hand, the sector is marked by significant uncertainty, technical, regulatory, and market-based. On the other, these very conditions create space for early movers to shape the rules of the game. Companies that can respond with agility, credibility, and institutional engagement are more likely to convert uncertainty into opportunity.

3. What are the growth trajectories and segmentation opportunities within the hydrogen sector for protective coatings?
The market analysis has indicated a sharp increase in hydrogen pipeline infrastructure, with demand for coatings projected to grow sixfold in volume by 2029. This growth is not evenly distributed, but geographically clustered in regions like Germany, France, and the Benelux countries. Such temporal and regional dynamics offer clear segmentation opportunities for firms able to align their strategies accordingly.

4. What are the perceptions and expectations of industry stakeholders regarding the challenges and opportunities for market entry in the hydrogen sector?
Interviews with stakeholders have revealed that hydrogen is seen as both a strategic imperative and an internal ambiguity. While some viewed it as an opportunity to build reputational capital and shape emerging standards, others questioned the near-term relevance or commercial viability. Despite this divergence, there was strong consensus on the importance of early visibility, regulatory engagement, and ecosystem positioning.

5. What components should a strategy for protective coatings companies entering hydrogen markets include?
A viable strategy must integrate technical readiness, regulatory foresight, commercial alignment, and internal coordination. The framework developed in this thesis identifies four interrelated strategic dimensions, entry mode, pace, scope, and learning, each of which must be tailored to the firm's capability profile and market context. Success hinges on the ability to deploy these elements coherently and adaptively.

In conclusion, the findings emphasise that market entry in emerging infrastructure domains like hydrogen required more than technical readiness. It demands ongoing alignment between internal capabilities and external signals. Strategic success is not about executing a static plan, but about dynamically configuring resources in response to an evolving opportunity space. The revised market entry framework developed in this research contributes to this transition by integrating internal capability dynamics, opportunity framing, and institutional engagement into a single analytical model. It shifts the focus from generic internationalisation steps to a more adaptive, resource-oriented approach suited for high-uncertainty sectors like hydrogen.

6.2 Discussion

6.2.1 Theoretical and Practical Contributions

This thesis contributes to academic literature on strategic market entry by extending the RBT into a context marked by high uncertainty, regulatory ambiguity, and emerging infrastructure. Whereas RBT has traditionally been applied to stable or moderately dynamic environments, this research shows that its principles remain relevant, but must be reframed. In particular, the findings suggested that capabilities such as regulatory agility, ecosystem engagement, and symbolic positioning are not auxiliary, but core to strategic success in emergent markets.

A key theoretical contribution lies in the integration of capability development with market sensing and adaptation. The research demonstrates that capability deployment is not a linear process, but a recursive one, shaped by learning loops, stakeholder feedback, and evolving standards. This dynamic interplay is underrepresented in conventional RBT-applications, which often treat capabilities as static or pre-defined assets. By contrast, the framework developed here highlights the need to treat capabilities as emergent, context-dependent, and co-evolving with the market.

Furthermore, the study nuances the concept of first-mover advantage. Rather than being solely about speed or technical superiority, early entry in this context involves building legitimacy, participating in standard-setting, and becoming visible in strategic ecosystems. This challenges more deterministic views of competitive advantage and foregrounds the role of perception, narrative, and symbolic capital as strategic resources in their own right.

From a practical perspective, the research offers concrete guidance to firms operating in the coatings industry. The findings suggested that successful market entry into the hydrogen segment is contingent not only on product readiness, but also on organisational coordination, strategic clarity, and external credibility. Protective coatings firms that treat hydrogen as a marginal Research and Development (R&D) initiative rather than as a dedicated strategic domain, are likely to miss the narrow window for influence and positioning.

The framework provides a structured approach for firms to assess their readiness across four capability domains: technical, regulatory, strategic, and relational. It also clarifies the types of entry strategies available, ranging from co-development to passive alignment, and under what conditions each may be viable. Importantly, it enables firms to reflect on their current configuration and identify where internal bottlenecks or misalignments may undermine their strategic intent.

In practical terms, the study underscores the importance of early-stage visibility, internal alignment, and third-party validation. These factors emerged consistently across interviews as critical enablers of specification inclusion, credibility with end-users, and long-term market relevance. Firms that operationalise these insights, by establishing cross-functional hydrogen teams, engaging in joint industry projects, and aligning product development with anticipated regulatory shifts, are more likely to secure a foothold in this evolving market.

Taken together, the theoretical and practical contributions of this thesis suggested that the hydrogen pipeline segment is not merely a new market, but a new strategic terrain and one that rewards adaptability, influence, and embeddedness as much as technical performance.

6.2.2 Reflections on the Research Process

This thesis adopted an abductive research design to explore the complex and under-theorised domain of strategic market entry into the hydrogen pipeline coatings sector. This approach was deliberately chosen to allow iterative movement between theory and empirical data. Rather than testing a pre-defined hypothesis, the research process involved co-evolving the conceptual framework alongside empirical insights from literature, market analysis, and interviews. One advantage of this abductive strategy was its responsiveness to contextual complexity. The ability to revisit earlier assumptions, refine the model, and incorporate emergent themes proved essential given the evolving nature of hydrogen infrastructure and the lack of established academic work on this topic. The use of semi-structured interviews allowed for both validation and discovery, surfacing novel dynamics such as internal strategic misalignment and the role of symbolic positioning.

However, the abductive process also presented challenges. It demanded a high level of interpretive reflexivity, especially when moving between different types of data. Analytical decisions had to be made without the scaffolding of a strict hypothesis-testing framework, which introduced the risk of subjective bias. While memos, coding consistency, and triangulation helped to mitigate this, the process was inherently interpretive. Moreover, the fluidity of the research topic posed procedural challenges. Key interview themes evolved during the data collection phase, and stakeholder opinions were not always aligned with the formal structures of the organisation. As a result, insights had to be situated not only within strategic roles but also within broader organisational narratives and tensions. This required balancing methodological structure with openness to unexpected findings.

