Feasibility of Using EPC vs EPCM to Deliver Power-to-X Projects in Finland

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Laurea University of Applied Sciences **Abstract**
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The purpose of this thesis was to evaluate the feasibility of using Engineering, Procurement and Construction (EPC) and Engineering, Procurement and Construction Management (EPCM) delivery models for the development of Power-to-X (PtX) projects, with a particular focus on the European and Finnish context. The study aimed to support project developers, investors, and industry stakeholders involved in early-stage PtX project planning by improving understanding of how delivery model selection influences investment readiness, risk allocation, and project performance prior to final investment decision (FID).

The development task of the research was to analyse how different contracting approaches affect investment activation, bankability, cost and schedule certainty, flexibility, and organisational requirements in PtX projects. The theoretical framework consisted of literature on EPC and EPCM delivery models, project delivery in large energy and infrastructure projects, and the technological and market characteristics of the PtX sector, including known barriers to investment and implementation.

The study applied a qualitative research approach combining literature analysis and semi-structured expert interviews with project developers, contractors, consultants, and industry professionals with experience in energy and infrastructure projects. The researcher used thematic analysis to examine collected data and find recurring patterns which showed how organizations allocated risks and their level of financing readiness and their flexible operations and their total organizational capacity. The results indicate that delivery model selection plays a significant role in investment activation in PtX projects. Investors and lenders showed a preference for EPC contracts because these contracts provided single-point responsibility and fixed-price structures and detailed risk transfer, which increased their perception of bankability. However, EPCM approaches were found to provide greater flexibility, transparency, and technological adaptability, which are important in early-stage and first-of-a-kind PtX projects. The findings also highlight that organisational capability of the project owner is a critical factor influencing the suitability of EPCM arrangements.

The study concludes that EPC and EPCM should not be viewed as mutually exclusive alternatives but rather as complementary tools that may be applied at different project stages. Hybrid or phased approaches, combining EPCM during early development with EPC elements for risk-critical components before FID, may offer the most effective strategy in emerging PtX markets. The research provides practical recommendations for project developers and investors regarding delivery model selection based on project maturity, risk tolerance, and organisational capability.

Keywords: Power-to-X, EPC, EPCM, Project delivery models, Risk allocation, Project financing, Project Management, Green Hydrogen

Contents

1 Introduction

This chapter introduces the context and motivation for examining the feasibility of using Engineering-Procurement-Construction (EPC) and Engineering-Procurement-Construction Management (EPCM) models to deliver Power-to-X (PtX) projects. Europe, and Finland particularly, are rushing through the transition to carbon neutrality and have come up with a mixture of tools, including PtX, to help them overcoming the decarbonization challenge, which is the case of the steel, chemicals, and transport industries. However, even though policy support has been constantly increasing, and the technologies are almost mature, still the large-scale PtX projects are not able to make their way up to the final investment decision due to the uncertainties involving the financing, regulations, and project execution. To comprehend these obstacles, one needs not only to be acquainted with the technological and policy background of PtX but also to assess the extent to which different project delivery models influence investment risk and stakeholder confidence. Thus, this chapter provides the study with a start by giving a detailed account of the PtX concept, outlining the problem and the research purpose, and expressing the main questions that the thesis will be built upon.

1.1 Background

Power-to-X (PtX) is the term that encompasses various technologies and processes that turn electrical power, mainly the one generated from renewable sources, into other energy carriers or products. To put it simply, PtX allows the separation of electricity generation from the power industry for usage in the transport or chemical sectors (LUT University 2023). The “X” in PtX stands for the intended product or energy carrier. The main PtX routes are as follows:

- Power to Hydrogen: Green hydrogen production through water electrolysis using renewable electricity represents a critical pathway for decarbonization and sustainable energy systems. Water electrolysis converts surplus renewable electricity into hydrogen, providing an energy storage solution for intermittent renewable sources like wind and solar power.
- Power to Gas: Power-to-Gas (P2G) technology converts surplus renewable electricity into gaseous fuels, primarily synthetic natural gas through the combination of green hydrogen and captured CO2 (Becker, Penev & Braun 2012). This process enables long-term energy storage and utilizes existing gas network infrastructure, facilitating the transition from fossil fuels.
- Power to Liquid: producing liquid fuels (e-fuels) such as methanol, ammonia or synthetic diesel/kerosene from renewable hydrogen and carbon inputs (Vinson & Elkins

LLP 2024). These drop-in fuels can replace fossil-based liquids in sectors like aviation (e.g. sustainable aviation fuel) and shipping or serve as chemical feedstocks.

- Power to Chemicals: synthesizing chemicals and materials using renewable hydrogen, electricity and other reagents. For example, green ammonia (from hydrogen and nitrogen) can be used for fertilizer production or as an industrial chemical, displacing fossil-based methods (Vinson & Elkins LLP 2024). Similarly, methanol produced from PtX can sever as chemical building block.

Strategic Role in Decarbonization; PtX has emerged as a strategic solution for deep decarbonization of hard to abate industries and transport modes that cannot be easily electrified. These carbon intensive sectors (e.g. steel and cement production, heavy road freight, maritime shipping, aviation, chemicals) currently account for a large share of global CO_2 emissions (Vinson & Elkins LLP 2024). PtX pathways offer a way to produce low carbon fuels and feedstocks to replace the fossil fuels in these applications (Vinson & Elkins LLP 2024). For instance, green hydrogen can directly fuel fuel-cell trucks or be used in steel making instead of coal, methanol and ammonia can be used to fuel ships, and e-kerosene can power airplanes (named as “SAF” sustainable aviation fuel). Thus, cutting emissions where batteries or direct electrification are impractical.

Beyond fuel substitution, PtX also can play a key role in enabling energy system flexibility. By converting surplus renewable electricity into storable fuels (like hydrogen, methane or ammonia, eSAF), These fuels offer the advantage of an existing storage infrastructure and furthermore allow for the coupling of all energy sectors, e.g. transportation, industry, heating etc., to wind and solar power. It provides a mechanism to flexibly transfer energy across sectors, time and locations, for example using excess wind power generated at night to produce hydrogen that can later be used for transportation or reconverted to electricity when needed (Good News Finland 2021). This helps balance the grid and overcome the instability and inconsistency of solar and wind. Notably, hydrogen and derived PtX fuels can leverage existing infrastructure (gas pipelines, storage caverns, fuel distribution networks) minimizing the need for entirely new logistics systems (Good News Finland 2021).

PtX serves a dual strategic purpose; decarbonizing challenging sectors and acting as a “bridge” between power grids and other energy uses, increasing the overall resilience and flexibility of a renewable-based energy system (Good News Finland 2021).

Policy and Regulatory Context in the EU; The importance of PtX, and specifically renewable hydrogen, is strongly reflected in EU policy frameworks. Under the European Green Deal’s climate neutrality agenda, the EU launched a dedicated hydrogen strategy in 2020 to scale up PtX technologies as a pillar of the green energy transition. This strategy set ambitions targets, installing 40 GW of renewable hydrogen electrolyzers by 2030 and producing up to 10 million tons of renewable hydrogen within the EU by 2030 (European Commission 2024). To put this in perspective, 10 million tonnes of hydrogen correspond to roughly one-third of the EU's current hydrogen consumption (most of which is fossil-based) and could replace around 4–5 % of total EU natural gas demand or provide enough energy to power more than 30 million households annually (IEA, 2023; European Commission, 2020). These targets were seen as a first step to making renewable hydrogen cost-competitive and widely available, with an eye towards 2050 when renewable hydrogen and e-fuels are expected to play a significant role in the EU energy market.

At the national level, Finland provides a case study of PtX's strategic role as an EU member state. Finland has set one of the most ambitious climate targets in the world, aiming to reach carbon neutrality by 2035, well ahead of the EU's 2050 goal (State Treasury 2025). Achieving this will require transforming Finland's energy and industrial base, and PtX is viewed as key enabler. In fact, the Finnish government's climate and energy strategy envisions Finland becoming a leader in renewable hydrogen and PtX production. A national hydrogen roadmap was published in 2020 (business Finland) to guide the development of a hydrogen-based economy and PtX solutions across various sectors (Good News Finland 2021).

1.2 Problem: (Investment delays despite technical readiness)

Power-to-X (PtX) projects across Europe have seen ambitious announcements but relatively slow investment decisions, even as the core technologies reach maturity. The European Union has set bold hydrogen targets (10 million tonnes of renewable hydrogen production by 2030 (European Commission 2024) and hundreds of PtX projects have been proposed, yet only a small fraction have secured funding and begun execution. The European Investment Bank (EIB) reports that out of ~23 GW of electrolyzer capacity planned for the Eu by 2030, less than 2% - about 350 MW - is underway or has reached final investment decision (European Investment Bank 2022). Globally, studies find a similar trend – one analysis notes that only ~4 of projected 2030 green hydrogen output is tied to projects that have reached final investment decision, with many announced projects delayed or on hold (University of Copenhagen 2024). In Finland, the pattern is analogous: over 40 hydrogen/PtX projects (worth more than €17 billion) are in the development pipeline (Business Finland 2024), yet very few have progressed to construction. Finland’s first industrial-scale hydrogen plant (20 MW by “P2X Solutions” in Harjavalta) only came online in 2025, and officials acknowledge that numerous hydrogen production investment projects are in the pipeline, but not many have reached the finish line yet due to the risks and uncertainties of pioneering projects (Business Finland. 2025). In short, technical readiness is high – key PtX units like electrolyzers, hydrogen storage, and synthesis units are available and have been proven in pilot settings – but investment activity remains sluggish, creating a deployment gap.

From my professional experience in the Power to X industry several barriers are holding back investment in PtX projects despite the technical maturity of the technology:

- **Regulatory uncertainty:** An unpredictable policy environment is a major deterrent to investors, Rule for hydrogen and PtX markets are still evolving – for example, defining what qualifies as “green” hydrogen, future carbon pricing, or infrastructure regulations. This uncertainty makes future revenues and costs hard to predict (University of Copenhagen 2024). The European Investment Bank EIB observes that regulatory ambiguity (and fragmented, inconsistent policies across countries) directly increases project risk and undermines viability, thus reducing investments and private sector interest (European Investment Bank 2023). Investors are reluctant to commit capital when basic market rules or inventive schemes remain in flux.
- **Permitting and bureaucratic delays:** Lengthy permitting procedure for large energy projects usually immensely delay PtX projects. Complex environmental and safety approvals, grid connection permits and other licenses may last for several years, delaying commencement of construction. Industry analyses identify ongoing permitting process as a major hurdle that slows down projects even before Phase of Investment Decision (Budzier et al. 2023). The EU has recognized this problem under the

REPowerEU plan a recent directive (EU2023/2413) was enacted to simplify and accelerate renewable energy permitting, yet some Member States have struggled to implement it. Notably, Finland was admonished by the European Commission in mid-2025 for failing to transpose these permitting reforms, indicating that its legal framework still contained “gaps” impeding efficient permitting (Strategic Energy Europe 2025). Such delays not only stall individual projects but also create a climate of uncertainty that can deter both public and private investors.

