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Project Finance in Renewable Energy Projects

An empirical study on hydropower and wind power projects in Norway from 2010 to 2023

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NORWEGIAN SCHOOL OF ECONOMICS

Acknowledgment

This master's thesis concludes our studies at NHH. Through this work, we aim to provide insights into the use of project finance in Norway's renewable energy sector, exploring its implications for hydropower and wind power projects. We are sincerely grateful to our supervisor, Dr. Konrad Raff, for his valuable guidance and feedback during the writing process. While the process has presented challenges, it has also been a highly rewarding experience, enhancing our knowledge and understanding of this important topic.

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Abstract

This thesis explores the financing mechanisms behind renewable energy projects in Norway, focusing on the distinction between project finance (PF) vs. corporate finance (CF). Using a dataset of 75 renewable energy projects from 2010-2023, the study examines the factors influencing financing choices in a market dominated by hydropower and financially robust domestic utilities that favor CF. However, PF plays a significant role in large-scale wind power projects, particularly those involving foreign sponsors. By drawing on economic and financial theories alongside insights from prior research on Germany (Steffen, 2018), this study provides a comparative perspective to understand the drivers and limitations of PF in a stable, low-risk market like Norway.

Employing a Generalized Linear Model with a logit function, the thesis analyzes key factors influencing the choice between PF and CF. The findings challenge traditional drivers of PF, such as contamination risk and agency conflicts, showing that these factors are not decisive in Norway's market. Instead, the financial strength and experience of Norwegian utilities enable them to rely on CF, even for larger wind power projects, by absorbing risks directly without the need for complex PF structures. However, PF remains relevant for high-risk wind projects sponsors by foreign utilities, where it mitigates information asymmetry and shields sponsors from liabilities through SPVs.

The findings highlight Norway's unique energy landscape, where stable market conditions, public financing mechanism, and robust institutional frameworks favor CF. Nonetheless, PF plays critical role in managing risks for specific projects, particularly those involving foreign sponsors and financial investors. The research underscores the importance of contextual factors, such as market stability and sponsor capacity, over traditional PF drivers like project size or ownership structure. These findings contribute to a broader understanding of renewable energy financing in mature, low-risk markets and provide a foundation for future comparative studies.

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1. Introduction

This study delves into the financing strategies employed in Norway's renewable energy sectors, analyzing the interplay between project finance (PF) and corporate finance (CF) in renewable energy projects from 2010 to 2023. CF dominates the financing landscape in Norway, driven by the strength of domestic utilities and the established nature of hydropower. However, PF emerges as an essential tool for high-risk, large-scale projects, particularly within the wind power sector. By combining an original dataset with theoretical insights from economics and finance, this thesis aims to shed light on the key drivers behind financing choices and the broader implications for Norway's renewable energy market.

Norway presents a unique case for studying the financing of renewable energy projects. With a renewable-dominated power system and a long history of stable energy markets, the country provides insights into how PF and CF function in a low-risk, well-established environment. Unlike countries like Germany, where utilities face a challenging transition from fossil fuels to renewables, Norwegian utilities operate in a market already dominated by renewables, allowing for strategic financing decisions tailored to project-specific risks (Steffen, 2018, p. 286).

CF is the predominant financing model for renewable energy projects in Norway. This dominance is driven by the Big Four utilities and regional/municipal utilities, which possess strong balance sheets, significant capital resources, and decades of experience in the sector. These entities favor CF for its simplicity, especially in hydropower projects, which are commonly medium-sized and low-risk. In contrast, PF is selectively used for large-scale wind power projects, where higher technological and market risks make it a more suitable choice.

Overall, the financing landscape for renewable energy in Norway is characterized by medium- to large-scale projects, where CF dominates due to the financial strength and expertise of domestic utilities. Larger project size and contamination risk are not primary drivers of PF usage in Norway, as these utilities are well-capitalized and experienced in both hydropower and wind power. Instead, PF is selectively used in large-scale wind power projects, reflecting its traditional role in managing high risks and shielding sponsors' core businesses (Steffen, 2018, p. 281). This is particularly relevant for foreign utilities in Norway, which face higher uncertainties and challenges related to information asymmetry and contamination risk. These factors remain key drivers of PF usage in such cases, despite their diminished significance in broader models.

Building on prior studies, such as Steffen (2018), this thesis examines PF in Norway's unique context. This analysis highlights the selective application of PF in a low-risk, well-established country and provides new insights into the dynamics of renewable energy finance in Norway. By analyzing the financing structures of renewable energy projects in Norway, this thesis sheds light on the nuanced roles of PF and CF in a renewable-dominated market. The findings contribute to a better understanding of how financing models are adapted to manage risks, ensure stability, and meet the specific needs of projects and sponsors in a stable, low-risk environment.

1.1 Primary Research Question

The financing of renewable energy projects in Norway, whether through PF or CF, has received limited attention in previous research. While the drivers of PF have been extensively studied in other low-risk environment, such as Germany, studies examining the interplay between PF and CF in Norway are scarce. This thesis aims to explore the relative importance of PF compared to CF for renewable energy projects in Norway. Specifically, we seek to understand the factors influencing the choice of financing structure and the underlying reasons behind the preference for PF over CF (or vice versa) in different contexts. To address this, our thesis focuses on the following research question:

"How important is project finance for renewable energy projects in Norway, and what are the drivers and underlying reasons behind its use?"

1.2 Outline

The thesis is divided into 11 sections. Section 2 provides an overview of financing methods, while section 3 reviews prior literature. Section 4 examines renewable energy technologies in Norway, and section 5 presents the hypotheses. Sections 6 and 7 focus on data and methodology, including testing assumptions and model selection. Selection 8 contains the descriptive analysis, and section 9 presents and interprets regression results. Section 10 concludes the thesis, while section 11 discusses its limitations and suggests directions for further research.

2. Financing Methods: An Overview

This section provides a comprehensive exploration of PF and CF, focusing on their defining characteristics, historical development, and applications. It begins by examining the evolution and core principles of PF, including its unique advantages for large-scale, high-risk projects. The discussion then transitions to CF, emphasizing its simplicity, reliance on the sponsor's balance sheet, and suitability for stable, low-risk projects. A comparison illustrates the strategic distinctions between the two models, followed by an analysis of their application within Norway's renewable energy sector, particularly for wind power and hydropower projects.

2.1 Exploring Project Finance and Corporate Finance

2.1.1 The Evolution of Project Finance

The concept of PF dates back centuries, with one of its earliest documented uses in 1299, when the English Crown obtained a loan from an Italian merchant bank to develop the Devon silver mines. Under this arrangement, repayment and risk were tied exclusively to the mine's output, rather than traditional collateral (Finnerty, 2013, p. 4). This precedent established the foundation for financing structures focused on project-specific outcomes.

In the 20th century, PF emerged as a preferred method for funding large-scale, resource-based projects. A notable example is the Trans-Alaska Pipeline System (TAPS) in the 1970s, where an alliance of oil companies used PF to distribute financial and operational risks associated with constructing an extensive and high-cost infrastructure project (Finnerty, 2013, p. 4). PF's adoption expanded significantly in the energy sector, particularly following regulatory changes such as the Public Utility Regulatory Policies Act (PURPA) of 1978 (Yescombe, 2014, p. 10). PURPA facilitated long-term contracts for independent power producers, providing predictable revenue streams that enhanced the feasibility of financing renewable energy and cogeneration projects (Finnerty, 2013, p. 5). Additionally, the 1980s witnessed the growth of Public-Private Partnerships (PPPs), leveraging private sector expertise and capital for infrastructure projects, including the Channel Tunnel and other energy facilities. These partnerships demonstrated PF's capacity to attract diverse funding sources while addressing public funding constraints (Yescombe, 2014, p. 10).

The evolution of PF reflects its adaptability across industries and regions. Initially applied to high-risk natural resource ventures, its scope expanded into energy and infrastructure, supported by regulatory innovations and the involvement of international financing institutions. Today, PF remains a vital financing method, enabling the development of large-scale and complex projects while efficiently managing risk and attracting diverse sources of capital.

2.1.2 Defining and Characterizing Financing Methods

Project Finance is a specialized financing method where the project's cash flow and assets serve as the primary sources of repayment and collateral, rather than relying on the sponsor's overall financial resources (Finnerty, 2013, p. 1). This structure is traditionally suited for large-scale, high-risk projects, such as those in the energy and infrastructure sectors, because it isolates financial risks to the project itself (Steffen, 2018, p. 281). At the core of PF is the establishment of a Special Purpose Vehicle (SPV), a legally independent entity created exclusively to develop and operate the project. The SPV confines financial risks within the project, shielding the sponsor's core business and assets from potential liabilities (Steffen, 2018, p. 281).

The emphasis on contractual frameworks and predictable cash flows is reflected in widely accepted definitions. According to the US Export-Import Bank, PF involves "*...the financing of projects that are dependent on project cash flows for repayments, as defined by the contractual relationships within each project*" (Yescombe, 2014, p. 5). Similarly, the Basel II Committee highlights PF's reliance on the revenues generated by a single project as both the source of repayment and the security for exposure (Yescombe, 2014, p. 6). These definitions emphasize PF's utility in complex, large-scale projects, such as power plants, infrastructure initiatives, and chemical facilities, where tailored financial arrangements and risk isolation are crucial (Steffen, 2018, p. 281).

A defining characteristic of PF is its risk allocation through a network of integrated contractual agreements – such as insurance policies, performance guarantees, and supplier contracts. This structured approach distributes risks among specialized stakeholders, such as contractors managing construction delays, insurers covering operational risks, and lenders focused on market volatility (Finnerty, 2013, p. 8). This structured approach reduces the likelihood of any single entity bearing excessive burdens and fosters collaboration among stakeholders. Furthermore, PF employs non-recourse or limited-recourse financing, meaning lenders rely exclusively on the project's cash flows for repayment, thereby minimizing the sponsor's financial exposure (Yescombe, 2014, p. 8).

Another distinctive feature of PF is its reliance on high leverage, enabling sponsors to finance up to 70–90% of a project's capital costs through debt (Yescombe, 2014, p. 8). This minimizes equity contributions while providing tax advantages through deductible interest payments, effectively reducing the overall cost of capital (Yescombe, 2014, p. 24). However, the high reliance on debt introduces vulnerabilities; cash flow disruptions can jeopardize debt repayment schedules. To address such challenges, PF often includes mechanisms like Debt Service Reserve Accounts (DSRAs), which act as safety nets during periods of low revenue. This feature makes PF particularly suitable for renewable energy projects with fluctuating cash flows, such as wind power in Norway (Whitelaw-Jones, 2024).

PF's long-term orientation further aligns financing arrangements with a project's operational lifespan – typically ranging from 15 to 25 years (Finnerty, 2013, p. 5; Yescombe, 2014, p. 7). This ensures consistent repayment schedules and financial stability throughout the project's lifecycle. Additionally, PF encourages joint ventures, enabling multiple stakeholders to share financial responsibilities and pool expertise. Such collaborations reduce individual exposure while fostering technical and financial innovation, which is particularly valuable in large, complex ventures (Yescombe, 2014, p. 23).

Beyond its practical application, PF has emerged as an area of academic interest. Researchers have explored how this method shapes corporate decisions on leverage, debt structuring, and equity allocation, as well as its impact on managerial behavior and overall business value (Finnerty, 2013, p. 44). Shah and Thakor (1987), in their theoretical study, argue that PF is especially advantageous for large, high-risk projects due to its ability to allocate risks more effectively. Subsequent empirical research, such as Chen, Kensinger, and Martin (1989), demonstrates the growing use of PF in medium-sized, lower-risk energy projects, reflecting its adaptability to diverse project scales and risk profiles (Finnerty, 2013, p. 13). These findings underscore the versatility of PF across varying project scales and risk profiles.

In contrast, **Corporate Finance** is the traditional method of funding investments and operations through a company's existing financial resources, such as retained earnings, equity, or debt (Berk & DeMarzo, 2020, p. 525). Unlike PF, CF integrates the financial outcomes of individual projects into the company's overall balance sheet, leveraging the firm's creditworthiness and broader financial position to secure funding (Finnerty, 2013, p. 23). This approach simplifies financing for projects with stable and predictable cash flows, as it allows firms to utilize internal capital efficiently while maintaining control over their operations.