Overall, the research process reflected the very characteristics of the domain it studied: uncertain, iterative, and shaped by emergent learning. These characteristics enriched the analysis, but also necessitated careful judgement in the synthesis and presentation of findings.

6.2.3 Limitations of the Research Design

Despite its strengths, this research was subject to several limitations. First and foremost, the empirical base was largely limited to a single case company and a small number of expert interviews. While participants were selected to represent a broad range of functions, the insights remained context-specific. The conclusions may therefore not be fully transferable to other firms with different organisational cultures, market strategies, or regional orientations. Also, the interview data was subject to limitations of access and openness. Certain organisational dynamics, such as internal scepticism, capability gaps, or political tensions, may have been downplayed by participants or remained invisible to the researcher. In addition, the research did not include external stakeholders such as EPC contractors, regulators, or customers, whose perspectives could have enriched the analysis and validated firm-side assumptions.

Second, the hydrogen sector itself is in flux. Many of the infrastructure projects and policy signals discussed in this thesis are still in planning phases or lack full regulatory clarity. As such, parts of the framework, especially those related to timing, specification dynamics, and opportunity sizing, rely on projections that may shift over time. This temporal volatility limits the stability of some of the conclusions and suggested that any strategy developed using this framework must be regularly updated.

Finally, while this study employed both qualitative and quantitative data sources, the quantitative component, primarily drawn from literature and market data, was limited in scope. These sources were used to validate general trends, inform the conceptual model, and guide the design of the interview phase. However, the market data itself was largely based on planned infrastructure projects and did not permit rigorous statistical analysis. As a result, the framework developed in this thesis remained largely exploratory. Its predictive validity and broader applicability would benefit from further testing using more extensive and systematic quantitative methods across diverse organisational contexts.

In light of these limitations, the framework presented in this thesis should be seen as a generative tool for reflection and strategy design, not as a prescriptive model with universal applicability.

6.2.4 Recommendations for Future Research

This research was situated within the abductive stage of the research cycle, iterating between empirical observations and theoretical concepts to refine a context-sensitive framework. As such, its findings and limitations provide a grounded basis for further theoretical development. The findings of this thesis open up several avenues for future research, particularly given the evolving nature of both the hydrogen sector and strategic responses to it. While the developed framework provides a structured lens for analysing market entry, its context-specific nature and qualitative foundation leave important questions for further investigation.

First, future research could apply the framework to other firms within the coatings industry or adjacent sectors, such as pipeline manufacturers or hydrogen storage providers. Comparative case studies could assess whether the same capability configurations and strategic dynamics hold in different organisational or national contexts. This would help determine the extent to which the framework captures generalisable mechanisms or is contingent on firm-specific factors.

Second, a valuable extension would involve quantitative validation. Survey-based studies or structured data collection across a broader sample of firms could be used to statistically test the relationship between specific capabilities, such as regulatory engagement or cross-functional alignment, and observed entry outcomes. Such validation could draw on advanced quantitative techniques frequently applied in strategic and operational management research, including structural equation modelling (Kolagar & Hosseini, 2019; Sarstedt et al., 2022), multiple criteria decision-making methods (Kolagar et al., 2021; Yasmin et al., 2020), and fuzzy-based configurational approaches (Kolagar et al., 2024; Pappas & Woodside, 2021). These methods offer nuanced insights into causal pathways and configurational dynamics, and would significantly enhance the empirical robustness and predictive potential of the proposed framework.

Third, long-term research could examine how firms adapt their strategies over time as the hydrogen market matures. Such studies would provide insights into how early-stage entry strategies evolve, whether initial first-mover advantages persist, and how firms respond to the eventual formalisation of technical standards and regulatory regimes.

Fourth, future studies might explore customer-side perspectives in more detail. Including EPC contractors, pipeline owners, and regulators could provide a more holistic view of specification dynamics, risk preferences, and procurement processes. This would help validate the relational and institutional aspects of the framework from the demand side.

Fifth, there is room for further theoretical refinement. While this thesis integrates the RBT with strategic market entry literature, future work could incorporate perspectives from institutional theory, signalling theory, or behavioural strategy to explore how firms navigate uncertainty and build legitimacy in pre-structured markets.

Finally, given the novelty and fluidity of the hydrogen economy, exploratory research in other segments, such as storage, mobility, or ammonia-based transport, could reveal whether the strategic principles outlined here apply more broadly. These sectors may face different technological and institutional constraints, and comparing entry strategies across them could contribute to a more comprehensive theory of market entry in transitional energy systems.

In sum, this thesis provides a foundation, but not a final word. As the hydrogen sector develops, so too must the analytical tools used to study it. Future research will play a critical role in refining, challenging, and extending the insights presented here.

6.2.5 Recommendations for Protective Coating Firms

The findings of this thesis offer not only theoretical contributions, but also a practical foundation for strategic reflection and decision-making within protective coating firms. The Market Entry Framework developed and applied in this study can be used as a diagnostic tool to structure internal discussions, identify strategic blind spots, and assess organisational readiness for entering the hydrogen infrastructure market.

There is a compelling strategic case for entering this market now. The hydrogen sector presents not only a massive infrastructure investment opportunity due to its expected scale and policy momentum, but also a rare chance to shape the market from the outset. In emerging sectors like this, being among the first can lead to outsized returns, both in direct revenue and in long-term positioning. Firms that secure early influence often gain specification access, preferred supplier status, and brand legitimacy, advantages that are much harder to obtain once the market stabilises.