- **Lack of proven business models and demand:** Since most PtX projects are not clear about their mechanisms for the generation of stable returns, financiers do not find it attractive to invest in them. The end market for PtX products (green hydrogen, efuels, etc.) remains in the formative or developing stage. Few long-term offtake contracts have been established, and demand growth largely depends on future decarbonization policies that remain uncertain. Due to this absence of secured revenue agreement, a manufacturer of any fuel cannot demonstrate a bankable business proposal. Analysts note that and “absence of off-take commitments” is a common roadblock to reaching final investment decision (Budzier et al. 2023). Moreover, the economics of first-of-a-kind PtX plants are challenging. Fuel production costs remain higher than traditional fossil alternatives without subsidies. As a result, announced projects have been postponed or cancelled due to uncertain market. In short, the commercial viability of PtX projects is not yet proven at scale, and the private sector is hesitant to invest without clearer evidence of profitable operation or strong policy support (such as carbon pricing, mandates or guarantees for green products).
- **Financing gaps and risk perception:** The combination of the above factors has led to a funding gap. The European Investment Bank EIB notes that, despite hundreds of billions of euros in investment being needed this decade, funding commitment to hydrogen projects today remains relatively low, due to various uncertainties (European Investment Bank 2022). Investors currently perceive green hydrogen/PtX projects as high-risk, low return endeavors under existing conditions. A recent academic study found a widespread view among energy financiers that “the risk associated with hydrogen seen as bad investment” (University of Copenhagen 2024). Several risk factors drive this perception. Technical scale-up risk is one even though electrolysis and main units are mature in principle, there is limited operating experience at the multi-megawatt level. Lenders worry about whether large PtX plants can perform as expected and run reliably over time. Uncertainties around efficiency, uptime, and components lifetime (for example, how long electrolyzer stacks last before replacement) remain, given the limited track record at scale (European Investment Bank 2022). This operational risk makes dept financing more expensive or unavailable. Likewise, supply chain immaturity (e.g. back logs in electrolyzer manufacturing and qualified contractors) add risk of cost overruns or delays (European Investment Bank 2022). All

these factors raise the perceived risk premium for PtX projects, meaning investors demand either higher returns or extra guarantees. In practice, this has meant that many projects will not proceed without substantial public-sector support or derisking. Indeed, public funding agencies have had to step in to fill the financing gap for initial project. For example, in Finland the government (though Business Finland) provided a €60 million grant to the company P2X Solutions' planned hydrogen-methanol plant in Joensuu, a subsidy explicitly intended to move the project closer to the investment decision and help a first-of-a-kind project reach commercial scale (Business Finland. 2025). Such public cofinancing is seen as crucial to offset investor risk aversion in early projects. Yet public resources are limited, and even government-lead programs have encountered delays; the EU's important Projects of Common European Interest (EPCEI) framework for hydrogen was launched in in 2020 to mobilize major cross-border projects and yet it is still in the process of selecting projects and allocating funds years later (European Investment Bank 2022). In short, both private and public sector investments face inertia: Private capital hesitates without risk mitigation, and public funding mechanisms have been slow or insufficient to kick-start all the needed projects.

- **Delivery model and execution uncertainty:** Large Power-to-X (PtX) and green hydrogen projects are characterized by significant technical, financial, and delivery uncertainties. Even when funding and permits are secured, investors carefully evaluate the construction and integration risks associated with the proposed implementation approach. Although the underlying technologies are generally mature, many PtX initiatives represent first-of-a-kind deployments at industrial scale, which introduces elevated execution risks compared to conventional power or fuel generation projects. When project scope is ambiguous or responsibilities are fragmented among multiple contractors without clear interface management, the likelihood of cost overruns and schedule delays increases substantially. Such setbacks can quickly undermine project economics. Consequently, from an infrastructure financier's perspective, a delivery strategy that clearly allocates responsibilities and ensures effective interface management is essential to minimizing risk and safeguarding investment viability.

Traditionally, one way to reduce execution risk is through a single Engineering, Procurement, and Construction (EPC) contracts represent a comprehensive contracting approach where a single contractor assumes full responsibility for delivering complete, operational facilities on a turnkey basis. Under EPC arrangements, contractors handle all engineering, procurement, construction, commissioning, and testing activities, providing owners with a single point of responsibility, communication, and coordination. This approach offers better cost realization and promises project delivery within scheduled timeframes while transferring majority of project risks from owner to contractor. By consolidating obligations in one contract, an EPC wrap transfers much of the execution risk to the contractor, which gives debt financiers a higher degree of certainty that the project will meet its targets. For example, pairing novel electrolyzer technology with an established EPC firm can offer investors “bankable execution, cost control, and delivery assurance,” as one industry hydrogen lead noted (H2 View 2024). In essence, the EPC contractor provides performance guarantees on price and schedule, a model that is familiar and comforting to commercial lenders in project finance.

However, the EPC wrap approach has its own trade-offs. Transferring more risk to the contractor comes at a price, research demonstrates that contractors add significant premiums of approximately 3% to their bids when projects have high risk or when they have low need for work (Eversheds Sutherland 2023). This can make the project more expensive upfront. Moreover, in cutting-edge hydrogen projects, it may be challenging to find a single contractor willing to take on a full wrap for a reasonable price. Many large engineering firms are cautious about providing lump-sum turnkey contracts for unproven technologies, and indeed some first-of-a-kind projects have seen lack of bidder interest in an EPC structure, forcing sponsors to consider alternative delivery model (Eversheds Sutherland 2024). In such cases, the project may have to adopt a multi-contract execution strategy despite the financing preference for a wrap.
As a contrast to a turnkey EPC, project developers can opt for an Engineering–Procurement–Construction management (EPCm) or multi-contract delivery model. In this approach, the project owner signs separate contracts with multiple contractors or equipment suppliers and takes on the role of integrator, managing the interfaces between various work packages. This model has several potential advantages. First, it can be more cost-effective: avoiding a single EPC means avoiding the risk premium that a turnkey contractor would charge (Reed Smith LLP 2022). By competitively tendering individual packages (for example, awarding the electrolyzer supply, the balance-of-plant construction, and the grid connection to different specialized firms), the owner might achieve lower overall capital costs. Second, a multi-contract setup offers greater flexibility and control to the project owner. The owner can select the most qualified vendor for each component and maintain direct oversight of critical parts of the project. This direct contractual relationship with each key supplier can be advantageous, as it affords more control over scope and performance of individual contractors (Eversheds Sutherland 2024). Greater flexibility can also translate to schedule benefits – certain activities can proceed in parallel before the entire project design is finalized, potentially accelerating the timeline (Eversheds Sutherland 2024). In other words, an EPCM approach allows starting work on some packages early (e.g. early equipment orders or site works) without waiting for a single turnkey contract to

be negotiated, which can speed up delivery in the right circumstances (Reed Smith LLP 2022).

1.3 Purpose: Compare EPC & EPCM models in PtX

The purpose of this thesis is to assess and compare the feasibility of using Engineering, Procurement and Construction (EPC) versus Engineering, Procurement and Construction Management (EPCM) delivery models for Power-to-X (PtX) project development. This comparative evaluation is set in the context of Europe’s expanding PtX industry – with a special focus on Finland – where numerous initiatives are underway to decarbonize energy, transport, and industry. By examining these two project delivery approaches, the study aims to determine which model (or which aspects of each) is more suitable for delivering PtX projects under various conditions there is an identified contemporary gap in understanding how the project execution strategy impacts the early development of PtX projects in Europe, where countries like Finland are launching their first industrial-scale green hydrogen and e-fuel plants (Fimpec 2024).

The analysis scope has been intentionally limited; thus, the emphasis is given only to the early stages of project development-from initial concept and feasibility studies, through Front-End Engineering Design (FEED), and up to Final Investment Decision (FID). In other terms, the analysis concentrates on the period leading to investment commitment rather than the entire construction or operational lifecycle of PtX projects. The rationale for this focus is that key decisions about contract strategy and risk allocation must be made prior to final investment decision to secure financing and stakeholder commitment. By concentrating on the pre- final investment decision stage, the research isolates how EPC vs. EPCM choices influence project setup and investor decision-making, without conflating these effects with later construction-phase outcomes. This geographic and phase-specific focus (Europe – especially Finland – and pre- final investment decision development) ensures that the findings are contextually relevant to the region’s current PtX efforts while remaining within a manageable scope for a master’s thesis.

This comparative study evaluates tangible project performance and financing-related aspects under EPC and EPCM modes. Key criteria from the project performance point of view have been adherence to the schedule, cost control, and risk management in the early stages of the project. In other words, the research also examines if one of the delivery models tends to keep the project timeline or budget more on track than the other and how risk identification and mitigation are carried out under each of these models. Equally important in this thesis, effects on the investors' confidence and project bankability shall be looked at.

Delivery models are distinguished from one another by the different methods through which their responsibilities and risks are distributed, which in turn affect investors' and lenders' perceptions of a project. The EPC contract warrants a single point of responsibility, with unified performance guarantees and fixed-price commitments, which once made, may have implications on the ease of coordination and bankability. On the contrary, the EPCM closes more options for suppliers and design changes from the project owner, however, it bears more interface and integration risks. This shift in risk allocation means that under an EPCM model, more effort is needed to convince lenders and investors that the project will be delivered on time and on budget. By comparing these aspects, the study evaluates how each model influences project outcomes (in terms of cost, schedule, and risk profiles) as well as the perceived reliability and financeability of PtX ventures from an investor's perspective.

To serve its aims, the research makes use of the mixed-methods approach, coupling the desktop review plus the qualitative interviews. The desktop review involves surveying academic works, industry reports, and best-practice guidelines on project delivery models and PtX project development for the theoretical and contextual background. It looks into previous analyses of EPC versus EPCM in large-scale energy or infrastructure projects and into the literature concerned with the challenges and success factors of PtX projects. Extending this basis, the research utilizes insights from semi-structured interviews with stakeholders like project developers heading PtX projects, professionals from EPC and EPCM contracting firms, and industry experts familiar with European PtX projects. These interviews allow the research to capture practical experiences, perceived advantages and drawbacks of each model, with opinions on aspects relating to project bankability and risk management that might not be fully accounted for by others in published literature. Integration of published knowledge with the testimony of experienced experts is pursued to uphold a balanced, evidence-based treatment of the EPC and EPCM models as they apply to the delivery of Power-to-X projects.

1.4 Research questions

How do EPC and EPCM project delivery models influence investment activation, risk management, and project performance (in terms of schedule and budget control) in Power-to-X projects?