The Modigliani-Miller theorem provides a theoretical basis for understanding CF. It asserts that in a perfect capital market, the firm's value is unaffected by its choice between debt and equity financing, as total cash flows remain unchanged regardless of the capital structure (Berk & DeMarzo, 2020, p. 529). However, market imperfections – such as tax advantages, transaction costs, and risk preferences – influence financing decisions. For example, debt financing offers significant benefits through tax-deductible interest payments, which reduce taxable income and the overall cost of capital (Berk & DeMarzo, 2020, p. 556). Conversely, equity financing raises funds by distributing ownership, aligning shareholder interests with the firm's long-term performance.

This flexibility allows firms to optimize their capital structure by issuing new securities, leveraging their balance sheets, or repurchasing shares. Share buybacks, for instance, can reduce outstanding shares, increase earnings per share (EPS), and signal confidence in the firm's valuation to investors (Berk & DeMarzo, 2020, p. 636). However, this integration of project outcomes into the firm's broader financial structure introduces risks. Excessive reliance on debt may incentivize managers to pursue high-risk strategies, knowing creditors bear much of the downside (Berk & DeMarzo, 2020, p. 623). On the other hand, underutilized leverage can result in inefficiencies, as surplus cash flow may be diverted to unproductive investments, particularly in firms with weak investor protections (Berk & DeMarzo, 2020, p. 623). Thus, CF's success hinges on maintaining an optimal balance between debt and equity, ensuring financial stability while promoting disciplined capital allocation. This balance highlights both the strengths and challenges of CF, particularly in projects with varying levels of risk and cash flow predictability.

While PF offers a structured, risk-isolated approach suited for large-scale, high-risk projects, CF provides a flexible and cost-efficient alternative for projects with predictable cash flows and lower risk profiles. The combination of PF's emphasis on contractual frameworks, high leverage, and risk-sharing mechanisms contrasts with CF's reliance on internal financial resources and simplified financing processes. These distinctions between PF and CF are particularly significant when analyzing financing decisions in renewable energy sectors, where project risks, cash flow predictability, and capital intensity vary significantly between technologies like wind and hydropower.

2.1.3 Comparing Strengths and Applications

Determining the optimal financing structure for a project requires a careful evaluation of PF and CF in relation to the project's goals, risk profile, and the sponsor's financial capacity (Finnerty, 2013, p. 22). CF pools cash flows and risks across the sponsor's portfolio, which enables efficient resource management but reduces transparency for individual project performance. PF, on the other hand, relies on a Special Purpose Vehicle (SPV) to isolate financial risks and liabilities to the project itself, making it particularly effective for high-risk, capital-intensive investments (Finnerty, 2013, p. 23).

A key difference between PF and CF lies in control and monitoring. CF is managed under general company oversight, providing managerial flexibility but with limited project-specific accountability. In contrast, PF imposes stricter monitoring through contractual arrangements, covenants, and cash flow controls, ensuring that project performance aligns with financial and operational objectives (Finnerty, 2013, p. 23).

Risk allocation further differentiates the two methods. PF isolates project risks through non-recourse or limited-recourse financing, tying repayment to the project's cash flows and assets. In CF, creditors have full recourse to the sponsor's broader portfolio, which spreads risks but increases the sponsor's exposure if a project underperforms (Finnerty, 2013, p. 23).

In terms of financial flexibility, CF allows for quick access to internal resources and existing credit lines, making it ideal for stable, predictable projects. PF, however, preserves the sponsor's balance sheet and enables higher leverage, though at the cost of greater complexity and financial scrutiny (Finnerty, 2013, p. 24).

Agency costs also differ between the two approaches. PF reduces agency costs by tying managerial incentives directly to project outcomes and enforcing closer monitoring by lenders and investors. CF may incur higher agency costs as corporate-wide objectives sometimes take priority over individual projects (Finnerty, 2013, p. 24).

Finally, CF's interconnected financial structure can help protect individual projects from financial distress but risks destabilizing the broader organization if one project fails. In contrast, PF confines liabilities within the SPV, ensuring that financial challenges remain isolated to the project (Finnerty, 2013, p. 25).

While PF offers risk isolation and structured financing for high-risk, large-scale projects, CF provides simplicity and flexibility for stable, predictable investments. Understanding these key differences allows sponsors to align financing choices with project-specific needs, financial strategies, and long-term goals.

2.1.4 Challenges and Limitations of Project Finance

Despite its widespread use and advantages, PF has several limitations that can impact on its practicality and cost-effectiveness. These challenges arise primarily from its structural complexity, higher transaction costs, and dependence on project-specific cash flows, making it less suitable for certain projects.

One of the key drawbacks of PF is its higher overall costs compared to traditional financing. These costs stem from arrangement fees, legal and consultancy expenses, and the extensive due diligence required by lenders (Finnerty, 2013, p. 30). Ongoing monitoring and financial oversight further add to these expenses, which can be particularly burdensome for smaller or mid-sized projects where the benefits of risk isolation may not justify the costs. The complexity of PF further amplifies these challenges. Coordinating multiple stakeholders, including sponsors, lenders, contractors, and regulatory bodies, creates a highly intricate framework that demands significant time and resources. This complexity can delay project implementation and increase administrative expenses, while adjustments to financial or operational plans often require renegotiation, adding further costs and rigidity (Finnerty, 2013, p. 30).

Another limitation of PF is its dependence on project-specific cash flows. Unlike CF, where repayment can be supported by the sponsor's broader financial resources, PF relies exclusively on the project's ability to generate revenue. This makes PF particularly vulnerable to market volatility, regulatory changes, and operational disruptions. For projects without stable cash flow streams – such as those lacking long-term Power Purchase Agreements (PPAs) – lenders often demand higher risk premiums, further increasing financing costs (Finnerty, 2013, p. 30).

Inflexibility is another critical challenge associated with PF. The rigid contractual structure, while offering risk allocation benefits, makes it difficult to adapt to changing market dynamics or unforeseen circumstances. Long-term projects are particularly exposed to this inflexibility, as renegotiations can be costly and time-consuming, posing additional risks for both sponsors and lenders. Moreover, the substantial transaction costs and structural complexity of PF make it less viable for smaller-scale projects. Legal, tax, and compliance expenses – combined with the need for specialized consultants – can outweigh the benefits, reducing profitability and feasibility for projects with limited budgets (Finnerty, 2013, p. 30). In such cases, CF often emerges as a more practical and cost-effective financing option. However, under specific circumstances, PF may still offer cost advantages, particularly when higher leverage and tax shield benefits lead to a lower after-tax, risk-adjusted cost of capital (Finnerty, 2013, p. 31).

While PF's challenges – such as high costs, complexity, and inflexibility – cannot be ignored, its unique ability to isolate risks and secure financing for capital-intensive projects ensures its continued relevance. A balanced evaluation of these limitations is essential to determine PF's suitability for specific projects and align it with stakeholder objectives.

2.2 Application in Norwegian Renewable Energy

The financing choices in Norway's renewable energy sector reflect the distinct characteristics of wind power and hydropower projects, as well as the risk profiles and capacities of their sponsors. PF is typically employed for large-scale, high-risk investments like wind power, while CF is preferred for more stable, low-risk projects such as hydropower.

Wind power projects in Norway face higher technological and market risks due to variability in wind resources and exposure to market-based electricity prices. These projects are often dominated by foreign utilities, which favor PF to manage and allocate risks effectively. By using a SPV, sponsors isolate project risks and financial performance from their core operations (Steffen, 2018, p. 281). This structure allows sponsors to attract external funding through non-recourse or limited-recourse loans, where repayment is tied solely to the project's cash flows and assets (Yescombe, 2014, p. 8). Given the high upfront capital costs and inherent risks, PF offers tailored risk-sharing mechanisms and financial flexibility, making it particularly suited for wind power development.

In contrast, hydropower projects benefit from the stability and predictability of water resources, along with regulated production frameworks. These attributes make CF the preferred financing method for Norway's regional/municipal utilities and the Big Four utilities, which have significant experience and strong financial positions. These sponsors typically integrate hydropower project outcomes directly into their balance sheets, leveraging their creditworthiness to secure favorable loan terms (Finnerty, 2013, p. 23). CF's simplicity and lower transaction costs align well with the lower risk profile of hydropower projects, while the stable, long-term revenue streams allow sponsors to maintain operational flexibility and manage multiple projects simultaneously.

The level of control and monitoring required further influences the choice of financing method. PF, with its detailed contractual arrangements and financial covenants, ensures strict oversight of project performance, reducing agency costs and aligning stakeholders' interests (Finnerty, 2013, p. 24). This is particularly relevant for wind power projects, where risks are higher, and foreign sponsors require robust governance frameworks. Conversely, CF offers greater managerial discretion, as creditors evaluate the sponsor's overall creditworthiness rather than individual project outcomes (Finnerty, 2013, p. 25). This approach suits hydropower projects, where operational and financial risks are lower, and sponsor stability ensures consistent performance.

This analysis illustrates how PF and CF align with the distinct attributes of renewable energy technologies in Norway. The higher risk and capital intensity of wind power favor PF's structured, risk-isolated framework, while the stability and predictability of hydropower revenues align with CF's flexibility and simplicity. By examining these dynamics, this thesis will explore how project size, sponsor type, and risk profile influence financing decisions in Norway's renewable energy sector, providing a comprehensive understanding of PF's and CF's respective roles.

3. Literature Review

This section provides the theoretical basis for our study on the drivers behind the use of PF in renewable energy projects. It offers an overview of theoretical insights by emphasizing key factors that may explain the use of PF, focusing on how it addresses specific project characteristics and market conditions. These factors are categorized into three main groups: financial synergies with existing operations, market imperfections, and organizational structure considerations.

Economic theory and financial literature have developed various models to explain how PF can create added value by addressing specific project characteristics and market conditions. In practice, there is rarely a single decisive reason for choosing PF (Steffen, 2018, p. 282). Instead, its applicability depends on a combination of factors specific to each project. These theoretical insights form the foundation for our hypotheses and guide the empirical analysis in identifying the drivers of PF usage in Norway. Furthermore, our study draws on prior research, particularly the theoretical framework established by Steffen (2018), which outlines key drivers behind the use of PF in renewable energy projects. This framework serves as a foundation for categorizing and analyzing the factors influencing financing decisions in the Norwegian context.

3.1 Negative Financial Synergies with Existing Business

When companies undertake new projects, such as building a power plant, they must carefully consider how the project aligns with their broader operations. While operational benefits like cost-sharing and improved efficiency are common, financial challenges can arise if the new project disrupts or complicates the company's overall financial structure. To mitigate these challenges, financial literature illustrates three key motivations for using PF to reduce the risk of negative financial synergies (Steffen, 2018, p. 282).

Reason 1: Contamination Risk

Contamination risk refers to the financial threat posed to a company's existing business when new projects are financed through CF. Under this approach, the parent company's assets and cash flows are used as guarantees to secure loans for the project. If the new project performs poorly, it can directly impact the financial stability of the parent company, potentially increasing its bankruptcy risk (Steffen, 2018, p. 282). This issue becomes particularly critical for large projects, as their size relative to the company's existing operations can increase the potential for financial distress. Risk is further heightened if the project's cash flows are both uncertain and correlated with the parent company's core business activities (Steffen, 2018, p. 282).

PF addresses contamination risk by isolating the financial risks of the new project within a separate legal entity (Steffen, 2018, p. 282). By structuring the project this way, any financial difficulties remain contained within the project itself, shielding the parent company from potential spillover effects. This separation not only protects the company's core operations but also lowers financing costs, as lenders view the reduced risk more favorably. In the context of power generation projects, such as large-scale wind power developments, PF is particularly suitable because these projects often involve high levels of investment and financial risk (Steffen, 2018, p. 282). While the motive to prevent contamination of a core business can theoretically apply to firms of any size, it is particularly relevant for companies with large, established operations (Steffen, 2018, p. 288).

Reason 2: Debt Overhang

Debt overhang occurs when a company's ability to finance new projects is constrained by an already high debt ratio on its balance sheet. This challenge reflects not only financial synergies but also broader market imperfections, as lenders may be unwilling to extend further credit even for profitable projects, particularly when multiple investments are planned in succession (Steffen, 2018, p. 283). In a CF setting, new projects are funded through a mix of equity and debt, but the availability of additional financing depends on the financial strength of the sponsoring company. If the sponsor's debt ratio is elevated, lenders may perceive the company as overleveraged, which can prevent the realization of otherwise viable investments (Steffen, 2018, p. 283).