Firms are advised to use the framework iteratively, revisiting each component, motives, entry barriers, contextual factors, capabilities, strategic choices, and outcomes, as their internal and external environments evolve. Rather than treating market entry as a fixed decision point, the framework encourages firms to view it as an ongoing process of interpretation, configuration, and adaptation. This is particularly important in transition markets like hydrogen, where standards, client expectations, and policy landscapes remain in flux.

In particular, firms with sufficient internal alignment and resource flexibility are recommended to adopt a strategic orientation best described as *fail-fast, course-correct, and continue*. This approach reflects the realities uncovered in the interviews: that early-stage entry is not primarily about capturing market share, but about accelerating organisational learning, building credibility, and shaping ecosystem rules. It requires a willingness to test assumptions through pilot projects, learn from imperfect outcomes, and revise strategies in response to feedback. Firms with established technical, regulatory, and relational capabilities are especially well positioned to benefit from this adaptive strategy.

By engaging with the framework in a structured way, firms can better understand not only whether to enter the hydrogen market, but how to do so in a manner consistent with their capabilities, motives, and risk tolerance. This thesis therefore functions as both a lens for analysis and a guide for action, offering a grounded, flexible, and empirically informed approach to navigating market entry under uncertainty.

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Note: AI-assisted tools (e.g., ChatGPT) were used during the thesis development process to support language refinement, formatting, and idea structuring. All academic content, interpretations, and conclusions reflect the work and responsibility of the researcher.

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A Hydrogen Market Analysis

This appendix presents the detailed findings of the hydrogen market analysis that supports the development of the strategic framework outlined in the main thesis. The objective is to map the growth trajectories, regional investment trends, and coatings demand projections associated with the rollout of hydrogen infrastructure in Europe. These insights complement the theoretical and empirical findings presented in Chapters 4 and 5 and serve as an evidence base for the interview phase and strategic recommendations.

Limitations of the Data

While the datasets used provide valuable insights into the growth trajectory and infrastructure planning for hydrogen in Europe, they also come with important limitations. The market projections are based on internal industry data derived from strategic planning and historical trends, which means they reflect expected developments rather than guaranteed outcomes. As such, they may not fully account for unexpected regulatory, geopolitical, or technological shifts that could accelerate or delay market growth.

The project-level data includes publicly and commercially available information on planned hydrogen infrastructure across Europe. However, these projects are not confirmed executions; they represent intentions and proposals that are subject to change. Many are in early development stages and may face delays, re-scoping, or even cancellation depending on investment conditions, permitting, or broader policy changes. This means the timing and volume of actual infrastructure deployment, and therefore coating demand, may deviate from what is represented in the data. Additionally, the database includes only announced projects, excluding those that are still confidential or not publicly disclosed, which may result in an underrepresentation of future activity. These limitations were considered throughout the analysis and interpretation of findings.

Role of Hydrogen

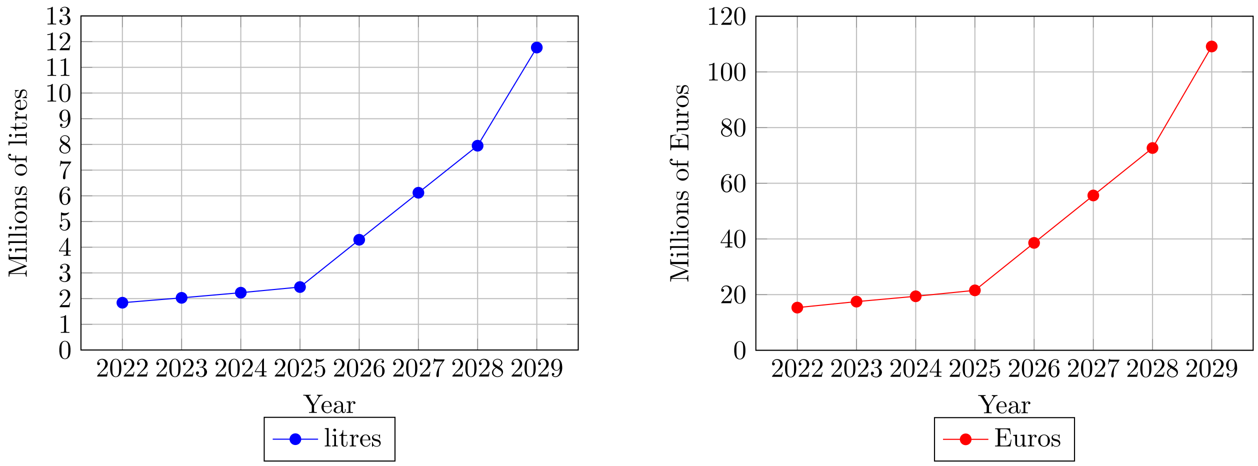
Hydrogen is emerging as a critical enabler of the global energy transition, particularly in sectors that are difficult to electrify. As fossil fuel use declines and renewable electricity becomes more widespread, hydrogen offers a versatile pathway for storing, transporting, and applying clean energy across industrial, transport, and power sectors. According to the IEA, global hydrogen demand reached 97 million tonnes in 2023, yet low-emissions hydrogen accounted for less than 1 Mt of that total International Energy Agency, 2024. This underlines the early stage of deployment, but also the scale of untapped potential. Despite this limited baseline, the trajectory is clear. Announced low-emissions hydrogen projects are accelerating, supported by evolving policy frameworks and increasing investment confidence. Final investment decisions already made could enable a fivefold increase in production by 2030, rising to over 4 Mt annually. Electrolyser capacity, which underpins green hydrogen production, has scaled from just above 1 GW to 20 GW globally, with further expansions in the pipeline International Energy Agency, 2024. In its Energy Transition Outlook 2024, DNV forecasts that hydrogen and its derivatives will account for approximately 4 percent of global final energy demand by 2050, with Europe leading adoption and potentially reaching 7 percent under favourable regulatory and technological conditions DNV, 2024.