Given the quick rise of PtX initiatives in Europe, and mostly Finland, and the difficulties of actually putting these PtX projects forward for final investment decision, this thesis studies how project delivery model choice affects key success factors. Special emphasis is laid on two critical factors present in the early stage of PtX project development specifically investment activation and change management. Investment activation deals with how easily actually a project can get funds and commitment (bankability, financing readiness, risk-sharing arrangements). Change management points out the adaptability of the project and stakeholder dynamics (accepting new inventions, coordinating stakeholders, and pushing necessary organizational changes). These dimensions are highly interdependent: for instance, Engineering, Procurement and Construction (EPC) contracts have traditionally been a cornerstone of securing project financing, transferring substantial risk to the contractor to give lenders comfort (White & Case LLP 2022) whereas Engineering, Procurement and Construction Management (EPCM) approaches leave more risk with the owner but offer greater flexibility for integrating novel technologies and design changes (MASTT 2024). This flexibility can be crucial for emerging PtX technologies (such as green hydrogen), where fewer contractors are willing to take full lump-sum EPC risk at a reasonable cost, making risk-sharing models like EPCM attractive (Hogan Lovells 2024). At the same time, adopting an EPCM model requires the owner to coordinate multiple contractors and possess strong in-house expertise (MASTT 2024), effectively a deeper organizational involvement that may be challenging for nascent PtX developers. Given these trade-offs, the study undertakes a comparative analysis to generate insights relevant to early-stage PtX project development (up to final investment decision) in the European/Finnish context.

Main Research Question:

How do EPC and EPCM project delivery models influence investment activation, risk management, and project performance—particularly in terms of schedule and budget control—in Power-to-X projects within the European and Finnish context?

To address this overarching question, the research is guided by several supporting sub-questions that break down the comparison between EPC and EPCM along the key themes:

1. **Bankability and Financing:** What are the implications on bankability and financing readiness of a PtX project when selecting an EPCM or EPC delivery model? How, for example, do the different risk allocations under each model impact lenders' and investors' willingness to fund the project? (White & Case LLP 2022) (MASTT 2024)
2. **Risk Distribution**: In what ways do EPC and EPCM frameworks differ in risk allocation between the project owner, contractors, and other stakeholders, and what are the implications of these differences for early-stage project viability and investment activation? (MASTT 2024).
3. **Technological Adaptability**: How do the two models, EPC and EPCM, compare in adapting to new technologies or design changes during project development? (The sub-question is to assess which model better fosters innovation and flexibility in PtX projects since the technology is rapid in this sector and insecure. (MASTT 2024) (Hogan Lovells 2024).
4. **Stakeholder Coordination and Organization:** How might the choice of EPC or EPCM affect stakeholder coordination and the organization setup of the project owner's team? What changes in terms of project governance or internal capability would need to be put in place to allow the owner to manage the project under either model (i.e.,

stronger internal project management may be needed under an EPCM arrangement while EPC involves more of a turnkey arrangement for the owner)?

By answering these sub-questions, it will be possible to understand the comparative advantages and disadvantages offered by EPC and EPCM in catalysing investment and effecting change in the execution of PtX projects. This is intended to give practical insights to developers and other stakeholders in the very early-stage planning (concept, feasibility, engineering up to final investment decision) of PtX projects so that they can make informed decisions on the most viable delivery model in the setting of Europe's energy transition and Finnish emerging PtX industry. Each sub-question answers a dimension of the main question, ensuring that the analysis stays focused on the theme of feasibility of EPC vs. EPCM for delivery of PtX projects. The findings will clarify how contracting affects not only the bankability of cutting-edge energy projects but further their ability to transform and succeed in response to technological innovations and challenges that are organizational in nature.

2 Knowledge Base and Literature Review

The theoretical framework and conceptual framework which this chapter presents serve as the basis for studying how project delivery models affect Power-to-X (PtX) project development and execution. The research problem and research objectives were introduced in Chapter 1, but research needs to study both delivery frameworks to understand which factors drive investment activation and risk distribution and project results. The chapter establishes its first section by explaining the Engineering, Procurement and Construction (EPC) and Engineering, Procurement and Construction Management (EPCM) delivery systems which serve as the main research focus for this investigation. The study first explains essential PtX technologies before it examines existing research about delivery models used in infrastructure and energy projects and finally investigates the obstacles that affect investment and project development in the PtX industry.

2.1 Definition of EPC and EPCM

Engineering-Procurement-Construction (EPC) – EPC is a project delivery model (often called a turnkey contract) where a single contractor is entrusted with the engineering design, procurement of equipment/materials, and construction of a facility. An EPC contractor delivers a turn-key project to the client by a fixed completion date and for a fixed price (Freshfields LLP 2025). In such a contract, the client will provide the project requirements (specifications), project financing, and access to the site, while the EPC contractor undertakes all other aspects of the project (Freshfields LLP 2025). This includes subcontractors and suppliers - the EPC contractor holds the subcontracts and is held fully accountable as the single point of responsibility to deliver the project in accordance with the terms of the contract (Taylor Wessing 2023). Because the contractor takes on the majority of cost, schedule, and performance risks, EPC contracts are typically lump-sum arrangements where the contractor's price includes a contingency or premium to cover those risks (Taylor Wessing 2023). Standard contract forms published by international organizations reflect this allocation for example, the FIDIC Silver Book (Conditions of Contract for EPC/Turnkey Projects) provides a widely used template in which the contractor must deliver a functional facility for a fixed price and time, taking on the turnkey obligations and risk (Taylor Wessing 2023). This risk allocation makes EPC contracts attractive in project-financed infrastructure and energy projects, as they offer funders and owners greater certainty over cost and completion date (Henchie 2007). Indeed, EPC contracts have been "traditionally the most 'bankable' procurement method" for large projects, given the owner can hold one party liable for the outcome (Taylor Wessing 2023). However, the flipside is that EPC contractors charge a premium for bearing these risks, and owners cede a high degree of control over design and execution to the contractor during the project.

Engineering-Procurement-Construction Management (EPCM) – EPCM is a fundamentally different contract model despite the similar acronym. An EPCM contract is not a single lump-sum build contract but rather a professional services agreement for project management and engineering (Freshfields LLP 2025). Under an EPCM arrangement, the EPCM contractor (or consultant) is hired to perform engineering design, manage the procurement of equipment and trade contractors, and co-ordinate the construction on behalf of the owner (Freshfields LLP 2025). Unlike EPC, the EPCM contractor does not directly hire subcontractors to perform the construction; instead, the owner enters numerous direct contracts with various contractors and suppliers for different portions of the work (Freshfields LLP 2025). In essence, the EPCM contractor acts as the owner's agent or construction manager, administering these contracts and ensuring the design and construction by others are properly integrated (Henchie 2007). The EPCM contractor does not provide a turnkey deliverable or assume overall liability for delivering the completed facility by a certain date or price, there is no single point performance guarantee to the owner for the entire project (Henchie 2007). Instead, risk is distributed among many parties, each contractor bears responsibility for its own scope (under its contract with the owner), and the owner retains the overall project risk if there are cost overruns or delays, since the EPCM contractor typically does not guarantee the project's total cost or schedule. The EPCM contractor's liabilities are generally limited to professional negligence or breach of its duties (e.g. design errors, poor project coordination or late procurement); it does not underwrite the project delivery risk in the way an EPC contractor does (Henchie 2007). Because of this structure, EPCM contracts are often reimbursable (cost-plus-fee) arrangements rather than fixed-price – the owner pays the actual construction costs of each works contract, plus a management fee to the EPCM contractor (Taylor Wessing 2023). (The new IChemE Blue Book

(2023), the first standard form EPCM contract, does allow alternative payment models such as target cost or fixed fee options, but the core concept remains that the owner, not the contractor, carries the cost risk of the works (Taylor Wessing 2023). In summary, an EPCM contract provides the owner with greater control and flexibility during project execution, but in return the owner must be willing to assume a larger share of project risk and management effort (Freshfields LLP 2025).

Contractual Structure and Responsibilities: The EPC and EPCM models differ markedly in how contracts and responsibilities are structured. In an EPC structure, the owner typically signs one single contract with the EPC contractor, who then may subcontract portions of the work but remains solely responsible to the owner for delivering the entire project (single point responsibility) (Taylor Wessing 2023). The contractual hierarchy is simple, the owner manages one main contractor, and that EPC contractor in turn manages all subcontractors/suppliers (the owner usually has no privity with those subs). In an EPCM structure, by contrast, the owner enters into multiple direct contracts, one with the EPCM contractor for management services, and separate contracts with each works contractor (construction trade contractors, equipment suppliers, etc.) for execution of the project packages (Freshfields LLP 2025). The EPCM contractor assists the owner in drafting, tendering and administering these numerous contracts, but is not itself a party to them (Freshfields LLP 2025). Figure 01 illustrates this difference in structure.

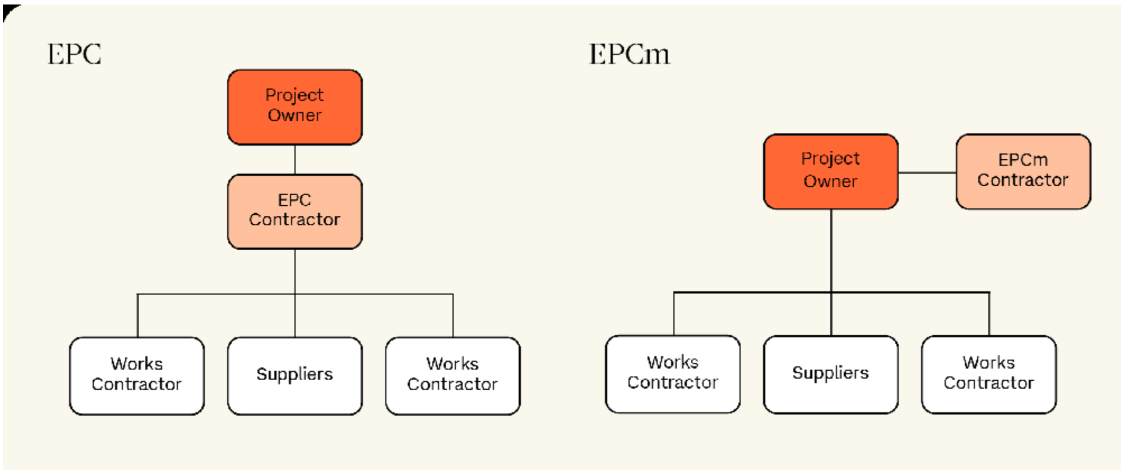

Figure 1 Simplified contractual relationships in EPC (left) versus EPCM (right). (Freshfields LLP 2025)

In EPC, the project owner has a single contract with an EPC contractor, who in turn manages all subcontractors and suppliers. In EPCM, the project owner directly contracts multiple works contractors/suppliers while supported by an EPCM management contractor (Freshfields LLP 2025).