PF addresses this by isolating the financial risks of a new project within a separate legal entity. This structure enables sponsors to raise capital specifically for the project without impacting their core balance sheet, protecting their existing operations from potential spillover risks (Steffen, 2018, p. 283). Additionally, PF allows for a higher debt ratio within the project itself, leveraging the associated tax benefits and enhancing financial efficiency (Steffen, 2018, p. 283). This approach is particularly advantageous for sponsors undertaking large-scale projects, as it demonstrates financial discipline to lenders while enabling them to adapt to the unique conditions of new markets more effectively.

Reason 3: Securitization

Securitization in PF is about separating safer, low-risk projects from a sponsor's main business if the main business is considered risky (Steffen, 2018, p. 283). Instead of connecting the project's financing to the sponsor's overall balance sheet, PF creates a separate legal entity for the low-risk project. This allows the project to secure loans or investments based on its own stable cash flows and lower risk, rather than being affected by the sponsor's high-risk activities (Steffen, 2018, p. 283).

This approach is useful for sponsors whose main business involves unpredictable or risky investments, as it lets them finance renewable energy projects on better terms. This is especially relevant for sponsors aiming to reduce overall financing costs or ensure that valuable, low-risk projects are not burdened by the risks of their broader business activities (Steffen, 2018, p. 283). In short, securitization ensures that the financing terms reflect the low risk of the project itself, rather than the financial challenges of the sponsor's broader operations.

3.2 Market Imperfections

In addition to financial synergies with existing operations, another key reason for using PF is its ability to address market imperfections. Economic theory underlines how PF can be an effective tool for managing challenges such as asymmetric information and agency costs. By structuring projects within a separate entity, PF creates mechanisms that help align incentives and reduce risks associated with information gaps and conflicting interests.

Reason 4: Information Asymmetry

Information asymmetry occurs when one party in a financial transaction has less knowledge or understanding of critical factors than the other, leading to increased uncertainty and risk. For companies operating in unfamiliar markets, such as foreign utilities entering new regulatory or operational environments, this asymmetry can be particularly pronounced. Lenders may perceive greater risks due to the sponsor's limited local expertise, making traditional CF less attractive or more costly.

PF addresses information asymmetry by isolating the project's financial and operational risks within a separate entity (Steffen, 2018, p. 283). This structure provides lenders with greater transparency into the project's cash flows, contracts, and risk profile, reducing the uncertainty caused by knowledge gaps. By offering a clearer, more focused view of the project's financial viability, PF becomes an effective mechanism to manage these risks and secure funding on more favorable terms. This makes it a preferred option for risky projects involving sponsors with limited familiarity with the market in which they are investing (Steffen, 2018, p. 283).

Reason 5: Agency Conflicts Between Project Owners and Contractual Parties

Agency conflicts occur when the goals of project owners and other parties involved in key contracts, such as fuel suppliers or electricity buyers, are not aligned. This misalignment can lead to situations where one party attempts to take advantage of their position, particularly in cases of close, exclusive partnerships. For example, after a project is completed, a contractual partner may push for more favorable terms, creating what is known as a "hold-up" problem (Steffen, 2018, p. 283). PF addresses these challenges by establishing detailed long-term contracts and, in some cases, integrating ownership across the supply chain. These measures ensure that all parties' roles and responsibilities are clearly defined and legally enforced, reducing the chances of such opportunistic actions (Steffen, 2018, p. 283).

Reason 6: Agency Conflicts Between Project Owners and Managers

Agency conflicts between project owners and managers occur when managers make decisions that do not align with the interests of the owners. In industries like power generation, where projects often generate free cash flows, managers may prefer to retain control over these funds rather than distribute them to shareholders. This can lead to reinvestments in projects or initiatives that may not provide sufficient value, reducing overall returns for the owners (Steffen, 2018, p. 283).

PF helps address this issue by imposing stricter financial controls. High debt ratios ensure that a significant share of the project's cash flow is allocated to debt repayment, reducing the flexibility managers must spend funds on other purposes (Steffen, 2018, p. 283). This financial structure encourages a focus on operational efficiency and value creation rather than unnecessary expansion or investments. By aligning financial incentives and creating accountability, PF reduces the risk of inefficient decision-making and helps safeguard the interests of the owners.

3.3 Considerations Regarding Organizational Structure

Additionally, PF can help create organizational structures that benefit the companies involved. By setting up a separate entity, it becomes easier to manage risks, allocate responsibilities, and align the interests of different stakeholders. This approach is often discussed in management and stakeholder theory to improve project efficiency and focus.

Reason 7: Allowing for Horizontal Joint Ventures

PF facilitates horizontal joint ventures, where companies operating at the same stage of the value chain, such as utilities, collaborate to develop a project. These partnerships are often driven by strategic goals, including the opportunity to share resources and risks or to acquire specialized knowledge about new technologies. For example, utilities may work together on a power generation project to learn operational skills for a specific technology, a motive highlighted in strategic management literature (Steffen, 2018, p. 284).

By structuring the project as a separate legal entity without recourse to the sponsors' balance sheets, PF ensures that the risks and responsibilities are distributed among the participants. This setup reduces potential conflicts and allows all parties to focus on the project's success. Moreover, horizontal joint ventures are particularly beneficial for projects where multiple similar sponsors can leverage their shared expertise to achieve better results (Steffen, 2018, p. 284).

Reason 8: Independence Through Regional/Municipal Ownership

Lastly, regional/municipal utilities often prioritize local energy independence and community-based sustainability goals, making PF a relevant tool for supporting these initiatives. Like civic projects, where independence from larger energy companies is a key motivation, regional/municipal utilities may also seek to maintain autonomy by using non-recourse PF structures. This ensures that the financial risks of the project remain confined to the project itself, safeguarding the broader financial stability of the municipality or region (Steffen, 2018, p. 284).

By adopting PF, regional/municipal utilities can structure projects to reflect local priorities, such as renewable energy development, while avoiding reliance on national or international energy companies. This approach allows these entities to operate as independent energy providers, focused on securing a stable and sustainable energy supply for their communities. Thus, the motivations for using PF align closely with the desire to maintain regional control and support long-term community goals (Steffen, 2018, p. 284).

4. Renewable Energy Technologies in Norway

Norway’s renewable energy sector is dominated by hydropower and onshore wind power, two technologies that have shaped the nation’s energy landscape. This chapter explores the historical significance and current role of hydropower, the growing potential of onshore wind power, and the ownership structures underpinning the sector. Furthermore, it examines policy instruments such as the elcertificate system, and evaluates the risks associated with these renewable energy technologies. Together, these topics form the foundation for understanding the unique context in which financing decisions are made for renewable energy project in Norway.

4.1 Hydropower

Hydropower dominates Norway’s energy system, accounting for over 90 percent of its electricity production, compared to a global average where hydropower contributes approximately one-sixth of electricity generation (Statkraft, n.d. A). This abundant and emissions-free energy positions Norway uniquely as a global leader in renewable energy, enabling the country to maintain a low-emission society powered by regulated hydropower reservoirs. Since the 19th century, Norway has leveraged its vast water resources to drive industrialization and economic growth, a legacy that continues to define its renewable energy landscape today (Regjeringen, 2019).

Historical Development and Industrialization

The potential of Norway’s water resources was recognized early by industrial pioneers and political leaders. In the late 19th century, Sam Eyde secured rights to hydropower development in Telemark to produce cheap electricity for industrial use (Regjeringen, 2019). This paved the way for the establishment of major companies such as Norsk Hydro and Elkem. In 1892, former Prime Minister Gunnar Knudsen emphasized the importance of hydropower, declaring it essential for national prosperity and the collective benefit of the population (Regjeringen, 2019).

Norway’s hydropower infrastructure began with the establishment of Hammerfest’s municipal hydropower plant in 1891, which made it the first Norwegian city with electric streetlights (Regjeringen, 2019). Oslo followed shortly after, with the construction of Hammeren power station in 1900, which remains operational to this day (Regjeringen, 2019). Although initially believed to meet Oslo's energy need indefinitely, Hammeren now supplies less than a day's worth of the city's electricity demand, illustrating the dramatic increase in energy needs over the last century (Regjeringen, 2019). While many countries relied on coal and oil during their industrial revolutions, Norway uniquely built its industry growth on clean hydropower. Today, Norwegian companies export hydropower technology globally and support other countries in developing their own renewable energy systems (Regjeringen, 2019).

Current Infrastructure and Upgrades

Norway's theoretical hydropower potential exceeds 600 TWh, if every waterfall would be utilized for energy production (NVE, 2024 A). However, this would require the development of multiple projects with significant environmental impacts. Over the past two decades, Norway has focused on upgrading and expanding existing hydropower facilities. More than 200 projects have been upgraded and expanded, resulting in an increase in power production of approximately 5 TWh, with 3.1 TWh generated under the electricity certificate scheme (NVE, 2024 A). Examples of modernized facilities include Lysebotn 2, Nedre Røssåga, and Vamma Power Station 12. While many hydropower plants constructed between 1950 and 1980 remain operational, aging infrastructure necessitates reinvestments, a trend expected to continue (NVE, 2024 A). These upgrades extend operational lifespans and enhance production efficiency, often serving as a more sustainable and cost-effective alternative to building new power stations (NVE, 2024 A).

Advancements in turbine technology have been a major focus of modernization efforts. NVE has identified significant potential for increasing efficiency in power plants over 10 MW by replacing the runner wheels, which is a critical turbine component. Although turbines typically have a technical lifespan of 50 years, many Norwegian turbines have outlasted this timeframe due to high maintenance standards. Replacing runner wheels in plants built before 1970 has already demonstrated measurable efficiency gains, with estimates suggesting an additional 2.1 TWh in annual production (NVE, 2024 A). Expanding this modernization across all plants over 10 MW could theoretically yield an additional 4.4 TWh annually (NVE, 2024 A). Beyond boosting production, these upgrades enhance water management and reduce flood risks in vulnerable waterways. As NVE underlines in its report *Climate Change and Future Floods in Norway*, adapting infrastructure to account for larger and more frequent floods will be essential in the coming decades (NVE, 2024 A).

Flexibility and Reservoir Management

Hydropower's flexibility remains one of its greatest strengths. Norwegian reservoirs store water during periods of excess supply and release it during times of high demand, allowing rapid responses to fluctuations in electricity needs (Statkraft, n.d. D). This flexibility makes hydropower an ideal partner for variable renewable energy sources like wind and solar, ensuring grid stability during periods of low wind or sunlight (Statkraft, n.d. D). Historically, flexibility in the European power system has been provided by fossil fuels, whereas Norway has relied on its regulated hydropower to balance the system (NVE, 2023 B, p. 3).

With nearly half of Europe's reservoir capacity, Norway plays a key role in balancing the continent's energy demands (Statkraft, n.d. A). These reservoirs act as Europe's largest "battery", enhancing Norway's strategic importance in the energy sector, particularly through its export capabilities (Statkraft, n.d. A). Additionally, hydropower reservoirs contribute to flood control, mitigating risks associated with extreme weather events.

Hydropower's Role in a Changing Climate

As climate change intensifies and energy demands rise, the modernization of hydropower infrastructure becomes increasingly critical. Regulated hydropower reservoirs offer significant advantages, including flexibility to accommodate variable energy sources and resilience against climate-induced challenges (Statkraft, n.d. E). Hydropower plants equipped with reservoirs also play a crucial role in mitigating flood damage, ensuring a stable energy supply, and reducing price fluctuations in the energy market (Statkraft, n.d. E). This creates security for both the energy market and broader society.

Norway's leadership in renewable energy is underscored by its renewable energy share of 106 percent, primarily from regulated hydropower, which gives the country a power surplus (Statkraft, n.d. E). As shown in the figure below, Norway's high share of renewable energy far exceeds that of other European nations, such as Germany and France, where renewable energy contributions range from 13 to 31 percent. These countries rely heavily on variable wind and solar power, which requires additional flexible solutions like hydrogen storage and improved digital systems to ensure energy reliability. For now, hydropower remains the most effective and reliable solution for achieving a low-emission energy future (Statkraft, n.d. E).