This projected growth is driven by hydrogen's ability to decarbonise sectors such as steel production, heavy-duty transport, shipping, and aviation, where direct electrification remains challenging. Moreover, hydrogen can act as a seasonal energy storage medium and grid-balancing mechanism, supporting the integration of intermittent renewables like wind and solar. However, unlocking this potential hinges on the rapid deployment of enabling infrastructure, most notably hydrogen pipelines. According to the IEA, pipelines are the most efficient and least costly method for transporting hydrogen over distances up to 2,500 to 3,000 km, especially when repurposing existing natural gas pipelines International Energy Agency, 2024. This infrastructure is essential for connecting production sites with industrial users and storage facilities.

Market Size and Growth Trends

The first internal dataset revealed that the European hydrogen pipeline coatings market is projected to grow rapidly between 2022 and 2029, both in physical volume and total value. In 2022, the market size was 1.84 million litres and €15.33 million. By 2029, this is expected to rise to 11.77 million litres and €109.13 million, which can be seen in Figure 28. This substantial increase reflects the growing role of hydrogen in the European energy mix and the corresponding need for dedicated infrastructure, including pipeline networks that require durable and compliant protective coatings. Throughout this period, the market shows a compound annual growth rate of 30 percent in volume and 32 percent in value. This alignment between volume and monetary growth indicates that the market expansion is driven primarily by increased project deployment, rather than significant changes in pricing. The price per litre remains relatively stable, increasing incrementally from €8.33 in 2022 to €9.28 in 2029. This modest upward trend of just over 11 percent across seven years indicates pricing consistency amid rising demand. This price stability suggests a consistent technical and regulatory standard across the industry, likely driven by maturing supply chains and converging requirements for hydrogen transport applications.

The steepest acceleration in demand occurs after 2025. In 2026 alone, the market volume grows by nearly 75 percent compared to the previous year, followed by continued double-digit growth: 42.8 percent in 2027, 30 percent in 2028, and 48 percent in 2029. This surge is mirrored in market value, where year-over-year growth exceeds 50 percent in 2029, reinforcing the scale of financial investment required. These growth rates reflect not only policy momentum but also the transition of project pipelines from planning to implementation. The timing of this spike corresponds with anticipated investment cycles in hydrogen production and transport infrastructure, following policy commitments under initiatives such as REPowerEU and various national hydrogen strategies.



(a) Projected coating volume

(b) Projected market value

Figure 28: Projected demand for hydrogen pipeline coatings in Europe made from internal datasets(volume and value)

Together, these developments position hydrogen pipeline coatings as a distinct high-growth segment within the European protective coatings industry. The outlook through 2029 reveals both the scale of opportunity and the importance of aligning product offerings with the specific technical and timing requirements of this emerging market.

Hydrogen Project Landscape in Europe

The second internal dataset revealed that the European hydrogen project pipeline consists of 253 identified initiatives, representing a total planned investment of approximately $9.1 billion. This reflects a considerable commitment across the region to scale up hydrogen infrastructure, of which pipelines are a central component. The size and timing of these projects offer a valuable proxy for forecasting demand for specialised protective coatings.

Germany accounts for the largest national share, with 102 projects totaling over $3 billion in expected investment. This is followed by France and Belgium, with 36 and 24 projects respectively, both exceeding $900 million in value. Notably, several mid-sized countries such as Portugal and Romania also report substantial individual project values despite fewer initiatives, indicating the presence of large-scale infrastructure undertakings. This concentration of activity in key industrial economies highlights the geographical hotspots where coating demand is likely to intensify in the coming years.

Temporal analysis of project timelines reveals two important dynamics. First, the number of projects scheduled for completion peaks between 2025 and 2026, suggesting a surge in infrastructure rollout during this period. From 2027 onward, completion rates decline, but this does not imply reduced activity. Rather, it reflects the long lead times of large hydrogen projects—many of which begin operation earlier but continue into the next decade. This is corroborated by an analysis of live projects per year: the number of active hydrogen projects grows steadily from 110 in 2022 to a peak of 242 in 2025, before gradually tapering to 30 by 2029. This pattern illustrates the cumulative nature of operational capacity and emphasises the sustained demand for coatings during early-stage infrastructure deployment.

In addition to total project count and investment value, projects were categorised into small, medium, and large based on investment size. This reveals notable variation in the composition of hydrogen project portfolios across countries. For instance, while Germany and France lead in absolute volume, they also show a balanced mix of project sizes. In contrast, countries like Romania and Portugal, despite a smaller number of initiatives, are disproportionately represented by large-scale projects. This variation has implications for supply chain planning, coating volume forecasts, and the timing of technical engagement.

Summary and Implications

The hydrogen pipeline coatings market in Europe is positioned for rapid expansion, both in scale and timing. Between 2022 and 2029, demand is projected to grow sixfold in volume and more than sevenfold in value, supported by stable pricing and consistent technical specifications. This trajectory reflects a shift from early-stage experimentation to full-scale infrastructure rollout. The steepest acceleration occurs after 2025, aligning with national and EU-level policy timelines and investment frameworks.

From a geographical standpoint, Germany, France, and Belgium lead both in the number of projects and in total investment. However, countries such as Romania and Portugal also demonstrate disproportionately high project value relative to project count, suggesting the presence of large-scale, strategic installations. An additional breakdown of projects by investment category, small, medium, and large, reveals that national portfolios vary not only in quantity but also in project scale, further refining expectations for supplier capacity and engagement scope. The geographical distribution points toward regional clusters of demand concentration, relevant for supply chain planning and customer targeting. The timing of project completions and live operations confirms that the critical window for coatings demand will emerge between 2024 and 2026. Projects initiated earlier in the decade come online during this period, while investment continues in parallel for projects completing toward the end of the 2020s and early 2030s. This creates a time-bound opportunity for market entry and product positioning.