Because of these structural differences, the division of responsibilities and risk allocation also diverge. In an EPC contract, the EPC contractor carries most of the project risks, the risk of late completion (often backed by liquidated damages), the risk of cost overruns (since the price is fixed unless scope changes), and the risk of under-performance (usually backed by performance guarantees or warranty) (Freshfields LLP 2025). In EPC, the owner has relatively limited responsibilities which primarily involve stating the requirements of the project, furnishing the site and access to the site, paying as the law requires, and refraining from interference with the contractor's work. If one were to attempt to create a finished facility that does not comply with the contract; then recourse may lie against the EPC contractor, under whose obligation it lies to rectify any defects or pay damages. This consolidated responsibility works to minimize interface risk for the owner and provide a reduction in the dispute process, i.e., the owner need not go through the trouble of placing blame on whichever subcontractor since the EPC contractor accounts for all of them). The EPCM contract, in a sense, means no individual contractor ever warrants any sort of overall project outcome. Integration risk is borne by the owner, and he must cooperate with the EPCM contractors to manage the multiple interfaces. If a trade contractor is late or a supplier does not do a good job, the owner (with assistance from the EPCM consultant) enforces his contract against the contractor, but generally the EPCM contractor has limited liability for delay or cost enlargement by third parties. In fact, EPCM contracts rarely include project-wide delay liquidated damages or a fixed total price; the focus is on the EPCM firm performing its duties with due care. The risk of cost overruns and schedule slippage rests largely with the owner in EPCM, meaning the owner must have adequate contingency plans and project management capability. As one industry analysis notes, owners who lack sufficient in-house expertise may find that expected cost savings of EPCM “diminish during execution” as they incur greater management costs and face potentially multiple claims across different contractors (Freshfields LLP 2025). Thus, EPCM requires the owner to take on a proactive role in project oversight, often with support of a strong owner’s project team, whereas EPC allows the owner to step back and rely on the contractor to deliver a result for an agreed price.

Risk Allocation and Incentives; EPC contracts transfer most major risks to the contractor, which incentivizes the contractor to control costs and schedule but also means the contractor will include a risk premium in the price. The contractor in an EPC typically commits to deliver the project for a lump-sum price and by a guaranteed date, absorbing any cost overruns or delays (unless caused by owner). If the project is completed under budget or earlier than planned, that savings or gain usually accrues to the contractor (hence EPC contractors have an incentive to be efficient). In contrast, EPCM contracts adopt a cost-reimbursable model in many cases, which minimizes the contractor’s exposure to financial risk – the EPCM firm’s compensation is often a fixed management fee or a fee proportional to the project cost, sometimes with a target cost incentive structure. This means the owner, not the contractor, ultimately pays for the actual construction costs, whether higher or lower than initial estimates. The EPCM contractor's incentive is to manage the project effectively to meet the owner's budget and schedule, but their fee is not directly at risk in the same way an EPC contractor's profit is. Some EPCM contracts include performance incentives or penalties tied to the EPCM contractor's services (for example, a bonus for meeting the schedule or a penalty for poor coordination), but these are targeted at the management performance, not full project delivery. Schedule risk under EPCM is shared in the sense that each works contractor may have schedule commitments to the owner, yet the overall completion date is not guaranteed by any single party; the EPCM contractor is expected only to use reasonable care in managing the schedule. As a result, under EPCM, more of that uncertainty in final cost and date of completion generally has to be taken on by the owner, whereas under EPC, the owner transfers this uncertainty to the contractor in return for the guarantee (a contractual right) that the project will be completed on time and price or else the contractor will be subjected to damages (Freshfields LLP 2025).

Application in Energy and Infrastructure Sectors, Large energy projects and infrastructure work use both delivery methods, though the applicability of each depends on the nature of each project and industry practices. EPC contracts are more common in those projects where one assumes that a turnkey solution must or usually can be required for financing. For instance, in the power generation sector, it is typical for developers to engage an EPC contractor to deliver a power plant (e.g. a combined-cycle gas turbine plant or a wind farm) at a fixed price and performance level, which lenders find attractive (Taylor Wessing 2023). Many public infrastructure projects (such as highways or water treatment plants) likewise use EPC or design-build contracts to transfer delivery risk to contractors. Sectors like oil and gas also use EPC contracts for certain components (for example, a pipeline or a standard processing unit might be built on an EPC turnkey basis by a contractor consortium). On the other hand, EPCM contracts have been historically prominent in the mining and hydrocarbons industries, where project owners (e.g. mining companies or oil majors) often prefer greater control over procurement and design, or where the scope may not be fully defined upfront (Taylor Wessing 2023). In the oil and gas industry, many complex upstream and downstream projects have utilized EPCM, especially when the project is too large or risky for a single contractor to take on as EPC. For example, multibillion-dollar liquefied natural gas (LNG) terminals or petrochemical complexes are often broken into packages with an overall EPCM program manager, because no single contractor will accept full liability for cost and schedule on such megaprojects. Industrial process plants and manufacturing facilities (e.g. in petrochemicals, pharmaceuticals) are another domain where EPCM is common.

In summary, EPC and EPCM represent two distinct paradigms for project delivery. An EPC contract gives the owner a single accountable party and a high degree of upfront certainty at the expense of a higher price and less direct control. An EPCM approach, by contrast, allows an owner to leverage the expertise of a management contractor while maintaining direct control over procurement and construction, thereby potentially saving costs and increasing flexibility – but the owner must shoulder a greater burden in risk and project management. Well-grounded and established in many projects worldwide, both these models enjoy the backing of industry standards such as FIDIC or IChemE; however, they each have their own sets of advantages and disadvantages. The project complexity, owner's capability and risk appetite, market scenarios, and financing aspects should dictate a decision between EPC and EPCM. One legal writer rightly pointed out that, although the names appear similar, “the EPC and EPCM contracting models are vastly different,” making it necessary for the right model choice to be ensured based on the project's objectives and constraints. The EPC will be selected where one chooses to maximize risk transfer and certainty, while the EPCM will be selected where the preference is toward flexibility, owner control, or risk sharing as a result of uncertainty.

2.2 Overview of Power-to-X technologies

Power-to-X (PtX) refers to pathways that convert renewable electricity into carbon-neutral fuels or feedstocks, providing sustainable energy carriers for sectors that are hard to electrify. Key PtX technologies include green hydrogen, e-methanol, synthetic aviation fuel (e-SAF), and e-methane, all of which are gaining strategic importance as tools to decarbonize heavy industries and long-distance transport. Rather than delving into technical processes, this overview emphasizes use cases, economic relevance, maturity, and the role of these fuels in reducing emissions in “hard-to-abate” sectors like steel, shipping, and aviation.

Green hydrogen is hydrogen produced via water electrolysis using renewable power. It is foundational to many Power-to-X pathways and can be used directly to replace fossil fuels in high-emissions industries. For example, hydrogen can serve as a reducing agent in steelmaking (replacing coal in iron ore reduction) and provide high-temperature heat in cement and chemical production. It can also fuel fuel-cell trucks or be stored as an energy reserve for the power grid. The European union member states are obligated to reduce emissions of carbon dioxide to the atmosphere by 55% by 2030, and clean hydrogen will be a critical component in meeting these ambitions. This is emphasized in the REPowerEU plan, which defines targets to help drive growth of the European renewable hydrogen market and support European security of supply. It sets a domestic production target of 10 million tons annually (330 TWh/y) and an import target of an additional 10 million tons per year by 2030 (H2Cluster Finland 2023). Finland has aligned with this strategy – a 2023 government resolution even foresees Finland producing up to 10% of the EU’s green hydrogen by 2030.

E-methanol (electro-methanol) is a liquid fuel produced by combining green hydrogen with carbon dioxide (usually captured from biomass or industrial emissions). E-methanol offers a carbon-neutral substitute for conventional methanol and other fuels. Business interest in e-methanol is largely driven by two use cases: as a sustainable shipping fuel and as a chemical feedstock. In the maritime sector, e-methanol is emerging as a viable alternative to heavy fuel oil for decarbonizing shipping. It offers a carbon-neutral substitute for conventional methanol and other fuels. Business interest in e-methanol is largely driven by two use cases as a sustainable shipping fuel and as a chemical feedstock. In the maritime sector, e-methanol is emerging as a viable alternative to heavy fuel oil for decarbonizing shipping (Vazquez & Strittmatter 2025). Each vessel is expected to eliminate on the order of 1 million tons of CO_2 emissions per year compared to a conventional ship (Vazquez & Strittmatter 2025). The world's first large-scale e-methanol production facility was officially inaugurated in 2025 at Kassø, Denmark (European Energy 2024), marking a milestone in commercializing this fuel. Several other projects are in development, for example, in Finland the energy company St1 is planning the country's first synthetic methanol plant with a €35 million government grant (H2Cluster Finland 2023). These early projects indicate growing economic and policy support. However, e-methanol currently remains significantly more expensive than fossil fuels – roughly 2–3 times the cost of conventional methanol (around $1,000+ per ton) according to industry estimates (Vazquez & Strittmatter 2025).

The aviation sector is one of the hardest to electrify due to the high energy density required for jet fuel. Synthetic aviation fuel, often called e-kerosene or e-SAF, is a drop-in kerosene equivalent produced from green hydrogen and carbon dioxide via Power-to-Liquid processes. It can be used in existing aircraft engines as a direct replacement for fossil jet fuel, making it a crucial tool to decarbonize air travel without aircraft modifications. The economic and regulatory push for SAF is strong: in 2023 the EU adopted the world's most ambitious aviation fuel mandate (ReFuelEU Aviation), which includes dedicated sub-targets for synthetic fuels. By law, at least 1.2% of all jet fuel supplied at EU airports must be e-kerosene by 2030, rising to 35% by 2050 (Transport & Environment 2025). This policy has catalyzed a wave of investments – as of early 2025, 41 commercial-scale e-SAF projects had been announced across Europe (Transport & Environment 2025). Together these planned facilities could yield about 2.8 million tons per year of e-jet fuel at full capacity, nearly three times the volume required by 2032 under EU mandates (Transport & Environment 2025). E-SAF is estimated to cost 4–6 times more than standard Jet A-1 fuel at present (IRENA 2024). This cost premium is expected to persist in the near term. However, the strategic importance of e-SAF cannot be overstated. Meeting net-zero goals for aviation by 2050 will likely require large volumes of E-SAF.

E-methane (also called synthetic natural gas or renewable methane) is methane produced by methanation of green hydrogen with CO_2. Chemically identical to fossil natural gas, it can seamlessly integrate into existing natural gas infrastructure (H2Cluster Finland 2023). This drop-in characteristic makes e-methane a compelling option to green the gas supply for heating, power generation, and even transportation without waiting for new infrastructure.

Synthetic methane can help reduce reliance on imported natural gas while using the same pipelines and storage – a notable consideration given recent supply shocks in 2022. The Finnish hydrogen strategy notes that using e-methane could “reduce reliance on natural gas imports” and take advantage of the country’s biogenic CO_2 sources.