Figure 1: Comparison of Renewable Energy Shares in European Countries

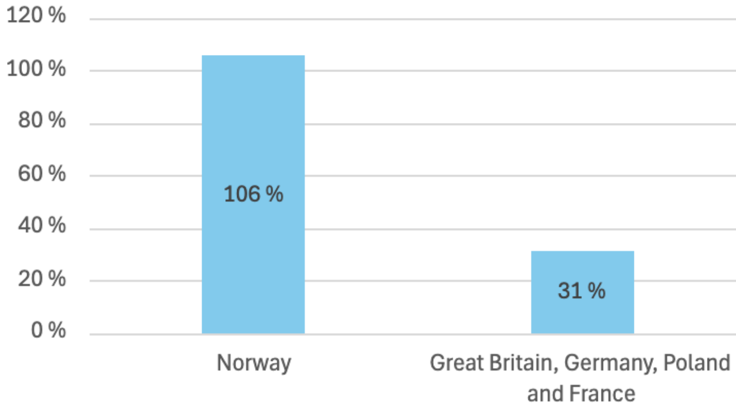


Figure 1 illustrates Norway's renewable energy share of 106 percent compared to other European countries like Germany and France, highlighting Norway's dominance due to hydropower and power surplus (Statkraft, n.d. E).

4.2 Wind Power

Onshore wind power has been utilized by humans for thousands of years, from the first sailboats to early ventilation systems developed several hundred years ago (Statkraft, n.d. B). Today, it is a cornerstone of renewable energy production, offering a clean, emission-free alternative to fossil fuels. In Norway, the country's favorable wind conditions along the coast and in mountainous areas have enabled the development of several wind farms, positioning wind power as a critical element in the nation's transition to a low-emission society (Statkraft, n.d. B). Despite debates about environmental and visual impacts, onshore wind power plays an increasingly significant role in Norway's renewable energy strategy, helping reduce greenhouse gas emissions and diversify the energy mix (Statkraft, n.d. B).

Technological Advancements and Cost Reductions

In recent years, wind power has become one of the fastest-growing energy sources globally. Technological advancements and economies of scale have significantly reduced costs, making wind farms cheaper to build than coal or gas power plants in many regions (Regjeringen, 2024). Improved turbine efficiency and durability have increased energy output, reduced maintenance needs, and extended the lifespan of wind farms (Statkraft, n.d. C). These innovations have made wind power more competitive and are expected to transform energy landscapes further as more cost-effective energy storage solutions for wind and solar become available (Statkraft, n.d. C).

Wind Power’s Role in Norway

Norway benefits from an emission-free power supply dominated by hydropower, but wind power is gaining importance as part of the renewable energy transition (Regjeringen, 2024). Favorable wind conditions, combined with low development costs, give wind power a unique role in expanding Norway’s renewable energy capacity. By supplementing hydropower, wind energy can help reduce emissions in key sectors such as transport, industry, and petroleum activities. Moreover, increased wind power production has been shown to lower electricity prices during periods of high wind, contributing to economic benefits for consumers (Regjeringen, 2024).

The Fosen Vind Project

Fosen Vind is Europe’s largest onshore wind power project, originally consisting of six wind farms in Central Norway with a total capacity of 1,057 MW. Construction began in April 2016, and the last turbine was installed in Geitefjellet wind farm in August 2020 (Fosen Vind, n.d.). After the sale of Roan wind farm, Fosen Vind now consists of five wind farms with an installed capacity of 801 MW and an annual production of approximately 2.6 TWh. It was constructed by Fosen Vind DA, a joint venture owned by Statkraft (52.1%), Aneo (7.9%), and Nordic Wind Power DA (40%), with Statkraft serving as the construction operator (Fosen Vind, n.d.). The project emphasized responsible development by addressing societal, minority, and human rights impacts (Fosen Vind, n.d.).

Despite its contribution to renewable energy, the Fosen project sparked significant controversy. In 2021, Norway’s Supreme Court ruled that parts of the project violated the rights of Sámi reindeer herders under international human rights law (Skogvang, 2024). The Storheia and Roan wind farms were found to infringe on the Sámi’s cultural rights protected by Article 27 of the UN International Covenant on Civil and Political Rights (Skogvang, 2024). While the wind farms remain operational, the case outlines the challenges of balancing renewable energy development with indigenous rights and raises questions about how future projects can be conducted more sustainably.

Environmental and Societal Challenges

While wind power contributes to the fight against climate change, it also presents environmental and societal challenges (Naturvernforbundet, n.d.). Wind farms require extensive land areas, often in pristine environments, leading to habitat fragmentation and ecosystem disruption. In Norway, these developments have particularly affected wild reindeer habitats and other endangered species, with land-use changes posing a major threat to biodiversity (Naturvernforbundet, n.d.).

In addition to environmental concerns, wind farms impact local communities. Noise from turbines can disturb people and wildlife, while flashing lights and robotic movements create visual disruptions in the landscape (Watten, 2023). These factors have reduced the quality of life for residents living near such facilities and, in some cases, caused health issues (Krog, 2022). For Sámi reindeer herders, as seen in the Fosen case, wind power development has severely affected their ability to practice their culture, demonstrating the broader societal consequences of these projects.

Balancing Renewable Energy Goals with Nature Conservation

The conflict between climate goals and nature conservation has become a central debate in Norway. Organizations like Motvind Norge argue that wind power development often lacks adequate environmental assessments and fails to involve local communities (Motvind, n.d.). They emphasize that efforts to combat climate change should not come at the cost of biodiversity or cultural heritage. Striking a balance between renewable energy expansion and environmental preservation will require innovative solutions and a stronger focus on sustainability in project planning.

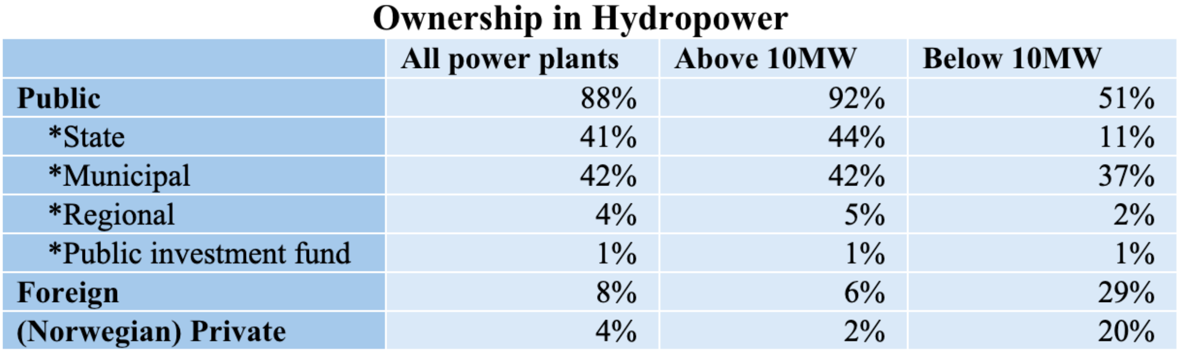
4.3 Ownership Structure

Norway's renewable energy sector is defined by its vast hydropower resources and the growing importance of onshore wind power. These energy sources have distinct ownership structures, reflecting their historical development and market dynamics. Hydropower, a long-established part of Norway's energy system, is primarily publicly owned. In contrast, wind power has a much larger share of foreign ownership, showcasing its appeal to international investors.

The "state-owned" category primarily consists of Statkraft for both hydropower and wind power. For hydropower, the largest additional contributor in this category is the Ministry of Trade, Industry, and Fisheries through its ownership in Norsk Hydro. The Government

Pension Fund Norway (Folketrygdfondet), which owns shares in Norsk Hydro, and Kommunal Landspensjonskasse (KLP) are the largest players in the "public investment funds" category for hydropower (NVE, 2024 B). However, hydropower is dominated by public ownership, with 88% of all hydropower projects under public control. For plants over 10 MW, this share rises to 92%, distributed among state (44%), municipal (42%), and regional (5%) ownership categories (NVE, 2024 B). Private Norwegian ownership accounts for only 2% of large projects, while foreign utilities own 6%. The table below illustrates this distribution, underscoring the dominance of public ownership:

Table 1: Ownership Distribution in Norwegian Hydropower



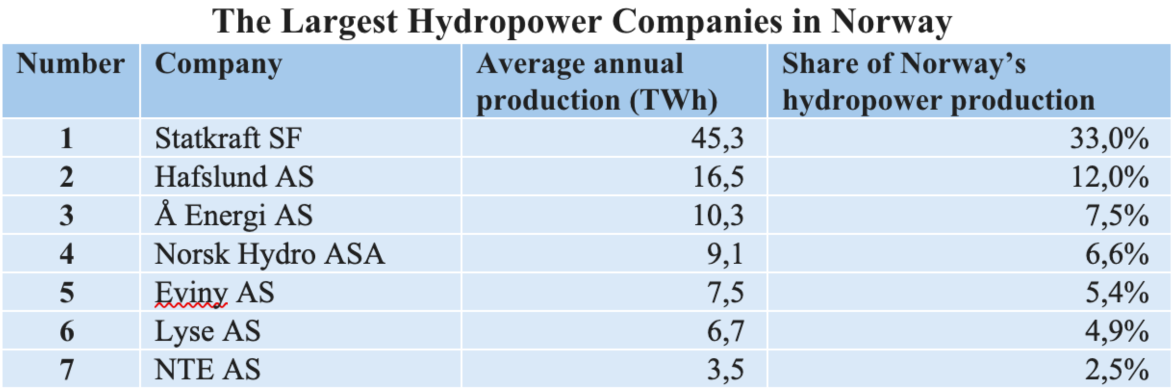
Ownership in Hydropower

	All power plants	**Above 10MW**	**Below 10MW**
Public	88%	92%	51%
*State	41%	44%	11%
*Municipal	42%	42%	37%
*Regional	4%	5%	2%
*Public investment fund	1%	1%	1%
Foreign	8%	6%	29%
(Norwegian) Private	4%	2%	20%

Table 1 presents the distribution of hydropower ownership in Norway, categorizing by power plant size (above and below 10 MW). Data reflects developed power plants as of July 2024, with ownership information derived the Norwegian Tax Administration's shareholder register (December 2023) and hydropower inflow averages from 1991-2020 (NVE, 2024 B).

From the table below we see that Statkraft is Norway's largest hydropower producer, accounting for 33% of total hydropower production. Producing 45 TWh annually, Statkraft significantly outpaces its closest competitors, Hafslund (16.5 TWh) and Å Energi (10.3 TWh) (NVE, 2024 B). This aligns with Norway's strong tradition of state involvement in managing its hydropower resources. Statkraft's dominance also extends beyond Norway. As Europe's largest hydropower producer, Statkraft operates 365 hydropower plants with an installed capacity of 15,741 MW, emphasizing its critical role in the Norwegian and European energy landscape (Statkraft, n.d. A).

Table 2: The Largest Hydropower Companies in Norway



The Largest Hydropower Companies in Norway

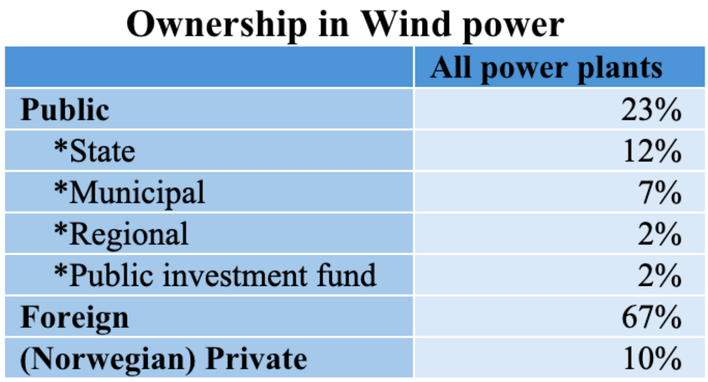
Number	Company	Average annual production (TWh)	Share of Norway's hydropower production
1	Statkraft SF	45,3	33,0%
2	Hafslund AS	16,5	12,0%
3	Å Energi AS	10,3	7,5%
4	Norsk Hydro ASA	9,1	6,6%
5	Eviny AS	7,5	5,4%
6	Lyse AS	6,7	4,9%
7	NTE AS	3,5	2,5%

Table 2 presents the average annual production for Norway's largest hydropower companies, based on the inflow reference period 1991–2020. Data reflects developed power plants as of July 2024, with company ownership information derived from the Norwegian Tax Administration's shareholder register (December 2023) (NVE, 2024 B).