These findings directly informed the formulation of interview questions, particularly those aimed at validating market expectations, timing assumptions, and regional focus areas. They also form a basis for the strategic recommendations presented later in the thesis, grounding future-oriented decisions in the concrete realities of market growth, infrastructure development and national investment patterns.

B Interview Set-up

This appendix outlines the design process behind the interviews conducted to address Sub-Research Question 4 (SRQ4): *What are the perceptions and expectations of industry stakeholders regarding the challenges and opportunities for market entry in the hydrogen sector?*

The interviews represent a key phase within the abductive research process, complementing the literature analysis and hydrogen market analysis presented in earlier chapters. While prior chapters helped establish a theoretical and data-driven understanding of market entry conditions, the interviews were designed to gather practice-based insights from professionals. These semi-structured conversations provided a deeper view into how internal stakeholders perceive barriers, opportunities, and strategic priorities related to hydrogen pipeline coatings.

Purpose

The interviews conducted in this study serve as a central qualitative component within the abductive research design. They are specifically aimed at addressing Sub-Research Question 4 (SRQ4). While earlier chapters established a theoretical and data-driven understanding of market dynamics, the interviews were designed to explore how these dynamics are interpreted by stakeholders with first-hand experience. In doing so, they contribute empirical depth to a framework that otherwise risks remaining abstract or detached from practical realities.

The interviews were intentionally designed to serve a dual function. First, they had a deductive role, validating key insights from the literature, such as the importance of internal capabilities (e.g., R&D, regulatory adaptability, strategic partnerships) as identified in the Resource-Based Theory (RBT) framework. Second, they fulfilled an inductive purpose: uncovering unexpected themes, strategic uncertainties, or organisational nuances not yet captured through literature or market data. This dual role aligns directly with the abductive methodology adopted in this research.

Development of Interview Questions

The development of the interview questions followed an abductive logic, integrating insights from both theory and empirical data. The guiding framework was the RBT, which emphasises the strategic importance of firm-specific resources and capabilities in achieving competitive advantage in uncertain markets. This foundation was combined with findings from the hydrogen market, including regional disparities and project timelines. The questions were therefore structured to both test and extend existing knowledge.

Each question was mapped to a category aligned with the conceptual model: internal capabilities, perceived challenges, opportunities, regional differences, strategic partnerships, and success expectations. Role-specific questions were developed to target functional expertise across R&D, strategy, product management, and sustainability.

Table 6: Breakdown of Interview Questions: Origin, Purpose, and Analytical Role

#	Question	Theme	Derived From	Purpose	Deductive / Inductive
1	What internal capabilities or resources do you believe are most critical for Hempel to succeed in the hydrogen pipeline market?	Internal Capabilities	Trindade et al. (2023), Beamish & Chakravarty (2021)	To identify internal enablers (e.g. R&D, regulatory insight, partnerships)	Deductive
2	Are there specific knowledge areas, technologies, partnerships, or systems that differentiate us in this context?	Internal Capabilities	Chang et al. (2022), Donnelly et al. (2023)	To identify sources of competitive advantage	Deductive
3	How is Hempel building or adapting its technical and commercial resources to meet the needs of hydrogen infrastructure?	Internal Capabilities	Chang et al. (2022), Donnelly et al. (2023)	To explore dynamic capabilities in action	Inductive

Continued on next page

Table 6 – continued from previous page

#	Question	Theme	Derived From	Purpose	Deductive / Inductive
4	From your perspective, what are the biggest challenges Hempel faces in entering the hydrogen pipeline coatings market in Europe?	Perceived Challenges	Rahman et al. (2017), Corsatea & Giaccaria (2018)	To explore perceived internal and external barriers	Inductive
5	What specific technical or regulatory hurdles make this sector difficult to serve?	Perceived Challenges	IEA (2023), OPSD (2024)	To confirm sector-specific constraints (e.g., hydrogen embrittlement, certification)	Deductive
6	What do you see as the most promising opportunities for Hempel in the hydrogen space?	Opportunities	EurObserv'ER (2023), IEA (2023)	To identify high-potential niches in hydrogen	Inductive
7	Are there niche areas where you believe Hempel has a unique advantage or could position itself strongly?	Opportunities	Stocker et al. (2022), Ahmadova et al. (2022)	To surface internal–external fit opportunities	Inductive
8	How do regional differences in Europe impact our ability to enter these markets?	Regional / Sector Differences	European Commission JRC, IEA (2023)	To examine market entry feasibility by geography	Deductive
9	Are there sectors within hydrogen that pose significantly different requirements or barriers?	Regional / Sector Differences	EurObserv'ER (2023), NREL (2023)	To identify sector-specific segmentation requirements	Inductive
10	To what extent does Hempel collaborate with external partners to strengthen our positioning in renewables?	Strategic Partnerships	Meygoonpoury et al. (2023)	To assess the role of collaboration in capability-building	Deductive
11	How important are these alliances when it comes to entering or scaling in new sectors?	Strategic Partnerships	Rahman et al. (2024), Ahmadova et al. (2022)	To evaluate the strategic impact of alliances	Deductive
12	In your view, what would successful market entry into hydrogen look like for Hempel?	Expectations of Success	Beamish & Chakravarty (2021), Donnelly et al. (2023)	To define internal benchmarks for success	Inductive
13	What capabilities or outcomes would signal that we are on the right track?	Expectations of Success	Donnelly et al. (2023), Chang et al. (2022)	To determine performance indicators for alignment	Inductive

Interview Structure and Execution

The interviews were conducted using a semi-structured format, with questions organised into clusters. Role-based adaptations ensured that participants with different expertise areas were asked relevant and meaningful questions. The interviewer retained flexibility to adapt the flow, probe emergent topics, and allow space for open-ended insights.