2.3 Literature on project delivery models in infrastructure/energy.

Delivering large infrastructure and energy projects requires choosing the right project delivery model, and two commonly used forms are EPC and EPCM contracts. Engineering, Procurement and Construction (EPC) contracts (often called turnkey contracts) and Engineering, Procurement and Construction Management (EPCM) contracts differ fundamentally in contract structure, risk allocation, and the roles of the parties (Hogan Lovells 2023). In an EPC arrangement, the owner hires a single contractor to design, procure, and construct the project and deliver a complete, operational facility by a fixed date for a fixed price (Hogan Lovells 2023). The EPC contractor assumes responsibility for virtually all aspects – from detailed engineering to hiring subcontractors – and is liable for delivering the final result “ready to turn the key” over to the owner (Hogan Lovells 2023). This single point of accountability is a defining feature of EPC, the owner interfaces mainly with the EPC contractor, who in turn manages all subcontractors and vendors, taking on the risk of any cost overruns or delays under the lump-sum agreement (Hogan Lovells 2023). By contrast, an EPCM model is not a turnkey delivery but rather a form of professional services contract (Hogan Lovells 2023). The EPCM contractor is contracted to provide engineering design, procurement of equipment/materials, and project management services on the owner’s behalf, while the owner itself retains the contracts with construction contractors and suppliers (Hogan Lovells 2023). In other words, the EPCM contractor mostly plans and oversees the project – handling detailed design, organizing tender packages, and managing day-to-day construction oversight – but does not typically perform construction work directly nor guarantee the overall project cost or schedule. The owner under an EPCM acts as the de facto general contractor in terms of contractual relationships, with the EPCM firm serving as its agent for project execution (Construction Law Made Easy 2024). This structural difference means that EPC provides a single contractual throat to choke (all responsibility concentrated in one contract), whereas EPCM spreads responsibilities across multiple contracts managed by the owner, with the EPCM firm coordinating them.

From a risk and control perspective, the differences explained in previous paragraph mean that EPC and EPCM contracts handle risk and control in very different ways. In an EPC contract, most of the project risks are passed on to the contractor, who takes them on in return for a higher price. The EPC contractor agrees to deliver the project for a fixed price by a set date, absorbing risks of cost overruns, schedule delays, and performance shortfalls. The EPC contractor’s role as single point of accountability (H+M EPC 2025). The main advantage for the owner in an EPC contract is the certainty and simplicity it offers, as once the contract is signed, the owner can step back and have little direct contact with the subcontractors since the EPC firm manages any disputes or issues with them. The owner mainly controls the project by setting performance requirements in the contract and approving key design decisions, but the EPC contractor manages the day-to-day work and methods. In contrast, under an EPCM model the owner retains far more control over the project execution. The owner makes key decisions on contracting and can select individual construction contractors, this can lead to greater flexibility but also means the owner bears more risk. With multiple direct contracts, the owner is exposed to cost increases and contractor performance problems, since there is no single lump-sum agreement to cover overruns. This setup also raises the risk of cost overruns. In fact, EPCM contractors are usually paid through a reimbursable or fixed service fee, so they do not take on the project's cost or schedule risks like an EPC contractor does. The owner needs to have the ability to manage project risks. EPCM contracts are better suited for owners who have the knowledge, resources, and willingness to handle risks themselves, rather than paying a high premium to transfer those risks to an EPC contractor. Therefore, choosing between EPC and EPCM depends on how much control and risk the owner is willing and able to take on. If the owner wants more control over design and purchasing decisions and is comfortable managing project risks, an EPCM contract is a good option. However, if the owner prefers a hands-off approach with fixed cost and schedule certainty, an EPC contract is usually the better choice.

Another important factor is how flexible a contract is in handling scope changes or new technologies. EPC contracts work suitable when the project scope and technology are clearly defined from the start, since their fixed-price structure means that major changes or uncertainties can lead to change orders, claims, and disputes. Owners are generally discouraged from making design changes mid-project under EPC, as those will likely incur extra costs and require renegotiation. EPCM, by contrast, is often cited as a more flexible approach in fast-evolving or complex projects (Alvarez & Marsal 2023), in EPCM the project is essentially managed in an open-book manner, the owner can more readily incorporate design refinements or new requirements as the project progresses. Risks are better managed under EPCM – for example, ambiguous or developing scope is less problematic when the owner and EPCM contractor can adjust packages on the fly compared to an EPC where unclear scope definition at contract signing can cause major conflict later (Alvarez & Marsal 2023).

A central question in comparing EPC vs EPCM is which model leads to better cost and schedule performance. EPC's fixed-price, fixed-date nature provides greater certainty to owners and lenders and in practice, project finance deals often require an EPC contract to ensure the project is "bankable" with a single point of responsibility (Loots & Henchie 2007). Lenders are more comfortable when a solvent EPC contractor guarantees to deliver the project, which is why turnkey EPC contracts are common in large power plants, refineries, and similar capital-intensive projects (Construction Law Made Easy 2024). However, the reality of megaprojects is that even under EPC, many projects struggle with overruns. Industry surveys show disturbingly low success rates for on-time, on-budget delivery for example, a McKinsey/KPMG analysis noted only 1 in 4 EPC projects was delivered within its initial schedule, and only about 31% of projects came within their budgeted cost (Knight 2022). EPCM projects, on the other hand, don't have a single headline metric for overruns since the owner carries the budget. In the oil & gas industry, a notable trend has been that some projects initially attempted in EPCM were later converted to EPC or vice-versa depending on outcomes; for instance, when schedule certainty became paramount, owners switched to lump-sum EPC, and in other cases where initial EPC bids came in too high, owners reverted to EPCM to break down the scope and reduce costs.

Table 1 Comparison of EPC and EPCM Delivery Models

Aspect	**EPC (Engineering, Procurement, and Construction)**	**EPCM (Engineering, Procurement, and Construction Management)**
Contract Structure	Single, fixed-price contract with one main contractor responsible for design, procurement, and construction ("turnkey").	Multiple contracts managed by the owner; EPCM contractor provides design, procurement, and project management services.
Risk Allocation	Most risks (cost, schedule, performance) are transferred to the EPC contractor.	Risks largely remain with the owner, who manages multiple contracts and interfaces.
Control and Decision-Making	Owner has limited control after contract signing; contractor manages execution and subcontractors.	Owner retains high control and flexibility over decisions, contractor selection, and scope management.
Cost and Schedule Certainty	High certainty due to fixed-price and fixed-schedule terms; preferred for "bankable" projects.	Lower upfront certainty; actual costs depend on management effectiveness and project complexity.
Flexibility and Change Management	Low flexibility; changes after contract signing often lead to claims or renegotiations.	High flexibility; easier to accommodate scope changes or technology updates during execution.

Aspect	EPC (Engineering, Procurement, and Construction)	EPCM (Engineering, Procurement, and Construction Management)
Owner's Role	Passive—monitors performance and ensures compliance with contract specifications.	Active—acts as de facto general contractor, supported by EPCM firm.
Contractor's Role	Takes full responsibility for delivery, performance guarantees, and handover of completed facility.	Provides engineering and management expertise but not construction or performance guarantees.
Best Suited For	Well-defined, mature projects where scope and technology are clear and stability is valued.	Complex, evolving, or first-of-a-kind projects requiring flexibility, collaboration, and ongoing owner involvement.

2.4 Existing Barriers to Investment and Project Implementation in Power-to-X (PtX)

Although the EU including Finland have set ambitious targets for renewable hydrogen and derivative e-fuels, only a small share of the announced project pipeline is moving to final investment decision (FID). The International Energy Agency IEA notes that in 2025 less than 10% of planned low-emissions hydrogen capacity worldwide is committed or under construction, with Europe being no exception. In the Nordic region, 167 hydrogen/PtX projects have been identified, but only about 1–2% are in implementation, the rest remaining at planning stage (Nordic Energy Research 2024, 7–9). This implementation gap is not primarily technical but business, regulatory and delivery related. In the European context, three clusters of barriers can be identified:

1. regulatory and permitting uncertainty,
2. market and financing constraints, and
3. delivery and execution risk.

Regulatory and permitting uncertainty

PtX projects in Europe still operate in a moving policy environment. Key regulatory elements — such as the detailed conditions for counting hydrogen as "renewable" under the RFNBO rules, sustainability criteria, and state-aid eligibility — have been introduced in stages, which has made it difficult for project developers to lock in business cases and for financiers to assess long-term revenue visibility (IEA 2025, 178; European Commission 2025). In practice, investors discount projects more heavily when they cannot be sure whether the product will qualify for EU support schemes or future national quotas. This is visible in Finland as well, although the Government Resolution on Hydrogen clearly signals that Finland aims to supply up to 10% of the EU's renewable hydrogen by 2030 (Finnish Government 2023), the resolution also acknowledges that national measures must still be aligned with forthcoming EU rules on certification, infrastructure and state aid (Finnish Government 2023). In other words, the political direction is clear, but the operational framework is not yet fully fixed.

A related barrier is slow and multi-layered permitting. The IEA highlights that lengthy environmental approvals, land-use decisions and grid-connection processes are among the most common reasons for European hydrogen project delays (IEA 2025, 116). The Nordic hydrogen valleys study reports the same, municipalities and regional authorities often have limited prior experience with hydrogen safety, high-voltage connections or large electrolysis plants, which prolongs permitting (Nordic Energy Research 2024, 78). Finland has started to address this, but at the time of writing the administrative pathway is still seen by developers as time-consuming and uncertain, especially when several authorities (environment, energy, grid, municipality) must approve the same project. For investors this matters because every month of permitting risk increases development costs and pushes FID further out, which worsens project net present value.

Market and financing constraints

The second group of barriers is commercial, not technical. Many European PtX projects are designed for future rather than current demand. The IEA shows that only about 5% of the announced hydrogen volumes are backed by firm offtake contracts, the rest relying on "expressions of interest" or expected future regulation (IEA 2025, 90). Without long-term, creditworthy offtakers for example steel mills, fertilizer producers or shipping companies willing to pay a green premium accordingly banks are reluctant to provide non-recourse project finance. This is precisely why several high-profile European e-fuel projects have been postponed or down-scaled in 2024–2025 (IEA 2025, 91–92). Finland's situation mirrors this pattern, the country can produce large amounts of low-cost wind power, but domestic hydrogen and e-fuel demand is growing more slowly than production potential (H2Cluster Finland 2023, 11). This creates a "supply–demand timing gap", production projects are ready to move, but the customers like steel, chemicals and shipping are not yet ready to sign multi-year take-or-pay contracts at current PtX price levels.

Because of this demand uncertainty, PtX projects often need public risk-sharing to get close to Final Investment decision. A good Finnish example is the Joensuu renewable hydrogen and e-methanol plant, Business Finland granted EUR 60 million to the company P2X Solutions in 2025 specifically to make the investment decision possible, and the company itself stated that the grant “moves us closer to the investment decision” (P2X Solutions 2025). That is, even a technically mature project with a clear industrial use needed substantial public co-funding to become bankable. The financing barrier is therefore less about the absence of capital in the market, and more about risk perception, lenders and equity investors still see PtX as first-of-a-kind, exposed to policy change, technology integration risk and demand volatility, so they require guarantees, contracts-for-difference or investment grants to participate (IEA 2025, 172). In smaller markets like Finland, where the number of large off-takers is limited and export routes (e.g. the hydrogen backbone towards Central Europe) are only planned for 2030 (Gasgrid Finland 2024), this perception is even stronger.

Delivery and execution risk

Finally, there is a barrier which is often underestimated in the policy discussion but very visible to financiers and EPC/EPCM companies: how the project will be delivered. PtX plants are not single-asset solar parks; they are multi-asset, multi-vendor systems that combine renewable power, electrolysis, CO_2 capture or import, synthesis units, storage and port or pipeline connections. The IEA notes that the wave of projects cancellations in 2024–2025 was not only due to costs, but also to supply-chain and implementation challenges for first large-scale plants (IEA 2025, 39). The Nordic hydrogen valleys report similarly states that coordination among several stakeholders, energy companies, municipalities, off-takers, grid operators is a specific barrier in Nordic projects, and that “multiple stakeholders must make investment decisions” for the value chain to work (Nordic Energy Research 2024, 78).