** Statkraft owns 67% of Skagerak Energi. This share is included under Statkraft in the table, and Skagerak Energi is therefore not listed separately. Statkraft's shares in Å Energi and Eviny are included under state ownership in Table 1 but not under Statkraft's ownership in Table 2 (NVE, 2024 B).*

Again, the "state-owned" category primarily consists of Statkraft also for wind power. The largest additional state-owned stakeholder is Finnmarkseiendommen, which holds shares in Finnmark Kraft AS. KLP is the largest in the category "public investment funds", primarily due to its ownership stakes in the Odal and Lista wind farms (NVE, 2024 B). From the table below, we observe that wind power ownership presents a contrast to hydropower. Two-thirds (67%) of wind power projects in Norway are owned by foreign utilities, while public ownership accounts for only 23% (NVE, 2024 B). This disparity reveals the global appeal of Norwegian wind power, driven by favorable conditions and competitive development costs.

Table 3: Ownership Distribution in Norwegian Wind Power



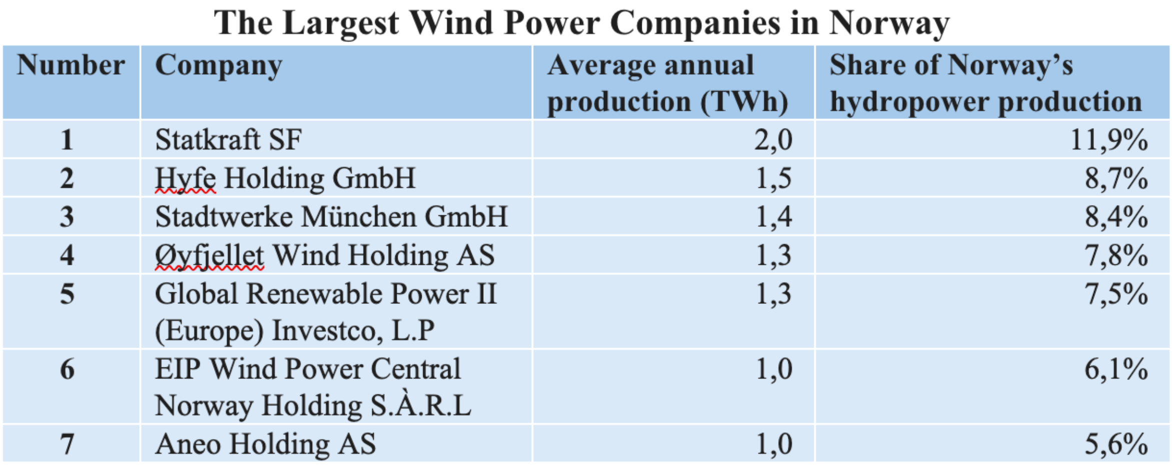
Ownership in Wind power

	All power plants
Public	23%
*State	12%
*Municipal	7%
*Regional	2%
*Public investment fund	2%
Foreign	67%
(Norwegian) Private	10%

Table 3 presents the ownership distribution in Norwegian wind power, based on normal annual production. Data reflects developed power plants as of July 2024, with ownership information derived from the Norwegian Tax Administration's shareholder register (December 2023) (NVE, 2024 B).

As shown in the table below, key players in Norwegian wind power include Statkraft, which produces 2.0 TWh annually, representing 11.9% of total wind power production (NVE, 2024 B). Other significant actors, such as Hyfe Holding GmbH and Stadtwerke München GmbH, illustrate the strong presence of foreign capital in this sector.

Table 4: The Largest Wind Power Companies in Norway



The Largest Wind Power Companies in Norway

Number	Company	Average annual production (TWh)	Share of Norway's hydropower production
1	Statkraft SF	2,0	11,9%
2	Hyfe Holding GmbH	1,5	8,7%
3	Stadtwerke München GmbH	1,4	8,4%
4	Øyfjellet Wind Holding AS	1,3	7,8%
5	Global Renewable Power II (Europe) Investco, L.P	1,3	7,5%
6	EIP Wind Power Central Norway Holding S.À.R.L	1,0	6,1%
7	Aneo Holding AS	1,0	5,6%

Table 4 presents an overview of the largest wind power companies in Norway, based on average annual production. Data reflects developed power plants as of July 2024, with company ownership derived from the Norwegian Tax Administration's shareholder register (December 2023) (NVE, 2024 B).

** * Foreign companies in table 4 may have underlying owners not registered in the Norwegian Tax Administration's shareholder register (NVE, 2024 B).*

Changes in Wind Power Ownership in Recent Years

The ownership structure of wind power in Norway has undergone notable shifts in recent years, reflecting changing dynamics between public and private ownership. From the end of 2022 to the end of 2023, public ownership in wind power experienced a modest increase, rising from 22% to 23% (NVE, 2024 B).

Between 2021 and 2022, Norwegian private ownership in wind power saw an increase from 8% to 10%, while public ownership decreased from 24% to 22% (NVE, 2024 B). This period shows a growing interest from domestic private investors, although the decline in public ownership underscores the ongoing transition toward private finance.

The most significant changes occurred between 2019 and 2021. During this time, foreign ownership in wind power increased from 62% to 67%, and Norwegian private ownership rose from 5% to 8% (NVE, 2024 B). Public ownership, however, saw a sharp decline, falling from 33% to 24% (NVE, 2024 B). These shifts illustrate the increasing dominance of foreign capital and the declining role of public entities in financing wind power projects.

These trends underscore the evolving landscape of wind power ownership in Norway. While public ownership remains an important component, its gradual reduction over time reflects the sector's transition to a more market-driven financing model, with private and foreign capital playing an increasingly central role.

Comparison of Hydropower and Wind Power Ownership

The contrast between hydropower and wind power ownership reflects the unique dynamics of these energy sources. Hydropower's historical role as a cornerstone of Norway's energy system has resulted in predominantly public ownership, ensuring national control over a critical resource. Conversely, wind power's rapid development and high capital requirements have attracted substantial foreign investment. Statkraft exemplifies Norway's ability to lead in both sectors, as its dual role as the largest producer of both hydropower and wind power demonstrates its adaptability and innovation in meeting evolving energy demands.

As Norway continues its renewable energy transition, balancing public and private interests will be essential. Hydropower's established public ownership model provides stability, while wind power's diverse ownership highlights the sector's international appeal. Together, these resources underscore Norway's leadership in renewable energy and its commitment to sustainable development.

4.4 The Norwegian Elcertification System

Norway's energy sector benefits from a support mechanism known as the elcertificate system, which is a Norwegian-Swedish scheme introduced in 2012 to promote investments in renewable energy technologies, including wind, hydropower, solar, and bioenergy (NVE, 2023 A). The program, which is regulated by the Elcertificates Act, is set to end in 2035 (Energifakta Norge, 2024). To qualify for the scheme, new projects had to be operational by December 2021, meaning that no new facilities can join the scheme. However, approved projects will continue to receive elcertificates until the scheme formally ends in 2035 (Energifakta Norge, 2024).

How the Elcertificate System Works

Elcertificates are awarded to approved renewable energy project companies, granting one certificate for every megawatt hour (MWh) of electricity they produce (NVE, 2023 A). These certificates can be sold from the project companies to power suppliers and certain electricity customers, who are legally obligated to purchase them to meet their quota of renewable energy. This dual income, from electricity sales and elcertificates, enhances project profitability, making renewable energy investments more attractive (Energifakta Norge, 2024). The system is ultimately funded by consumers, as power suppliers pass the cost of elcertificates onto electricity bills. This mechanism ensures a stable demand for elcertificates while incentivizing energy production, particularly in wind and hydropower sectors (Energifakta Norge, 2024). It has played a critical role in stimulating investments, reducing financial risks, and accelerating the development of renewable energy projects (NVE, 2023 A).

Benefits and Impact

The elcertificate system have enhanced the economic viability of renewable energy investments. By providing a predictable additional revenue stream, it has lowered financial risks and ensured income stability for producers. This support is especially valuable for wind power projects, which experience more variability in production compared to hydropower.

Elcertificates help compensate for periods of low wind generation, supporting both energy security and advancing environmental goals (Energifakta Norge, 2024).

4.5 Risk Factors in Renewable Energy Projects

Renewable energy projects come with varying degrees of risk, shaped by the operational characteristics of each energy source. Hydropower is unique among renewables due to its ability to regulate production, offering stability and flexibility unmatched by other energy technologies. As Statkraft explains, "Hydropower is a flexible and stable energy source. Water can be stored in reservoirs during periods of surplus and used to generate electricity when demand is high" (Statkraft, n.d. A). This operational flexibility reduces both market and operational risks, making hydropower one of the least risky renewable energy technologies. The Norwegian Water Resources and Energy Directorate (NVE) further emphasizes that Norway's hydropower reservoirs provide significant flexibility to balance variable renewable energy sources like wind and solar (NVE, 2023 B, p. 1). This risk-mitigating ability makes hydropower particularly well-suited to modern energy systems, offering a stable foundation for renewable energy integration.

In contrast, onshore wind power faces higher risks due to its reliance on weather conditions and limited flexibility. As Statkraft notes, "Wind power must be produced when the wind blows... Variable energy sources like wind and solar often operate at full capacity when market demand and prices are low and have reduced capacity when demand and prices are high" (Statkraft, n.d. E). This variability exposes wind power to greater market risks, especially in periods of low demand and low prices. The Norwegian Water Resources and Energy Directorate (NVE) emphasizes that the increasing share of unregulated wind and solar power reduces system flexibility, further amplifying operational and market risks (NVE, 2023 B, p. 3). NVE emphasizes that balancing this variability requires flexible solutions, with hydropower playing a crucial role in stabilizing the power system and meeting demand during critical periods (NVE, 2023 B, p. 3).

As electrification and weather variability place further pressure on the Norwegian power system, hydropower’s ability to store energy and provide renewable, flexible production becomes increasingly important. Norway’s reservoirs account for 50% of Europe’s storage capacity, positioning hydropower as a vital resource for managing variable renewable energy production in Norway and across Europe (NVE, 2023 B, p. 3).

Risk Factors in Renewable Energy Projects

To fully understand the economic dynamics of renewable energy projects, it is essential to introduce the concept of Levelized Cost of Electricity (LCOE) and its value-adjusted counterpart. LCOE is a key metric used to calculate the average cost of generating one unit of electricity (e.g., øre/kWh) over the lifetime of a power plant (NVE, 2024 C). It considers all costs, including initial investments, operational expenses, and maintenance, divided by the total electricity produced (NVE, 2024 C). This metric allows for direct comparison of generation costs across different energy technologies.

The value-adjusted LCOE refines this calculation by considering when electricity is produced in relation to market demand. Unlike the standard LCOE, which only accounts for production costs, the value-adjusted LCOE also includes the income generated from selling electricity (NVE, 2024 C). If a power plant produces electricity during periods of high demand and prices, the revenue per kilowatt-hour (kWh) increases. This means the cost of production is spread across a larger income, making the value-adjusted LCOE appear lower than the standard LCOE. Conversely, if electricity is produced during periods of low demand and prices, the revenue per kWh decreases, causing the value-adjusted LCOE to appear higher.

For this analysis, it is assumed that all electricity is sold on the spot market (NVE, 2024 C). This assumption allows for a consistent comparison of value-adjusted LCOE across different energy sources, reflecting market-driven pricing dynamics. Additionally, the discount rate used has a significant impact on LCOE calculations. Different LCOE estimates can vary substantially depending on the discount rate applied. NVE uses a 6% discount rate, as recommended by the Ministry of Energy, to provide a standardized basis for comparison (NVE, 2024 C). This dynamic is particularly evident when comparing hydropower and wind power in Norway:

- Hydropower benefits from its ability to regulate production, allowing it to store water and generate electricity during periods of high market prices. This flexibility increases its revenue and lowers the value-adjusted LCOE compared to the standard LCOE.