A total of nine interviews were conducted: eight with internal stakeholders from Hempel, and one with an external industry expert. Participants were selected through purposive sampling based on relevant experience in hydrogen strategy, coatings R&D, or market development. Interviews were held via Microsoft Teams, transcribed using its built-in transcription function, and manually reviewed for accuracy.

The sample was intentionally diverse across strategic, technical, and commercial roles, ensuring that the data reflected a broad and informed view of the company's readiness and challenges in entering the hydrogen market. Figure 6 shows the distribution of participants across functional categories.

C Interview Data

C.1 Coding Procedure

The qualitative analysis was conducted using *ATLAS.ti*, employing a hybrid coding strategy. Initial deductive codes were developed based on the literature review and conceptual framework. These were then expanded inductively as new themes emerged during transcript review. ATLAS.ti's AI-assisted suggestions were also used to cross-check, refine coding consistency and create new codes, though final decisions were researcher-led.

All codes were placed within one of ten overarching code groups, reflecting their thematic function. Sub-codes were created beneath these groupings to capture more specific insights. The process was iterative: new sub-codes were added as new content patterns were identified, and existing transcripts were revisited to ensure consistent application of evolving codes.

C.2 Codebook Structure

The following outlines the structure of the code groups and their corresponding sub-codes used throughout the analysis:

Table 7: Thematic Coding Scheme Used in Interview Analysis

#	Code / Sub-code	Grounded	Code Group
1	Industry Context	52	Contextual Factors
2	Applicator power in value chain	8	
3	Competitive landscape	12	
4	Customer risk aversion	10	
5	Government subsidy reliance	2	
6	Hydrogen maturity	9	
7	Industry fragmentation	3	
8	Pipeline ownership structure	6	
9	Slow market development pace	7	
10	Internal Capabilities	124	Firm Capabilities
11	Cross-functional alignment	13	
12	Data availability and internal visibility	12	
13	Internal communication	5	
14	IP Development and Management	4	
15	New product development process	15	
16	Organisational silos	5	
17	R&D Investment	12	
18	Resource allocation	34	
19	Speed to market / Agility	20	
20	Talent and expertise availability	35	
21	Knowledge Gaps	27	Motives and Barriers
22	Internal knowledge limitations	10	
23	Technical and regulatory understanding	23	
24	Market Opportunities	95	Motives and Barriers
25	Adjacent markets (methanol, CO_2)	9	
26	Commercial testing / Pilot projects	7	
27	Competitive whitespace	10	
28	Confusion in client needs	7	
29	Customer interest variability	8	
30	Early stage positioning	13	
31	Examples from wind sector	2	
32	Expanding existing customer relationships	9	
33	Experimental technologies	1	
34	Flow efficiency as value proposition	10	
35	Opportunity to define standards	10	
36	Pipeline repurposing projects	4	
37	Potential scale of hydrogen investments	17	
38	Partnerships	72	Firm Capabilities
39	Collaboration with pipeline manufacturers	8	

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Table 7 – continued from previous page

#	Code / Sub-code	Grounded	Code Group
40	End-user engagement	14	
41	External validation as market enabler	11	
42	Government / institutional partnerships	6	
43	Joint development initiatives	12	
44	Lack of cross-regional partner visibility	4	
45	Participation in industry groups	7	
46	R&D institute cooperation	20	
47	Technology licensing or acquisition	1	
48	Third-party testing / certification	16	
49	Regional Differences	32	Firm Capabilities
50	Applicator influence on specifications	4	
51	Country specific client requirements	10	
52	Difficulty with centralised European approach	1	
53	Exportability of European standards	6	
54	Fragmented regulatory environments	4	
55	Local vs. EU-level coordination	2	
56	National risk appetite and policy stance	4	
57	National vs. EU funding	1	
58	Regional business unit silos	1	
59	Varying infrastructure maturity	5	
60	Regulatory Challenges	46	Motives and Barriers
61	Anticipating future standards	17	
62	Barrier due to lack of clarity	12	
63	Changing EU legislation	2	
64	Compliance as competitive advantage	8	
65	EU regulation to other regions	3	
66	Risk of regulatory misalignment	7	
67	Third-party approval relevance	2	
68	Strategic Positioning	138	Market Entry Strategy
69	Balancing short-term vs. long-term priorities	13	
70	Customer-centric strategy	24	
71	Differentiation from competitors	18	
72	First mover advantage	20	
73	Internal strategic alignment	16	
74	Long-term vision and planning	36	
75	Market segmentation strategy	9	
76	Portfolio prioritisation	12	
77	Risk appetite and investment mindset	21	
78	Segment entry timing	7	
79	Success Criteria	77	Firm-Level Outcomes
80	Commercial test wins or pilots	6	
81	Expansion of client base	5	
82	External recognition	12	
83	Growing internal investment in segment	4	
84	Increase in customer adoption	7	
85	Internal alignment across functions	9	
86	Product differentiation confirmed	24	
87	ROI or market share growth	8	
88	Speed and responsiveness	10	
89	Standard / Specification inclusion	14	
90	Technical Challenges	92	Motives and Barriers
91	Compatibility with applicator processes	22	
92	Flow efficiency requirements	7	
93	Gas permeability and barrier performance	12	
94	High-performance coating requirements	6	
95	Hydrogen embrittlement	7	
96	Lack of hydrogen-specific coating knowledge	19	
97	Lack of hydrogen-specific testing standards	13	

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Table 7 – continued from previous page

#	Code / Sub-code	Grounded	Code Group
98	Productivity and curing times	2	
99	Unclear or inconsistent technical requirements	16	
100	VOC limitations and 100% solids coatings	9	

C.3 Illustrative Interview Quotes and Coding Examples

The following anonymised excerpts are illustrative examples that highlight how key themes emerged during qualitative analysis. They are intended to demonstrate the nature of stakeholder perspectives rather than serve as an exhaustive evidence base. Each quote is attributed by expert function and linked to the relevant code category for context.