From a business and contracting perspective, this translates into delivery-model uncertainty. Investors typically prefer a single point of accountability, i.e. an EPC contract, because it reduces interface risk and makes cost and schedule more predictable for the lender. But in PtX, very few contractors are willing (or even able) to wrap the entire value chain renewables + electrolysers + e-fuel synthesis into one lump-sum turnkey package without charging a significant risk premium. As a result, several projects are pushed towards an EPCM or multi-contract setup, where the owner keeps the contracts with equipment vendors and construction firms and relies on a management contractor only for engineering and coordination. This model is more flexible and better suited to first-of-a-kind Finnish or Nordic projects that still need to adjust technology choices, but it also shifts risk back to the owner and can make the project less attractive to conservative financiers. In other words, the choice between EPC and EPCM becomes itself an investment barrier when investors are not convinced that interfaces, performance guarantees and schedule risks are under control. This is precisely why analysing EPC vs EPCM in the PtX context is relevant for this thesis.

Table 2 Barrier categories and associated business impacts in Power-to-X projects

Barrier Category	**Business Impact**
Regulatory & permitting uncertainty	Delayed timelines, increased cost of capital, reduced investor confidence.
Market & off-take uncertainty	Lack of predictable revenue stream → projects not bankable.
Financing & delivery model risk	EPC/EPCM choice becomes critical to controlling risk and enabling implementation.

3 Methods

The research methodology section of this chapter shows how the researcher studied the impact of Engineering Procurement and Construction (EPC) and Engineering Procurement and Construction Management (EPCM) delivery methods on three areas which include investment activation and risk management and project execution performance in Power-to-X (PtX) projects. The researcher chose a qualitative research method because the PtX sector is still developing and there are few large-scale finished projects in existence. The chapter provides an overview of the research design which includes data collection techniques and study participants and data analysis methods and ethical standards and data handling procedures that were used during the research process. The research methodology establishes transparent procedures which enable researcher to confirm the accuracy of their findings which will be presented in upcoming chapters.

3.1 Approach: Qualitative research - Semi-Structured interviews, document analysis.

The researcher used qualitative research methods to investigate the impact of Engineering Procurement and Construction (EPC) and Engineering Procurement and Construction Management (EPCM) delivery systems on Power-to-X (PtX) project investment initiation and risk assessment and initial project development progress.

The implementation of a qualitative method remains necessary because European PtX projects especially those in Finland currently exist within development and pilot and initial execution phases which yield insufficient completed projects for quantitative assessment. The selection of delivery methods and financing preparedness and risk distribution decisions depend on the knowledge and experience of experts and existing institutional practices instead of using standardized performance metrics.

The research employs semi-structured expert interviews together with document and literature evaluation methods. The literature review establishes the conceptual and industry background, while the interviews provide practice-based insights into how EPC and EPCM models are applied, perceived, and negotiated in real PtX project contexts. The study combines semi-structured expert interviews with document and literature analysis. The literature review establishes the conceptual and industry background, while the interviews provide practice-based insights into how EPC and EPCM models are applied, perceived, and negotiated in real PtX project contexts.

The research adopted a qualitative methodology to investigate how Engineering, Procurement and Construction (EPC) and Engineering, Procurement and Construction Management (EPCM) delivery models influence investment activation, risk allocation, and early-stage project development in Power-to-X (PtX) projects. Qualitative research is particularly suitable when the objective is to explore complex phenomena, understand stakeholder perspectives, and generate insights in contexts where limited prior empirical evidence exists. According to Creswell (2018), qualitative research can be understood as a process of inquiry aimed at exploring and understanding the meaning individuals or groups attribute to a social or human problem, whereas quantitative research focuses on testing theories through measurement and statistical analysis. In this sense, qualitative research can be described as a “journey of discovery,” while quantitative research represents a “journey of testing,” where predefined hypotheses are examined using numerical data (Saunders, Lewis & Thornhill 2019).

The choice of a qualitative approach was considered appropriate because the European PtX sector, particularly in Finland, is still emerging, with many projects remaining at development, pilot, or early execution stages. As a result, there is limited availability of completed projects and standardized performance data suitable for quantitative analysis. Decisions regarding delivery model selection, financing readiness, and risk allocation are therefore largely influenced by expert knowledge, organisational practices, and contextual factors rather than measurable historical datasets. Qualitative methods enable capturing these experiential insights and industry perspectives more effectively than quantitative approaches.

3.2 Target Group: Project developers, project managers and investors.

The researcher used structured interviews to gather their data which they collected from professionals who had direct experience with every stage of PtX project work from development to financing and advisory activities. The researcher used purposeful sampling to choose their target group who had direct knowledge of EPC and EPCM delivery processes for complex energy and industrial projects.

The interviewees included:

- Project developers involved in early-stage PtX and green hydrogen projects
- Project managers and senior engineers from EPC and EPCM organizations
- Industry experts and consultants who have worked on large infrastructure projects and energy transition initiatives
- Professionals who work in finance and investment for capital raising activities and bankability assessments and investor discussions

The interviewees had experience which included Nordic and European and international backgrounds, and they conducted several interviews which specifically focused on Finnish and Nordic project conditions that included details about contractor availability and contracting practices and investor expectations. The different backgrounds of the participants allowed researcher to study how organizational roles and regional market conditions impact their work.

The interviews are documented in full transcripts.

3.3 Data Collection Tools: Interview guide

Data was collected primarily through semi-structured interviews, guided by an interview framework developed specifically for this thesis. The semi-structured format ensured that all interviews addressed the same core themes while the interviewers could adapt their questioning approach based on the interviewees personal background and expertise.

The interview guide covered the following key themes:

- EPC and EPCM delivery methods allocate their risks to different parties while creating distinct execution obligations
- The selected delivery model determines when investments begin and whether financing will be obtained
- Cost control and schedule performance received assessment from the participants who viewed delivery model choice as their primary project execution method.
- The integration of technology in PtX projects faces challenges due to technology maturity and system integration difficulties.
- Project development requires organizations to implement flexible change management methods.
- EPCM and EPC delivery methods require different organizational structures and organizational capabilities.

The open-ended questions allowed interviewees to use their actual project work and their industry expertise to respond to the questions. The interviewers used follow-up questions to obtain clarification on different points while investigating the actual contract implementation process which differed from the theoretical contract model.

The researcher conducted their interviews in professional settings which they recorded after receiving participant permission and they used these recordings for their comprehensive analysis.

3.4 Data Analysis Method

The interview data was analysed using a thematic analysis approach, which is well suited for identifying recurring patterns, contrasts, and explanatory insights across qualitative datasets.

The analysis process followed five main steps:

- Familiarisation
  The researcher read all interview transcripts multiple times to comprehend both content and context of the interviews.
- Initial coding
  The researcher found and coded statements that described delivery models and risk allocation and financing and execution uncertainty and organizational capability. The research questions helped direct coding while the data brought forth repeating concepts.
- Theme development
  The analysis used related codes to create broader analytical themes which included:
    - Investment activation and bankability
    - Risk transfer versus risk retention
    - Cost and schedule certainty
    - Owner capability and governance
    - Flexibility and change management
    - Regional and market-specific constraints
- Comparative analysis
  The researcher compared themes across interviews to find commonalities and distinctions between EPC and EPCM viewpoints and between developers and contractors and finance-oriented stakeholders.
- Interpretation
  The findings were interpreted in relation to the existing literature and the conceptual framework developed in Chapter 2, allowing the study to connect empirical observations with established theories and industry knowledge.
  This approach supports a structured yet flexible analysis that reflects the complexity and context-dependent nature of delivery model selection in PtX projects.

3.5 Ethical Considerations

Ethical principles were applied throughout the research process in accordance with Laurea University of Applied Sciences guidelines and General Data Protection Regulation (GDPR) requirements

The research employed these main ethical safeguards:

- Informed consent
  Interviewees were informed about the purpose of the research and how the data would be used.
- Confidentiality and anonymization
  Names, organizations, and identifiable project details were anonymized to protect participants and avoid commercial sensitivity.
- Voluntary participation
  Participation was voluntary, and interviewees could withdraw at any time.

The research did not use any sensitive personal data because all data was restricted to academic research purposes.

3.6 Data Management

All interview transcripts and research materials were stored in password-protected digital files on google drive accessible only to the researcher. Data management followed principles of confidentiality, data minimization, and secure storage.

- Interview data is stored only for the duration of the thesis project.
- Access to the data is restricted to the researcher.
- All interview materials will be deleted after thesis completion and approval, in line with good academic practice and GDPR requirements.

4 Results

This chapter presents the findings derived from the qualitative analysis of the semi-structured expert interviews. The results are organised thematically and comparatively, reflecting recurring patterns and contrasts across interviewee perspectives. The findings focus on how EPC and EPCM delivery models influence investment activation, risk management, and project performance in Power-to-X (PtX) projects, particularly in early development and pre–Final Investment Decision (FID) stages.

4.1 Thematic summaries of interview data.

The interview transcripts showed that stakeholders from three different groups which included project developers, EPC and EPCM contractors and industry experts shared multiple themes. The themes demonstrate that delivery model selection depends on three factors firstly Investment Activation and Bankability, secondly Risk Allocation and Responsibility, thirdly Flexibility and Change Management and fourthly Organizational Capability and Governance

4.1.1 Investment Activation and Bankability

The dominant theme across all interviews indicates that PtX projects receive investment activation through execution risk understanding rather than technology maturity assessment. The interviewees reached a general consensus that electrolysers and their associated process technologies have achieved proven status yet there exists uncertainty about how integrated PtX plants will be implemented at industrial scale. Several interviewees noted that financiers and investors tend to focus on:

- Who carries construction and performance risk
- Whether costs and schedules are contractually defined
- The presence of guarantees or a single accountable counterparty.

The delivery model itself establishes a crucial element which determines whether a project can advance toward FID. The interviewees showed that lenders face extended negotiation periods because of unclear or dispersed responsibility frameworks which sometimes result in halted investment processes. As one interviewee explained:

"F*or new technologies such as Power-to-X… investors prefer an EPC model because they see it as more certain — you're given a price and that is the price*".

It was also said that

"Investors and banks prefer EPC as it's a single point liability and the risk is only on one party really"

This highlights how fixed-price structures reduce perceived execution risk for lenders.

4.1.2 Risk Allocation and Responsibility

The analysis of risk allocation became the main focus of research. The interviewees described EPC and EPCM systems as two distinct methods which allocate project risks to different parties. The EPC contracts establish fixed-price and fixed-schedule requirements which shift most project risks to the contractor. Investors found this approach beneficial because it establishes clear responsibility and minimizes risks for the owner's operational responsibilities, As one interviewee said

“For an EPCM model the end client would carry the main risk… whereas for an EPC execution the risk more or less solely lies with the EPC provider.”

and another one clearly stated

“EPC supplier takes the risk of meeting the production guarantees, the budget and the schedule, whereas EPCM supplier doesn’t take those.”