- Wind Power, on the other hand, relies on weather conditions and produces electricity whenever there is sufficient wind, regardless of market demand. This often results in production during periods of low prices, increasing the value-adjusted LCOE compared to the standard LCOE.

Figure 2 below from NVE illustrates these differences. For onshore wind power in Norway, the value-adjusted LCOE is higher than the standard LCOE, at 47 øre/kWh compared to 42 øre/kWh (NVE, 2024 C). This indicates how wind farms tend to produce the most electricity during periods of low market prices, reducing the economic value of the energy produced and increasing the risk of lower returns.

In contrast, the value-adjusted LCOE for hydropower is lower than the standard LCOE, at 34 øre/kWh compared to 43 øre/kWh (NVE, 2024 C). Hydropower's ability to align production with periods of high demand and prices provides greater economic stability and reduces its exposure to market risks.

Figure 2: Comparison of LCOE and Value-Adjusted LCOE for Wind and Hydropower

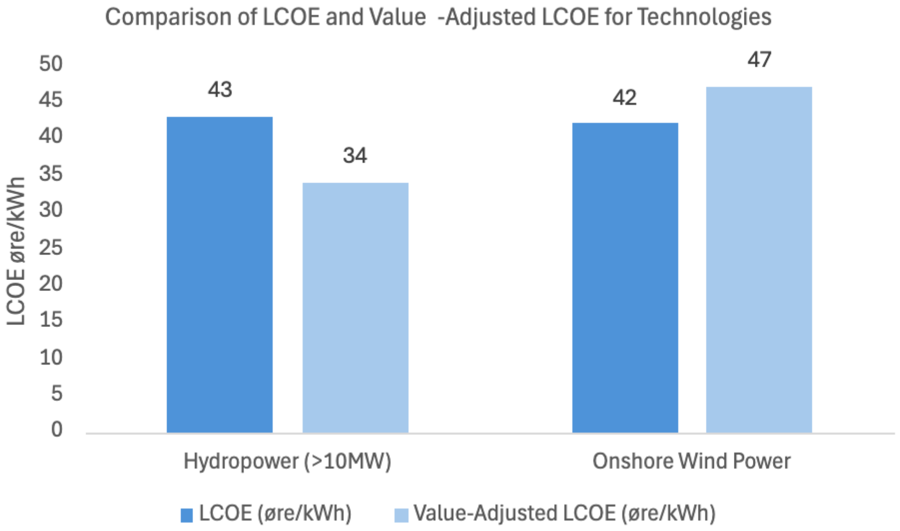


Figure 2 compares the Levelized Cost of Energy (LCOE) and the value-adjusted LCOE for different energy technologies. The value-adjusted LCOE accounts for a technology's ability to deliver power during periods of high demand, reflecting differences in flexibility and production profiles (NVE, 2024 C).

Construction Costs and Production Stability

Onshore wind power has the lowest average construction costs among renewable energy technologies in Norway, with costs dropping significantly in recent years (Regjeringen, 2024). However, its production remains highly variable and weather-dependent, which increases the cost per produced kWh compared to hydropower (NVE, 2024 C). Hydropower, with its ability to store water in reservoirs and regulate production, offers stable operating costs and less exposure to market volatility, making it a more reliable energy source over the long term (Statkraft, n.d. E).

The Role of Power Purchase Agreements (PPAs)

To mitigate the financial risks associated with variable production, wind power projects often rely on Power Purchase Agreements (PPAs). These long-term contracts between power producers and electricity buyers/suppliers secure a fixed electricity price, reducing exposure to price fluctuations in the electricity market (World Bank, 2024). Without PPAs, wind power producers are more vulnerable to market volatility, particularly on the Nord Pool power market, where prices can vary significantly (Regjeringen, 2024). Hydropower producers, with their ability to adjust production to market conditions, generally have less need for such agreements, as they can generate income when electricity prices are most favorable (Statkraft, n.d. E).

Defining Risk: Wind Power vs. Hydropower

Based on these factors, we define onshore wind power projects as riskier than hydropower projects. Risk in renewable energy projects can manifest in various forms, including construction risk, operational risk, political risk, and market risk. For this analysis, we consider operational and market risks to be the most relevant dimensions when comparing wind power and hydropower in Norway.

Wind power projects face higher operational and market risks due to their reliance on weather conditions, exposure to price fluctuations in the electricity market, and dependence on PPAs to secure stable income streams. Wind turbines typically have a lifespan of 25-30 years, requiring reinvestment and new permits for continued operation (Regjeringen, 2024). In contrast, hydropower turbines often last 50 years or more and require less reinvestment due to their durability and long-established infrastructure (NVE, 2024 A). Additionally, wind power involves higher technological risks, as turbines have more moving parts prone to failure, leading to greater maintenance needs. These projects also often face local opposition due to visual, noise, and environmental impacts, increasing regulatory and social risks (Watten, 2023).

In contrast, hydropower benefits from lower operational and societal risks. With its established role in Norway's energy system, hydropower has a proven ability to integrate with market dynamics and requires less reinvestment over time. This stability, combined with its durable infrastructure, contributes to a lower overall risk profile compared to wind power.

Looking ahead, advancements in energy storage technologies may mitigate some of the challenges associated with wind power. For instance, energy from wind power could be stored in large batteries or converted into hydrogen, which can then be stored and used when needed (Statkraft, n.d. E). However, in today's energy market, variable production from renewable sources like wind must often be supplemented by traditional energy sources such as oil, coal, nuclear power, or gas. As a result, wind power alone cannot fully replace fossil fuels. Hydropower, by contrast, stands out as the only renewable energy source that is both adjustable and reliable, providing a flexible and stable solution for energy production (Statkraft, n.d. E).

5. Hypotheses

This thesis investigates the research question: *"How important is project finance for renewable energy projects in Norway, and what are the drivers and underlying reasons behind its use?"* To address this question, the following hypotheses are formulated to explore the factors that influence the use of PF in Norwegian renewable energy projects. Each hypothesis targets a specific aspect of project characteristics, sponsor-related factors, or risk allocation, offering a focused lens to examine the adoption of PF.

H1: Project Size

H1: Larger renewable energy projects (measured by installed capacity) are more likely to use project finance than smaller projects due to higher levels of risk and extensive funding requirements.

Larger renewable energy projects, such as wind and hydropower developments, require significant investment and carry financial risks. PF is traditionally suited for these large-scale, high-risk ventures, as it isolates financial risks within a SPV, protecting both the project sponsors and their core business operations from potential spillover effects (Steffen, 2018, p. 281). This is especially relevant for large, established companies, such as Norway's Big Four utilities and regional or municipal utilities, which dominate as sponsors of these projects (Steffen, 2018, p. 288). For these firms, PF not only addresses contamination risks tied to their core operations but also enables them to undertake capital-intensive projects without jeopardizing their broader business activities.

H2: Foreign Utilities

H1: Projects sponsored by foreign utilities are more likely to use project finance due to increased risk and capital requirements.

Foreign utilities often face challenges, including information asymmetry and contamination risk, when entering Norway's unfamiliar energy market. PF addresses these challenges by isolating financial and operational risks within a SPV, offering lenders transparency into cash flows, contracts, and risk profiles, thereby reducing uncertainty (Steffen, 2018, p. 283). This makes PF particularly well-suited for risky projects involving sponsors with limited familiarity with the market in which they are investing (Steffen, 2018, p. 283). PF has been particularly important for foreign utilities investing in large-scale wind power projects, which involve higher technological and market risks compared to hydropower. By isolating risks within the SPV, PF enables foreign sponsors to safeguard their core operations while securing the substantial funding required for high-risk, capital-intensive ventures, aligning with the increased risk and capital requirements associated with such projects.

H3: Regional/Municipal Utilities

H1: *Regional/municipal utilities are more likely to use project finance compared to other sponsor types due to independence and ownership structure.*

Regional/municipal utilities are more likely to use PF due to their ownership structure and emphasis on financial independence. PF allows these utilities to maintain autonomy by isolating project-specific risks within a SPV, ensuring that these risks remain confined to the project and do not threaten the broader financial stability of the municipality or region (Steffen, 2018, p. 284). This non-recourse structure aligns with their need to avoid reliance on national or international energy companies while supporting locally driven renewable energy initiatives. By adopting PF, regional/municipal utilities can focus on achieving sustainable, community-oriented energy goals without placing undue strain on their existing financial resources or compromising their independence (Steffen, 2018, p. 284).

H4: Joint Ventures

H1: *Joint venture projects are more likely to use project finance compared to single-owner projects, particularly due to shared risks and agency conflicts.*

Joint venture projects are more likely to use PF compared to single-owner projects due to the need to share risks and manage agency conflicts. PF facilitates horizontal joint ventures by structuring the project as a SPV, ensuring that financial risks and responsibilities are distributed among the participants without recourse to their balance sheets (Steffen, 2018, p. 284). This structure reduces potential conflicts between stakeholders by providing a transparent and contract-driven framework, aligning their interests toward the project's success. For utilities collaborating on a power generation project, PF offers an opportunity to share resources, acquire specialized knowledge about new technologies, and leverage collective expertise to achieve better outcomes (Steffen, 2018, p. 284).

6. Data

In this section, we present an overview of the data used in our analysis. We begin by detailing the data collection and sampling process, including key criteria for identifying relevant projects and categorizing sponsor types. Next, we provide a comprehensive explanation of the dependent and independent variables utilized in the study.

6.1 Overview of the Dataset and Data Collection

This study examines renewable energy projects in Norway, focusing on their financing structures at the start of operation (2010–2023). Norway provides an ideal setting for analyzing PF due to its mature renewable energy market, strong legal framework, and significant investments in both hydropower and wind power (IEA, 2022). This combination of stability and growth makes Norway particularly suitable for exploring PF usage in a low-risk environment.

Data Collection

To construct the dataset, we employed a systematic three-step approach, inspired by Steffen (2018) and adapted to the Norwegian renewable energy context:

1. Identifying Projects

Project-level data were collected from the Norwegian Water Resources and Energy Directorate (NVE), focusing on renewable energy projects with an installed capacity above 10 MW that became operational between 2010 and 2023. This resulted in a dataset of 75 projects, comprising 47 wind power projects and 28 hydropower projects. Wind power projects outnumber hydropower projects during this period, reflecting Norway’s increasing focus on wind energy development (IEA, 2022). Key information gathered included project name, project company, installed capacity, year of operation, location, and ownership structure. Projects under 10 MW were excluded to ensure analytical relevance, as they often use simpler financing models less aligned with the scope of this study.

2. Gathering Financial Data

Financial data for the identified projects were obtained from Proff.no (2024) using company registration numbers. This process allowed us to collect detailed information from the balance sheets of project companies at the start of operation, including equity, debt, and debt ratios. Like Steffen (2018), we enriched the dataset by integrating project information with financial data. Additionally, we assessed whether a project company was an SPV by examining whether its name matched the project name.

3. Classifying Sponsors

Using the combined dataset, we categorized the project sponsors into four groups: foreign utilities, financial investors, regional/municipal utilities, and Big Four utilities. This classification enabled us to analyze how sponsor types influence financing structures. Detailed definitions and examples of each sponsor category are provided in Section 6.2.1.

Handling Missing Data and Outliers

As the dataset was manually constructed from publicly available sources, such as Proff.no (2024) and NVE, issues with missing data were minimal. Care was taken to ensure completeness by verifying relevant project information, including installed capacity, ownership structure, and financial data, at the time of operation. Outliers, such as large projects with significantly higher installed capacity or debt ratios, were reviewed and retained if deemed valid. No observations were excluded, and the dataset was considered robust for analyzing PF in Norway.

6.2 Identifying Financing Structures and Sponsor Types

The financing structures of renewable energy projects are closely tied to the characteristics of their sponsors and the financial criteria distinguishing PF from CF (Steffen, 2018, p. 288. This section examines how sponsor types shape financing preferences, followed by a detailed exploration of the financial criteria that differentiate PF from CF, as well as examples of both financing methods.

6.2.1 Definition of Sponsor Types

Sponsor characteristics play a pivotal role in shaping the financing structures of renewable energy projects (Steffen, 2018, p. 288). For this study, sponsors are classified into four distinct groups based on their ownership structure and operational focus.