Table 8: Illustrative Interview Quotes by Thematic Category

Thematic Category	Interviewee Role	Quote
Industry Context: Applicator Power in Value Chain	Sales Expert 2	"In pipe coatings, application defects become a serious risk due to the round surfaces and thin film requirements. We don't currently have infrastructure to simulate full-scale application in-house, which adds uncertainty."
Internal Capabilities: Data Availability and Internal Alignment	Technical Expert 3	"We don't have a separate sub-segment for hydrogen in our metrics. That lack of segmentation makes it harder to track our progress and see hydrogen as a distinct opportunity."
Knowledge Gaps: Technical and Regulatory Understanding	Technical Expert 1	"In my opinion, the key issue is that we currently lack the knowledge. Hydrogen is very different, and while I've heard that some people are investigating what kind of coatings can prevent brittleness on the interior of the pipe, I'm not sure we have the full knowledge internally. This includes not just technical understanding but also regulations and testing requirements."
Market Opportunities: Potential Scale of Hydrogen	Sales Expert 2	"Kilometres of pipeline are planned across Europe. If we can get a product to market with compelling test results, that opens significant mid-term opportunities."
Partnerships: External Validation as Market Enabler	Sales Expert 1	"Very important. Collaborating with customers and independent testing institutes adds technical credibility."
Regional Differences: Country-Specific Client Requirements	Technical Expert 1	"Regional differences often come down to customer-specific needs rather than country regulations."
Regulatory Challenges: Barrier Due to Lack of Clarity	Strategy Expert 1	"Regulations might come from governments, AMP, DNV, Lloyds—it's not even clear who to follow."
Strategic Positioning: Internal Strategic Alignment	Sales Expert 3	"We have decent products but lacked strategic alignment. Only recently did I feel like we're starting to take this seriously."
Success Criteria: Expansion of Client Base	Strategy Expert 3	"Sometimes success takes years to materialise, so patience is key. But if you can replicate success across countries, that's the ultimate signal."
Technical Challenges: Hydrogen Embrittlement	Technical Expert 2	"Hydrogen can induce steel embrittlement and may age pipelines prematurely."

Figure 29 provides a worked example of how interview data were transformed through the multi-step coding process. Raw interview quotes were first grouped into concrete, descriptive first-order codes (e.g., *Internal knowledge limitations* and *Technical and regulatory understanding*), which remained closely tied to participants' language. These were then abstracted into more conceptual second-order themes (e.g., *Knowledge Gaps*), capturing broader patterns across cases. Finally, these themes were assigned to one of the five overarching code groups used in this study (e.g., **Motives and Barriers**). This approach ensures analytical transparency and illustrates how insights were grounded in the data while allowing for theoretical abstraction.

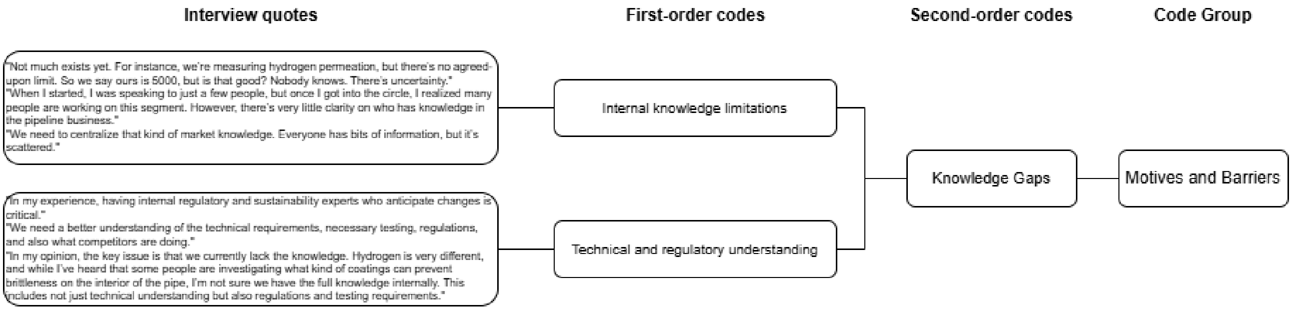

Figure 29: Example of the coding hierarchy from raw interview data to aggregate themes.

C.4 Summary Memos

To preserve participant anonymity and adhere to ethical commitments outlined in the informed consent and approved data management protocols, full interview transcripts and verbatim quotes are not included. Instead, the following table summarises thematic memos developed during qualitative analysis. Each memo is grounded in multiple coded segments across different interviews and synthesised into an analytical insight. The table shows the category of each memo, the primary codes it draws on, the approximate number of supporting quotations, and a brief interpretive summary. This ensures methodological rigour and traceability while maintaining confidentiality.