The interviewees described EPCM arrangements as risk-retention models which force project owners to bear all expenses and schedule delays and coordination difficulties. The method provides project owners more operational freedom, but it demands their complete responsibility to oversee all interactions between different contractors and suppliers. The interviewees said that EPCM projects need strong governance structures because their absence makes projects prone to cost overruns and delays.

4.1.3 Flexibility and Change Management

Organizations must have flexible methods for handling changes to project scope and their technological development processes. Interviewees widely agreed that PtX projects at their initial phases need to adapt their basic assumptions about feedstock availability and offtake structures and technology configuration and regulatory requirements. The fixed-price nature of EPC contracts creates rigid structures which prevent any contract modifications after signing and result in claims and contract renegotiations, as quoted from one interview

“The moment the contract is signed, it’s up to the EPC contractor to deliver… you have no opportunity to change things due to new insights”.

The project development process enables owners to use EPCM as a design methodology which allows them to make use of advanced technologies throughout the entire project development process, as one interviewee said

“*EPCM can be really a strong tool… the owners still have influence on the choices that are made*”.

4.1.4 Organisational Capability and Governance

The success of delivery models depended on organisational capability as the crucial factor that determined their effectiveness. The interviewees stated that EPCM operates successfully only when the owner possesses adequate internal resources together with necessary experience and decision-making power, as mentioned by one of the interviewees

“EPCM operates successfully only when the owner has adequate internal resources together with necessary experience and decision-making power.”

The key capability requirements included the following:

- Organizations need to develop strong project management and cost control functions
- Organizations need to establish clear governance and decision rights
- Organizations need professionals who can handle complex contractor relationships.

The EPC delivery method proved better for owners who wanted to stay uninvolved or who did not have the required skills to manage their projects. In these scenarios the increased EPC expenses functioned as a premium expense which helped decrease organizational burdens while transferring organizational risks to others.

4.2 Comparative findings between EPC & EPCM approaches.

The interview results show that EPC and EPCM methods do not have one superior model for use in all situations. The two models show different strengths and weaknesses which project teams must assess according to their specific project needs and stakeholder requirements.

EPC contracts receive higher investment backing because they define responsibilities clearly while maintaining contractual agreements. The interviewees revealed that lenders show a strong preference for EPC structures because these contracts help them handle critical integration risks during the initial development stage of PtX projects which lack operational experience.

EPCM systems enable owners to achieve better project execution through complete visibility and control which helps them reduce expenses and choose vendors. The organization gains execution advantages through this system yet needs to deal with execution risks and increased operational requirements, one interviewees cleary stated the difference

“*EPC gives less control but shifts risk to the contractor at a higher cost, while EPCM offers owners more control and flexibility but places more risk on them*.”

The interviewees explained that project teams decide between EPC and EPCM because they face practical constraints, which include:

- The existence of EPC contractors who accept PtX-related risks
- The price increases which come with lump-sum contract agreements

- The needs of investors and lenders
- The internal abilities of the project owner organization

4.3 Impacts on project stages

The interviews showed that project development needs different delivery models because EPC and EPCM delivery models show different suitability levels throughout the entire project development process especially in PtX projects. The early development stage and pre-FEED stage required EPCM or EPCM-like arrangements as their preferred choice. The interviewees indicated that this particular stage presents high uncertainty levels which create a need for flexibility that enables them to refine technical solutions while assessing offtake options and dealing with regulatory changes. The project team must focus on risk reduction activities which increase investment certainty as projects advance toward FID. The project team found that EPC contracts or EPC wraps for essential project components provided better solutions to meet lender standards and complete financing agreements. The interviewees shared different construction and commissioning experiences throughout their work. The single point of accountability in EPC execution makes it easier to manage projects. The project encountered disputes and delays because the original scope definition and contractor performance failed to meet project requirements. The strong owner governance system in EPCM enables organizations to execute complicated projects. The organization needed to accept additional responsibility and risk to achieve the project outcome. The research results demonstrate that delivery model selection functions as a continuously changing process which develops through the different project development stages from concept through execution of PtX projects. The understanding of EPC and EPCM as tools that work together should replace the current view that sees them as opposing options.

5 Conclusions and reflection

The chapter presents an analysis of study results which shows how these results impact theoretical frameworks and practical applications. The empirical findings create a connection between the research results and the knowledge base established in Chapter 2 which shows how Engineering Procurement and Construction and Engineering Procurement and Construction Management delivery systems affect investment activation and risk management and project results in Power-to-X projects. The chapter also evaluates the chosen research approach, discusses limitations, and outlines recommendations and areas for further research.

5.1 Conclusions and Interpretation

The thesis aimed to evaluate how EPC and EPCM delivery systems function in PtX projects while showing their impact on three areas which include the initiation of investments and the distribution of risks and the results of early project operations. The results demonstrate that delivery model selection creates essential elements which determine both project viability and financial backing throughout the period before investors make their Final Investment Decision. The study results match existing research about big infrastructure projects and project finance which shows that execution risk clarity functions as an essential factor which determines whether investments will be made. Investors continue to exercise caution regarding PtX technologies which include electrolysis and synthetic fuel production despite their rising technical maturity because of their uncertainties about integration and construction challenges and first-of-a-kind operational risks. The delivery model functions as a tool which organizations use to identify and control their operational hazards in this situation because it serves more than just its role as a legal agreement.

The results show that EPC contracts usually help to generate investments because they establish one responsible party who makes binding monetary commitments and performance promises. The characteristics of these elements match the lending and financing requirements which project bankability needs according to existing literature because these elements enable borrowers to transfer risk while creating definite legal agreements. EPC contractors charge their clients higher costs for uncertain situations because they need to establish risk premiums, and they must limit their operational capabilities.

The EPCM system provides better project control through its ability to adapt its operations and show project expenses while tracking project progress, which benefits initial PtX projects that require both process development and technical solution implementation. The research literature demonstrates that management-oriented delivery models provide better support for learning and adaptation needs required by complex and innovative project work, which leads to their identification as better-suited methods. The EPCM system transfers both risk management and project coordination duties to the client, which causes project execution to rely entirely on the company's operational skills and its development of governance practices. The literature and interview data reveal that organizations need to select their delivery system based on their internal capabilities, their project development stage, and their specific investor needs. The findings therefore challenge a binary "EPC versus EPCM" perspective and suggest that delivery model choice should be understood as a strategic decision contingent on context.

The study shows that EPC and EPCM operate as two distinct methods for managing project risks, which both offer different levels of risk certainty and operational flexibility. The combination of both methods tends to be the most practical solution within the PtX environment, which operates under conditions of high uncertainty and rapid technological progress.

5.2 Assessment of the development setting: results, chosen methods, including reliability and ethics

The study needed this research design because it matched their research objectives. The available quantitative data on PtX projects in Europe and Finland remains restricted because these projects continue to develop. The expert interviews showed important information about actual work methods and the ways people make decisions and think about things which quantitative methods could not capture. The researcher used semi-structured interviews to gather detailed information from participants while keeping their answers comparable. Thematic analysis showed researcher how to find repeated patterns and contrasting elements which enabled them to construct their findings through organized methods instead of using informal evidence.

The reliability of the findings is strengthened by:

- Interacting with industry professionals who possess extensive practical knowledge
- Gathering viewpoints from multiple stakeholder categories (developers contractors consultants finance-facing experts)
- Evaluating interview results together with academic research and industry publications

The research team solved ethical issues through three main methods which included obtaining participant consent and protecting their identities and handling data according to GDPR regulations. The research team designed these processes to guarantee the research fulfilled both academic and professional requirements.

The results of qualitative research produce expert-based interpretations which lack statistical validity for general application to broader populations. The findings should therefore be understood as analytical insights grounded in expert perspectives.

5.3 Recommendations: When to choose EPC vs EPCM in PtX projects

Based on the findings, several practical recommendations can be formulated for project developers, investors, and contracting organizations involved in PtX projects.

EPC becomes the better option when project needs both strong bankability and lender trust for financing needs and project needs defined project scope and technology configuration and if the owner needs to transfer construction risk and project team role is to manage the project internally.

EPCM becomes the better option when project needs design work because its technology needs multiple design iterations, and the organization needs to choose between managing internal projects with good capabilities and having better control over procurement and contractor selection and using risk retention as a cost-saving strategy.

Hybrid or phased approaches might become most effective when projects need flexible management through EPCM or management-led approaches during their initial phase and they need total project certainty through EPC wraps during their critical package development.

The hybrid model in this context operates as a project delivery method which uses both EPCM and EPC elements throughout the project execution process and through various project execution segments. The owner uses different delivery methods for project execution because project stages have different development statuses and risk assessment needs.

The project team uses an EPCM or management-led approach during early development and front-end engineering design (FEED) process because these phases need flexible scope definition and technology configuration and supplier selection processes. The owner maintains control at this stage because it lets them develop technical solutions while keeping costs visible and making adjustments without following the strict rules of lump-sum EPC contracts.

As the project progresses toward Final Investment Decision (FID) and financing negotiations, the focus shifts from flexibility to certainty. To satisfy lender and investor requirements, selected high-risk or capital-intensive elements of the project may then be transferred to EPC or turnkey contracts. These “EPC wraps” provide fixed-price commitments, schedule guarantees, and clear accountability, thereby improving bankability while limiting exposure to construction and performance risks.

5.4 Limitations

The research relied on expert interviews which were, the sample included experienced professionals yet it lacked representation from bankers or lenders in PtX market. The research findings show European and Nordic contexts as the main source of insights which particularly apply to Finland but do not match other regulatory or contracting systems. The research investigates projects which are in their initial development phase instead of delivered PtX facilities. The construction and operational phases of projects will provide additional data which can change the current conclusions about performance results.

5.5 Areas for Further Research \ Development

The ongoing development of Power-to-X (PtX) markets leads to the identification of essential research areas which require investigation. Research needs to focus on hybrid contracting methods because actual project execution requires construction teams to use integrated delivery methods instead of single delivery systems. The analysis of mixed approach systems needs to show their operational framework and show their impact on project risk management and project execution and financial institution approval process.

The study needs to include direct investor and lender participation since financing institutions control the process of selecting delivery models. The study of how financiers evaluate construction risks together with their assessment of contractual frameworks and bankability needs will explain the reasons behind specific contracting methods chosen during different phases of a project.

The execution of comparative research between multiple regulatory frameworks and geographical areas will improve knowledge about how local regulations and market development and contractor networks shape delivery model performance. The implementation of successful strategies from one market to another becomes difficult when applying them to emerging Power-to-X regions which include Finland and other Nordic countries.

The research directions which follow this description will support the study's qualitative findings and help create better evidence-based methods which help future Power-to-X investment decisions.