1. Big Four Utility

This group includes Norway's four largest energy companies, known for their significant financial resources and extensive expertise in renewable energy development. These companies – Statkraft (60 TWh annual production), Hafslund Eco Vannkraft (17 TWh), Å Energi (11.3 TWh), and Norsk Hydro (10 TWh) – are dominant players in the sector, primarily focused on electricity generation (Rosvold, 2024).

2. Regional/Municipal Utility

Regional and municipal utilities are owned by municipalities or regional authorities. Their focus lies in public infrastructure services such as electricity production, grid management, and distribution within their regions (Steffen, 2018, p. 291). Collaborations between these utilities are common to enhance efficiency and manage larger projects. Examples include Troms Kraft AS, Rauma Energi Holding AS, Nord-Trøndelag Elektrisitetsverk AS, and Salten Kraftsamband AS.

3. Financial Investor

Financial investors, including private equity firms, pension funds, and investment companies, prioritize maximizing financial returns rather than managing the operational aspects of projects (Steffen, 2018, p. 291). Examples include Susi Tonstad AS, Gulslettene Renewable Finance 2 DA, and Tellenes Renewable Finance II DAC.

4. Foreign Utility

This category includes foreign utilities investing in Norwegian renewable energy projects, such as Nordlicht Holding GmbH & Co, BKW Renewables Partners AG, SV Vattenkraft AB, and Hyfe Holding AS/Hyfe Holding GmbH. They typically operate outside Norway and often adopt diverse approaches to project development, ranging from large-scale investments to smaller targeted projects (Steffen, 2018, p. 291).

6.2.2 Our Criteria for Identifying Financing Structures

To distinguish between PF and CF, we analyzed the financial statements of project companies using data from NVE and Proff.no (2024). Building on Steffen's (2018) methodology, we adapted the framework to align with the Norwegian renewable energy market, incorporating additional criteria such as intercompany debt and external debt structures.

Key Indicators for Identifying Project Finance

1. **High Debt Ratio:** A debt ratio exceeding 70% is a hallmark of PF (Yescombe, 2014, p. 8). This high reliance on external debt reflects PF's core principle: repayment tied predominantly to project-specific cash flows. Projects with a high debt-to-equity ratio embody the risk-isolating nature of PF, where cash flows are directed toward servicing debt obligations (Finnerty, 2013, p. 1).

2. **Special Purpose Vehicle (SPV):** The use of an SPV – often indicated when the project company shares its name with the project – is a strong indicator of PF. SPVs isolate financial risks from the parent company, protecting its balance sheet while ensuring project-specific accountability (Steffen, 2018, p. 286). While an SPV alone does not guarantee PF, it serves as a significant criterion in conjunction with other factors.

3. **External Debt:** Projects financed through PF typically rely on external credit institutions for long-term debt. This includes "debt to credit institutions" and "other long-term debt," both of which emphasize non-recourse or limited-recourse financing. By isolating repayment expectations to the project's cash flows and assets, external debt reinforces PF's risk-isolating nature (Yescombe, 2014, p. 8).

4. **Absence of Intercompany Debt:** The absence of intercompany debt is a key indicator of PF, emphasizing financial independence and ensuring that repayment relies solely on the project's cash flows. In contrast, CF often involves intercompany debt, reflecting financial integration with the parent company. According to the Norwegian Accounting Act (§ 1-3), corporate groups are defined by control through majority ownership, with intercompany debt representing financial interconnectedness (Norwegian Accounting Act, § 1-3, Lovdata, n.d.). PF, however, follows the principle

of non-recourse financing, isolating risks to the project and minimizing reliance on parent company support.

Key Indicators for Identifying Corporate Finance

1. **Low Debt Ratio:** CF is characterized by a lower debt ratio, reflecting a balanced funding structure. The integration of project costs into the parent company's balance sheet underscores its financial strength and flexibility (Berk & DeMarzo, 2020, p. 525).

2. **Absence of an SPV:** Unlike PF, CF does not typically involve the establishment of an SPV. Instead, project liabilities are integrated into the parent company's broader operations, leveraging its balance sheet and financial resources (Finnerty, 2013, p. 23).

3. **Presence of Intercompany Debt:** The presence of intercompany debt is a defining feature of CF, signifying financial support from the parent company rather than reliance on external credit markets. This debt structure reflects the integration of project financing within the corporate group and reduces exposure to external lenders (Fiken, n.d.).

By applying these criteria, we were able to classify projects in the dataset as either PF or CF, providing a robust framework for analyzing financing decisions in Norway's renewable energy sector.

6.2.3 Examples of a Project Finance Case

Bjerkreim vindkraftverk (Bjerkreim Vind AS) serves as a compelling example of a renewable energy project financed through PF (see table 5 below). This large-scale wind power project, with a capacity of 155.4 MW, was put into operation in 2019. It is owned by HYFE Wind 4 AS, a Norwegian company fully owned by the German-registered HYFE Holding GmbH (Mullis, 2023). This ownership structure aligns with the characteristics of a foreign utility sponsor, as HYFE Holding GmbH operates as an international entity investing in Norwegian renewable energy projects.

Financial Indicators Supporting Project Finance Classification

Criteria 1: High Debt Ratio

Bjerkreim Vind AS has a debt ratio of 102%, far exceeding our threshold of 70%. This high reliance on debt signals that the project's repayment structure is heavily dependent on its own cash flows. With total debt of NOK 1,868,657 and equity of NOK -28,284, it is evident that external loans serve as the primary source of financing for the project.

Criteria 2: Use of an SPV

The project company operates as an SPV, evidenced by the company sharing its name with the project itself. The SPV structure isolates project risks and liabilities from the parent company, shielding it from potential financial losses.

Criteria 3: External Debt

Long-term debt to credit institutions amounts to NOK 1,568,344, making up most of the project's total debt of NOK 1,868,657. Moreover, the reliance on external debt from credit institutions, as opposed to internal financing or intercompany loans, further supports the classification of PF.

Criteria 4: Absence of Intercompany Debt

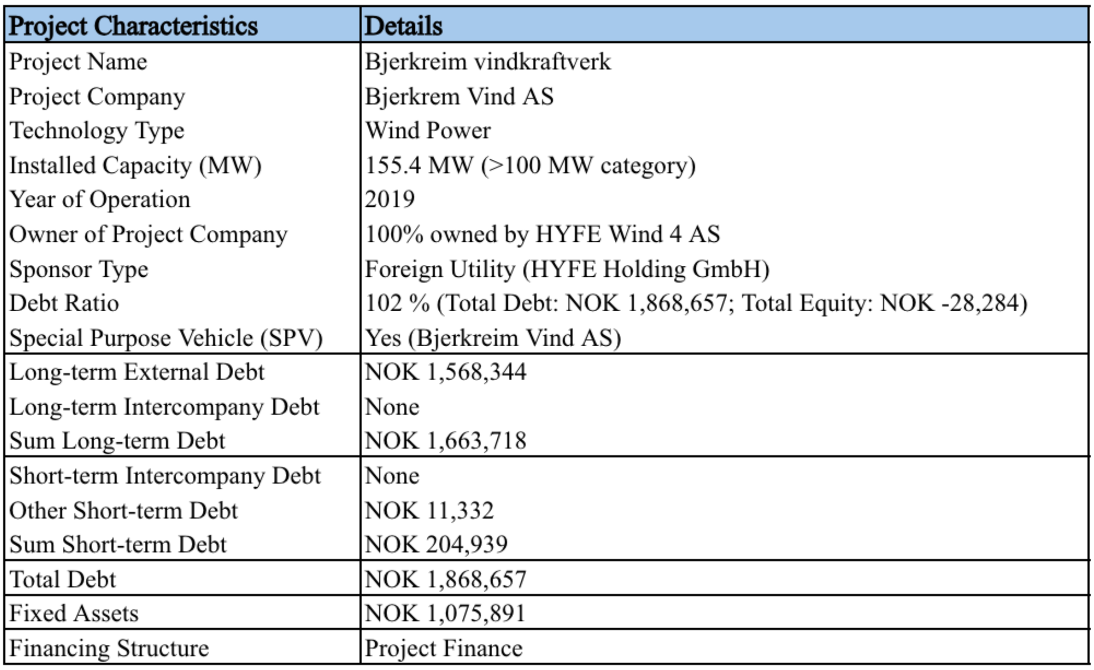
The balance sheet for Bjerkreim Vind AS shows no intercompany debt, further emphasizing the project's independent financial structure. Unlike CF, where the parent company often provides loans or direct financial support, this financing model relies entirely on external financial institutions.

Fixed Assets as Collateral

Bjerkreim Vind AS's fixed assets, valued at NOK 1,075,891, serve as collateral for the external debt. This asset-backed financing aligns with PF practices, where lenders secure repayment through the project's assets and cash flows, rather than relying on guarantees from the parent company (Yescombe, 2014, p. 8). This approach underscores the project's ability to operate as an independent financial entity.

The case of Bjerkreim Vind AS illustrates the defining features of PF, with its high debt ratio, use of an SPV, reliance on external debt, and absence of intercompany debt. This demonstrates how PF is used for large, capital-intensive wind power projects in Norway, enabling HYFE Holding GmbH to isolate project-specific risks and secure necessary capital while separating liabilities from its broader operations.

Table 5: Details of a Project Finance Case (Bjerkreim vindkraftverk)



Project Characteristics	Details
Project Name	Bjerkreim vindkraftverk
Project Company	Bjerkrem Vind AS
Technology Type	Wind Power
Installed Capacity (MW)	155.4 MW (>100 MW category)
Year of Operation	2019
Owner of Project Company	100% owned by HYFE Wind 4 AS
Sponsor Type	Foreign Utility (HYFE Holding GmbH)
Debt Ratio	102 % (Total Debt: NOK 1,868,657; Total Equity: NOK -28,284)
Special Purpose Vehicle (SPV)	Yes (Bjerkreim Vind AS)
Long-term External Debt	NOK 1,568,344
Long-term Intercompany Debt	None
Sum Long-term Debt	NOK 1,663,718
Short-term Intercompany Debt	None
Other Short-term Debt	NOK 11,332
Sum Short-term Debt	NOK 204,939
Total Debt	NOK 1,868,657
Fixed Assets	NOK 1,075,891
Financing Structure	Project Finance

Table 5 provides an example of a project finance case, detailing the financial structure and use of an SPV for the Bjerkreim vindkraftverk. Key characteristics such as debt ratio, sponsor type, and financing details are highlighted to illustrate the application of project finance.

Note: Sum Short-term Debt does not fully reconcile when summing components such as “Short-term Intercompany Debt” and “Other Short-term Debt”. While the exact cause of this discrepancy is unknown, all values have been extracted directly from the financial statements available on Proff.no (2024) to maintain consistency and transparency in reporting.

6.2.4 Examples of a Corporate Finance Case

Ringedalen vannkraftverk provides a clear example of a renewable energy project financed through CF (see table 6 below). This hydropower project, with an installed capacity of 23 MW, falls into the medium-scale category (20–50 MW) and was put into operation in 2017. It is owned by Statkraft Energi AS, a subsidiary fully owned by Statkraft AS, which is one of Norway’s “Big Four” utility companies. The project illustrates how Statkraft integrates financing and operations within its broader corporate structure.

Financial Indicators Supporting Corporate Finance Classification

Criteria 1: Moderate Debt Ratio

Statkraft Energi AS has a debt ratio of 63%, which falls below the PF threshold of 70%. This balanced funding structure combines total debt of NOK 26,362,000 with substantial equity contributions of NOK 15,524,000, reflecting Statkraft's financial strength.

Criteria 2: Absence of an SPV

Unlike PF projects, Ringedalen vannkraftverk is not operated through an SPV. Instead, it is integrated into Statkraft Energi AS, which manages multiple projects as part of Statkraft AS's corporate operations. This integration indicates the parent company assumes direct financial responsibility.

Criteria 3: Presence of Intercompany Debt

A significant portion of the debt, NOK 7,800,000, consists of long-term intercompany debt, with an additional NOK 3,000,000 in short-term intercompany debt. This reliance on internal funding underscores the CF model, where financing flows within the corporate group rather than from external lenders.