Table 9: Thematic Memos Synthesized from Interviews

Memo Title	**Extended Summary**	**Quote Count**
Market Category Ambiguity	The hydrogen coatings market is not clearly defined within Hempel. Stakeholders express mixed views on whether it should be treated as a standalone strategic segment or an extension of the oil and gas business. The ambiguity influences resource allocation, internal alignment, and strategic positioning. While some argue that the value chain and stakeholders remain the same, others highlight critical differences in risk perception, application needs, and external expectations—making hydrogen a qualitatively distinct space.	23
Technical and Operational Uncertainty	There is major uncertainty regarding technical requirements, application performance, and validation standards for hydrogen pipeline coatings. Internal teams highlight challenges with simulating pipeline conditions, replicating coating performance at scale, and lacking formal standards to benchmark permeation resistance or brittleness. Collaboration with external labs and universities is helping to bridge this gap, but uncertainty around product readiness, lack of in-house capabilities, and high testing costs continue to slow down commercialization.	51
Contextual Factors	The market for hydrogen coatings is shaped by external complexity: customer conservatism, infrastructure immaturity, uncertain standards, and the pace of energy transition. Europe is seen as a leader, but even there, regulation is evolving slowly, and customer needs are often vague or conflicting. Trust, long-standing relationships, and conservative risk postures dominate procurement decisions. Navigating these fragmented dynamics—and being proactive in anticipating regulatory changes and customer readiness—will be key to success.	82

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Memo Title	Extended Summary	Quote Count
Firm Capabilities	Hempel's ability to succeed depends on strengthening four interconnected capability domains: technical R&D, regulatory engagement, strategic partnerships, and internal organization. While the firm has strong foundations in flow coatings and legacy relationships, it faces critical gaps in application testing, hydrogen-specific product knowledge, formal regulatory involvement, and strategic focus. Coordination across teams is weak, and without a clearly defined internal structure or dedicated resources, hydrogen efforts risk stalling.	159
Market Entry Strategy	A successful entry into the hydrogen pipeline coatings market will require first-mover positioning, customer alignment, and commercial readiness. Hempel must focus on gaining early specifications, building technical credibility, and aligning its product roadmap with market needs. Strategic focus, dedicated teams, and investment timing will be essential to differentiate and avoid being overtaken by faster or more committed competitors. Europe is a key launchpad, and the ability to scale validated solutions will define long-term success.	152
Firm-Level Outcomes	Success will be measured through internal readiness, specification wins, validated performance, and early market capture. This includes proving product functionality, aligning with customer and certifier expectations, and investing in coordinated, strategic project structures. Clear sustainability narratives and first-mover differentiation can support visibility and pricing power. Ultimately, Hempel must monitor testing milestones, specification inclusion, and sales traction to know if it is converting potential into real market impact.	72

C.5 Interview Process, Coding Methodology and Analytical Rigour

Interview Setup and Data Handling

Nine semi-structured expert interviews were conducted with internal stakeholders, comprising strategy, technical, and sales profiles. Interviews were held via Microsoft Teams between February and March 2025, each lasting between 40 and 60 minutes. All interviews were recorded with consent and manually transcribed and cleaned by the researcher to ensure accuracy. Data were anonymised, stored securely on TU Delft's institutional servers, and used in accordance with the informed consent form, data management plan, and human research ethics checklist—all approved by the TPM Data Steward and the faculty's Human Research Ethics Committee.

Tools Used

The analysis was performed using *ATLAS.ti 23*. Coding followed a hybrid approach combining deductive categories derived from the conceptual framework (e.g., Resource-Based Theory, Market Entry Strategy) with inductive codes that emerged from the interview material. AI-assisted features within ATLAS.ti were used for exploratory grouping but were validated and revised manually by the researcher. Memoing and code groupings were used to capture evolving interpretations and refine thematic categories.

Code Development and Grouping

Initial coding was performed after each interview, with codes refined and merged over the course of the analysis. Codes were subsequently grouped into broader analytical categories aligned with the thesis framework (e.g., *Contextual Factors*, *Motives and Barriers*, *Firm Capabilities*, etc.). A full list of code groups and sub-codes is included in the appendix.

Anonymisation and Ethical Considerations

All personal identifiers were removed during the cleaning stage. Quotes used in the thesis have been proofread to avoid indirect identification (e.g., by role, geography, or phrasing). The cleaned transcripts and raw recordings are not publicly available and remain secured on TU Delft infrastructure in accordance with the GDPR-compliant data management plan.

Ensuring Rigour and Traceability

To ensure rigour, the analysis followed key qualitative validation principles: triangulation of interviewees across business domains (strategy, technical, sales); iterative memoing to document interpretation development; and theme saturation checking during the later interviews. A chain of evidence was maintained by linking direct quotes to codes, and codes to theoretical constructs. The theme development process was further validated by comparing interview findings with literature and market data from earlier thesis chapters. Internal peer debriefing was conducted through regular supervision meetings to reduce interpretive bias. A clear audit trail exists within ATLAS.ti, where codes, memos, and quote links can be traced step-by-step from raw data to analytical insight.

TU Delft Informed Consent Form

Study Title: Strategic Market Entry for Pipeline Protective Coatings in the European Renewable Energy Sector

Researcher Contact Information:

- Name: Noor Broersen
- Supervisor: Jan Anne Annema

Purpose of the Study:
You are invited to participate in a research study conducted by TU Delft to explore the challenges and opportunities for protective coatings manufacturers entering the European renewable energy market. This study aims to gather industry perspectives on market strategy and technical requirements for pipeline coatings in hydrogen and carbon capture infrastructure.

Participation Details:

- The interview will last approximately 30-45 minutes.
- Your participation is voluntary, and you may withdraw at any time without consequence.
- Interviews will be audio and video-recorded and transcribed for analysis, recordings will be deleted after transcription.
- The information provided will be used in an anonymous manner for a Master thesis, which will be publicly available
- All personal data collected during the interview will be deleted at the latest 1 month after the completion of the study (estimated date: 06/2025)

Confidentiality:

- Your responses will be kept strictly confidential.
- No identifying personal data will be shared in reports or publications.
- Data will be stored on TUD institutional storage, accessible only to the TUD Researchers.
- The research follows European GDPR guidelines, ensuring data protection and confidentiality for all participants.

Consent Statement:
By signing this form, you acknowledge that:

- You have read and understood the information above.
- You agree to participate voluntarily.
- You consent to the recording and anonymized use of your responses.
- You understand you can withdraw at any time without providing a reason.

Participant Signature: ________________

Date: ________________

Researcher Signature: ________________