6 References

Alvarez & Marsal. 2023. *EPC contracts: How to avoid disputes*. Accessed 14 September 2025. https://www.alvarezandmarsal.com/insights/epc-contracts-how-avoid-disputes

Bali, R. & Apte, M. R. 2014. *Financial risks and bankability in EPC contracts*. IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), 11(3) Ver. III, pp. 45-49. Accessed 16 October 2025. https://www.iosrjournals.org/iosr-jmce/papers/vol11-issue3/Version-3/F011334549.pdf

Becker, W. L., Penev, M. & Braun, R. J. 2012. *Production of synthetic natural gas from carbon dioxide and renewably generated hydrogen: A techno-economic analysis of a Power-to-Gas strategy*. Energy, 47 (1), 99–115. Accessed 12 July 2025. https://doi.org/10.1016/j.energy.2012.08.047

Budzier, A., Chaumontet, L., Hegnsholt, E., Zaayman, E., Holm, M., Møller, S. S., Grisard, M. & Iavarone, A. 2023. *Five strategies for optimizing Power-to-X projects*. Boston Consulting Group. Accessed 17 October 2025. https://www.bcg.com/publications/2023/five-strategies-for-optimizing-ptx-projects

Business Finland. 2024. How Finland is shaping Europe's hydrogen future. Accessed 13 July 2025. https://www.businessfinland.com/news/2024/how-finland-is-shaping-europes-hydrogen-future/

Business Finland. 2025. *Business Finland provided investment grant to P2X Solutions Joensuu plant*. Accessed 19 September 2025. https://p2x.fi/en/business-finland-provided-investment-grant-to-p2x-solutions-joensuu-plant/

Construction Law Made Easy. 2024. *EPC and EPCM - Construction Law Made Easy*. Accessed 19 September 2025. https://constructionlawmadeeasy.com/construction-law/chapter-2/epc-and-epcm/

Creswell, J. W. & Creswell, J. D. 2018. Research Design: Qualitative, Quantitative, and Mixed Methods Approaches. Sage

European Commission. 2024. *Hydrogen – EU policy*. Accessed 16 October 2025. https://energy.ec.europa.eu/topics/eus-energy-system/hydrogen_en

European Commission. 2025. *REPowerEU implementation monitoring report 2025*. Brussels: European Commission.

European Energy. 2024. *Power-to-X - European Energy*. Accessed 1 Novemberr 2025. https://europeanenergy.com/green-solutions/ptx/

European Investment Bank. 2022. *Unlocking the hydrogen economy — stimulating investment across the hydrogen value chain.* Accessed 10 August 2025. https://www.eib.org/files/publications/unlocking_the_hydrogen_economy_en.pdf

European Investment Bank. 2023. *Investment barriers in the European Union 2023.* Accessed 12 August 2025. https://www.eib.org/attachments/lucalli/20230330_investment_barriers_in_the_eu_2023_en.pdf

Eversheds Sutherland. 2023. *EPCM - the future of mega projects?* Accessed 14 October 2025. https://www.eversheds-sutherland.com/en/global/insights/epcm-the-future-of-mega-projects

Eversheds Sutherland. 2024. *EPCM - the future of mega-projects?* Accessed 1 November 2025. https://www.eversheds-sutherland.com/en/united-states/insights/epcm-the-future-of-mega-projects

Freshfields LLP. 2025. *The shift from EPC to EPCM: a recipe for more complex arbitrations?* Accessed 5 November 2025. https://www.freshfields.com/en/our-thinking/campaigns/international-arbitration-in-2025/the-shift-from-epc-to-epcm-a-recipe-for-more-complex-arbitrations

Fimpec. 2024. *Construction work begins at P2X Solutions' green hydrogen plant in Harjavalta.* Accessed 1 July 2025. https://fimpec.com/news/construction-work-begins-at-p2x-solutions-green-hydrogen-plant-in-harjavalta/

Finnish Government. 2023. *Government resolution on hydrogen - Finland could produce 10% of the EU's green hydrogen in 2030.* 9 February 2023. Accessed 2 July 2025. https://tem.fi/en/-/government-adopts-resolution-on-hydrogen-finland-could-produce-10-of-eu-s-green-hydrogen-in-2030

Gasgrid Finland. 2024. *Finland - a hydrogen great power. Could hydrogen be the next Finnish success story?* Accessed 12 August 2025. https://gasgrid.fi/en/2024/07/15/finland-a-hydrogen-great-power-could-hydrogen-be-the-next-finnish-success-story/

Good News Finland. 2021. *Finland building hydrogen-based economy.* Accessed 2 November 2025. https://www.goodnewsfinland.com/en/articles/news-spotlight/2021/finland-building-hydrogen-based-economy/

Henchie, N. 2007. *Worlds apart: EPC and EPCM contracts – risk issues and allocation*. London: Mayer Brown. Accessed 15 October 2025. https://www.mayerbrown.com/public_docs/worlds_apart_article.pdf

Hogan Lovells. 2023. *EPC or EPCM contracts?* Accessed 15 October 2025. https://www.hoganlovells.com/en/publications/epc-or-epcm-contracts

Hogan Lovells. 2024. *Current trends in construction contracts for energy transition projects*. Accessed 15 October 2025. https://www.hoganlovells.com/en/publications/current-trends-in-construction-contracts-for-energy-transition-projects

H2Cluster Finland. 2023. *Clean Hydrogen Economy Strategy for Finland*. Helsinki: H2Cluster. Accessed 16 October 2025. https://h2cluster.fi/wp-content/uploads/2023/06/H2C-H2-Strategy-for-Finland.pdf

H2 View. 2024. *Analysis: Balancing hydrogen project costs with delivery certainty in EPC wraps*. Accessed 17 October 2025. https://www.h2-view.com/story/analysis-balancing-hydrogen-project-costs-with-delivery-certainty-in-epc-wraps/2131172.article/

H+M EPC. 2025. *EPC vs. EPCM projects: Understanding execution models*. Accessed 15 October 2025. https://www.hm-ec.com/blog-posts/epc-vs-epcm-projects-understanding-execution-models-hm

IEA. 2025. *Global Hydrogen Review 2025*. Paris: International Energy Agency. Accessed 12 July 2025. https://www.iea.org/reports/global-hydrogen-review-2025

IEA. 2025. *Delivering Sustainable Fuels: Pathways to 2035*. Paris: International Energy Agency.

IRENA. 2024. *Decarbonising hard-to-abate sectors with renewables: Perspectives for the G7*. Abu Dhabi: International Renewable Energy Agency. Accessed 12 July 2025. https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2024/Apr/IRENA_G7_Decarbonising_hard_to_abate_sectors_2024.pdf

Knight, C. 2022. *EPC, EPCM or EPCOM – The evolving complexity of EPCs*. IFS Blog. Accessed 15 October 2025. https://blog.ifs.com/epc-epcm-or-epcom-the-evolving-complexity-of-epcs/

Loots, P. & Henchie, N. 2007. *EPC and EPCM contracts: Risk issues and allocation*. Geneva: FIDIC. Accessed 14 October 2025. https://fidic.org/sites/default/files/epcm_loots_2007.pdf

LUT University. 2023. *Power-to-X (P2X): What does it mean for energy and food production?* Accessed 1 August 2025. https://www.lut.fi/en/articles/power-x-p2x-what-does-it-mean-energy-and-food-production

MASTT. 2024. *EPCM vs EPC: Key differences explained.* Accessed 15 October 2025. https://www.mastt.com/blogs/epcm-vs-epc

Marvin, M. K. & Sarkinbaka, Z. M. 2023. *A review of Power-to-X and its prospects for integration in Nigeria's energy transition plan.* International Journal of Hydrogen Energy. Accessed 12 September 2025. https://sustainenergyres.springeropen.com/articles/10.1186/s40807-024-00129-9

Nordic Energy Research. 2024. *Nordic Hydrogen Valleys – Value Chain Mapping Across the Region.* Oslo: Nordic Energy Research. Accessed 15 August 2025. https://www.nordicenergy.org/publications/nordic-hydrogen-valleys-value-chain-mapping-across-the-region/

Norton Rose Fulbright. 2021. *Understanding hydrogen in the EU.* Accessed 1 October 2025. https://www.nortonrosefulbright.com/en/knowledge/publications/7b3fdaed/understanding-hydrogen-in-the-eu

Poly Consulting. 2025. *EPC and supply chain strategies in Power-to-X: Navigating technology, procurement, and risk.* Accessed 11 October 2025. https://www.poly.consulting/insights/power-utilities-and-renewables/epc-and-supply-chain-in-power-to-x

Reed Smith LLP. 2022. *Renewables projects: Structuring your construction contracts.* Accessed 12 September 2025. https://www.reedsmith.com/en/perspectives/energy-transition/2022/06/renewables-projects-structuring-your-construction-contracts

Saunders, M., Lewis, P. & Thornhill, A. 2019. Research Methods for Business Students. Pearson.

Strategic Energy Europe. 2025. *European Commission reprimands Greece and Finland over delays in transposing Renewables Permitting Directive.* Accessed 12 July 2025. https://strategicenergy.eu/european-commission-reprimands-greece-and-finland-over-delays-in-transposing-renewable-permitting-directive/

State Treasury. 2025. *Carbon-Neutral Finland 2035.* Accessed 2 October 2025. https://www.treasuryfinland.fi/investor-relations/sustainability-and-finnish-government-bonds/carbon-neutral-finland-2035/

Taylor Wessing. 2023. *"First of its kind: 'The Blue Book' Engineering, Procurement and Construction Management (EPCM) Contract."* Accessed 12 July 2025. https://www.taylorwessing.com/en/insights-and-events/insights/2023/06/uc-first-of-its-kind

Tichler, R., Bauer, S. & Böhm, H. 2019. *"Power-to-Gas."* In: [Editor's Name] (ed.) *Storing Energy*. Elsevier, pp. 25. https://doi.org/10.1016/B978-0-12-824510-1.00010-6

Transport & Environment. 2025. *E-kerosene - the role of synthetic aviation fuels in EU decarbonisation*. Brussels: Transport & Environment. Accessed 27 October 2025. https://www.transportenvironment.org/uploads/files/202504_e-kerosene_report.pdf

University of Copenhagen. 2024. *Researchers: If Power-to-X is to be a real climate solution, the state needs to use the stick*. Accessed 23 October 2025. https://www.eurekalert.org/news-releases/1067148

Vazquez, F. & Strittmatter, D.-A. 2025. *E-methanol - the game changer for decarbonizing shipping and industry*. World Economic Forum. Accessed 12 August 2025. https://www.weforum.org/stories/2025/02/emethanol-a-game-changer-for-decarbonizing-shipping/

Vinson & Elkins LLP. 2024. *EPC and EPCM Contracting in the Energy Transition*. Houston: Vinson & Elkins LLP. Accessed 22 October 2025. https://media.velaw.com/wp-content/uploads/2024/09/11134509/Features-775-p72-76.pdf

White & Case LLP. 2022. *Building the new: Creative solutions for procuring major energy projects*. Accessed 23 October 2025. https://www.whitecase.com/insight-our-thinking/building-new-creative-solutions-procuring-major-energy-projects

Whitehead, J. & Walters, K. 2014. *EPCM contracting: clearing the minefield*. The APPEA Journal, 54(1), 321-240. Accessed 29 October 2025. https://www.publish.csiro.au/ep/aj13023

Figures

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