Fixed Assets as a Core Resource

Statkraft Energi AS's fixed assets, valued at NOK 35,248,000, far exceed its total debt of NOK 26,362,000. This demonstrates a strong asset base, providing financial stability and reducing risk exposure. Unlike in PF, these assets are not used as collateral for external debt but remain part of the broader balance sheet of Statkraft Energi AS, further underscoring the CF structure.

The Ringedalen case exemplifies CF through its moderate debt ratio, absence of an SPV, reliance on intercompany funding, and integration into the parent company's financial operations. This approach reflects Statkraft AS's ability to leverage its financial resources and expertise to support medium-scale hydropower projects.

Table 6: Details of a Corporate Finance Case (Ringedalen vannkraftverk)

Project Characteristics	**Details**
Project Name	Ringedalen vannkraftverk
Project Company	Statkraft Energi AS
Technology Type	Hydropower
Installed Capacity (MW)	23 MW (20-50 MW category)
Year of Operation	2017
Owner of Project Company	100% owned by Statkraft AS
Sponsor Type	Big Four Utility
Debt Ratio	63 % (Total Debt: NOK 26,362,000; Total Equity: NOK 15,524,000)
Special Purpose Vehicle (SPV)	No
Long-term External Debt	NOK 4,877,000
Long-term Intercompany Debt	NOK 7,800,000
Sum Long-term Debt	NOK 12,677,000
Short-term Intercompany Debt	NOK 3,000,000
Other Short-term Debt	NOK 7,941,000
Sum Short-term Debt	NOK 13,685,000
Total Debt	NOK 26,362,000
Fixed Assets	NOK 35,248,000
Financing Structure	Corporate Finance

Table 6 provides an example of a corporate finance case for the Ringedalen vannkraftverk, highlighting its financial structure. It illustrates the use of equity contributions and long-term intercompany debt as key components of its financing approach, with no use of an SPV.

Note: Sum Short-term Debt does not fully reconcile when summing components such as "Short-term Intercompany Debt" and "Other Short-term Debt". While the exact cause of this discrepancy is unknown, all values have been extracted directly from the financial statements available on Proff.no (2024) to maintain consistency and transparency in reporting.

6.3 Dependent Variable

The dependent variable in this study represents the financing structure of renewable energy projects, classified as either PF (1) or CF (0). This binary variable reflects the fundamental financing choice and is central to understanding patterns in the Norwegian renewable energy sector. As mentioned above, a project is classified as PF if it meets specific criteria, including a debt ratio exceeding 70%, the use of an SPV to isolate risk, and the absence of intercompany debt, indicating financial independence from the parent company (Yescombe, 2014, p. 8; Steffen, 2018, p. 286). Projects that fail to meet these conditions, but instead exhibit lower debt levels, reliance on intercompany debt, and integration into the parent company's broader balance sheet, are categorized as CF. This variable serves as the foundation for the regression analysis, allowing us to investigate how independent variables – such as project size, sponsor type and technology type – influence the likelihood of using PF. By distinguishing between these financing structures, this study aims to provide insights into the drivers, preferences, and constraints shaping financing decisions in Norway's renewable energy projects.

6.4 Independent Variables

The independent variables in this study capture project-specific, sponsor-specific, and contextual factors influencing the likelihood of using PF. These variables were selected based on theoretical insights and prior empirical findings (Steffen, 2018), which suggest that financing decisions depend on a combination of risk characteristics, project scale, sponsor goals, and market conditions. By incorporating these dimensions, the analysis seeks to test the hypotheses outlined earlier and provide a nuanced understanding of financing choices in Norway's renewable energy sector.

6.4.1 Log(Installed Capacity)

The variable log(Installed Capacity) measures the size of renewable energy projects in megawatts (MW), using a log-transformed scale to account for skewness in the data and ensure linearity with the log-odds (Woolridge, 2019, p. 746). Project size is a critical factor influencing financing decisions, as larger projects often face significant contamination risks due to high capital requirements (Steffen, 2018, p. 282). These challenges can make PF more attractive, as it allows financial risk to be isolated through external debt financing and the use of SPVs (Steffen, 2018, p. 281). In contrast, smaller projects may favor CF, which relies on the sponsor's balance sheet to streamline financing.

6.4.2 Sponsor Type

Sponsor type captures the characteristics of project owners and their impact on financing decisions. Four dummy variables were created to reflect different sponsor types, based on our classification of the projects and financing structures:

Big Four Utility: Coded as 1 if the sponsor is one of Norway's largest utilities ("Big Four"), and 0 otherwise. In our dataset, these projects are 100% classified as CF. The strong balance sheets and extensive financial resources of the Big Four utilities enable them to finance projects directly through equity or internal loans, avoiding the need to isolate risks in an SPV (Steffen, 2018, p. 290).

Regional/Municipal Utility: Coded as 1 if the sponsor is a regional or municipal utility, and 0 otherwise. Regional sponsors often seek financial autonomy and prioritize regional interests (Steffen, 2018, p. 288). While some of these projects use PF, our analysis tests whether regional ownership influences the choice of financing structure.

Financial Investor: Coded as 1 for financial investors, including private equity firms, pension funds, and investment companies, and 0 otherwise. In our dataset, these projects are 100% classified as PF. Financial sponsors prefer PF due to its ability to isolate project-specific risks, ensure strict financial controls, and secure returns independently of the broader ownership structure (Steffen, 2018, p. 288).

Foreign Utility: Coded as 1 if the sponsor is a foreign utility, and 0 otherwise. Foreign sponsors exhibit a stronger likelihood of using PF, driven by information asymmetry and the need to isolate risks when operating in unfamiliar markets with high-risk projects (Steffen, 2018, p. 283).

The classification of sponsor type and financing structure (PF or CF) is based on our predefined criteria, as outlined earlier in this section. It is important to note that these patterns – such as the 100% alignment of Big Four utilities with CF and financial investors with PF – are specific to our dataset and the project classification process we implemented.

Because Big Four Utilities are 100% classified as CF and Financial Investors are 100% classified as PF, these two sponsor types cannot be included in the regression analysis. Including them would create perfect multicollinearity, leading to inflated standard errors and unreliable coefficient estimates (Woolridge, 2019, p. 95). As a result, the regression focuses on the remaining sponsor types – Regional/Municipal Utilities and Foreign Sponsors – to examine their relative influence on the choice of financing structure. The reference category in the analysis consists of all other sponsor types not specified by the dummy variable. This approach highlights key differences in financial strategies, risk management, and ownership priorities across sponsor types and allows us to examine the relative likelihood of using PF for each sponsor category.

6.4.3 Joint Venture

The variable JointVentureDummy captures the ownership structure of renewable energy projects, distinguishing between single-owner projects (coded as 0) and joint ventures (coded as 1). Joint ventures, where multiple sponsors share ownership, often make PF a more attractive option. This preference stems from PF's ability to address agency conflicts to ensure clear contractual arrangements, and allocate risks, responsibilities, and returns in a transparent manner (Steffen, 2018, p. 283).

Ownership structure plays a crucial role in financing decisions. Projects involving joint ventures typically require formalized financial structures to manage the complexities of shared ownership, which PF facilitates through the establishment of SPVs and non-recourse financing (Steffen, 2018, p. 284). These arrangements isolate project-specific risks and provide a clear framework for governance, which can be particularly important when multiple stakeholders with diverse interests are involved. In contrast, single-owner projects may be likely to rely on CF, because a single sponsor often leverages its strong balance sheet and financial resources to fund the project directly, without the need for intricate risk-sharing agreements (Steffen, 2019, p. 280-281). This simplifies financing decisions and reduces transaction costs associated with establishing PF structures (Steffen, 2018, p. 281). By including this variable in our regression analysis, we test whether joint ownership increases the likelihood of using PF compared to projects with a single owner. This variable contributes to understanding how ownership complexity influences financing choices in Norway’s renewable energy sector.

6.4.4 Technology Type

The variable Technology distinguishes between wind power and hydropower projects. Wind power is coded as 1, while hydropower is coded as 0. This distinction captures differences in risk profiles and operational characteristics. Wind power involves higher risks due to weather dependency, variable cash flows, and limited storage capabilities, aligning with technology-related risks described in Steffen (2018) (Statkraft, n.d. E). These characteristics increase the appeal of PF for wind projects, as it provides structured risk management and financial discipline. Hydropower, on the other hand, benefits from regulated production and reservoir storage, offering more predictable cash flows and lower operational risks (Statkraft, n.d. D). This stability may reduce the necessity for PF, making CF a viable option. By accounting for technology type, the analysis tests whether financing decisions are influenced by the risk inherent in renewable energy technology.

6.4.5 Control Variables

The variable Year represents the year of operation for each project and serves as a control variable to account for temporal trends. Over time, changes in regulatory environments, technology costs, and market conditions could influence financing preferences. For instance, a maturing renewable energy market may increase the adoption of PF as financial structures and institutions evolve.

An interaction term between log(Installed Capacity) and Foreign Sponsor was included to test whether project size amplifies the preference for PF among foreign sponsors. This interaction captures the potential combined effect of large-scale projects and foreign ownership, where risk isolation and external financing become particularly critical. A significant coefficient would suggest that foreign sponsors are especially inclined to use PF for larger projects, aligning with theoretical expectations around risk management and capital constraints in unfamiliar markets.

7. Methodology

In this section, we present the methodology applied in the thesis. This study employs a quantitative research design to analyze the determinants of financing decisions in Norwegian renewable energy projects. A quantitative approach is appropriate given the focus on measurable variables and its ability to test hypotheses using statistical models (Mohajan, 2020, p. 3). The research design is structured around logistic regression analysis to model the likelihood of using PF.

7.1 Empirical Framework

Logistic regression within the Generalized Linear Model (GLM) framework is employed to estimate the likelihood of using PF as a function of project-specific, sponsor-related, and risk-based characteristics (Dobson & Barnett, 2018, p. 159). Logistic regression is particularly suitable for binary outcomes, such as whether a project is financed through project finance (PF = 1) or corporate finance (CF = 0) (Dobson & Barnett, 2018, p. 149). The logit link function ensures the relationship between predictors and the outcome is modeled as the log-odds of the probability of PF (Dobson & Barnett, 2018, p. 153). This allows the coefficients to be interpreted as changes in the log-odds of PF for a one-unit change in the predictor variable (Woolridge, 2019, p. 715). The model is implemented in R using the *glm()* function. The model specification is as follows:

$$\mathrm{logit}\big(P(Y=1)\big) = \beta_0 + \beta_1 \log(\mathrm{InstalledCapacity}) + \beta_{2\mathrm{ForeignSponsorDummy}} + \\ \beta_{3\mathrm{RegionalMunicipalSponsorDummy}} + \beta_{4\mathrm{JointVentureDummy}} + \beta_{5\mathrm{TechnologyDummy}} + \beta_{6\mathrm{Year}} + \\ \beta_7(\log(\mathrm{InstalledCapacity}) \times \mathrm{ForeignSponsorDummy}) + \epsilon$$

A detailed description of how each coefficient is interpreted can be found in Appendix 1 – Explanation of Coefficients in the Regression Equation.

To improve interpretability and ensure the regression model met key assumptions, specific transformations were applied to the dataset. Details of these transformations, including log-transformations for continuous variables and dummy variable creation, are provided in Appendix 2 – Variable Transformation.

7.2 Testing Assumptions for Generalized Logistic Regression Model (GLM)

The assumptions for our regression model analysis follow the Generalized Linear Model (GLM) framework for logistic regression. Unlike multiple linear regression (MLR), logistic regression does not assume a linear relationship between predictors and the dependent variable (Dobson & Barnett, 2018, p. 104). Instead, it assumes linearity between continuous predictors and the log-odds of the binary outcome (Dobson & Barnett, 2018, p. 158). Additionally, the model assumes no multicollinearity, independence of observations, and an adequate sample size to ensure robust maximum likelihood estimates (Dobson & Barnett, 2018, p. 158). All these assumptions were tested and found to be satisfied, confirming the validity of the regression model. Further diagnostic tests and results for the GLM assumptions are presented in Appendix 3 – Testing the GLM Assumptions.

7.3 Selection of Regression Model

The selection of the final regression model was based on iterative testing and comparison of alternative model specifications. Given the binary nature of the dependent variable, logistic regression was selected as the most appropriate model (Woolridge, 2019, p. 852). The balanced nature of the dataset, with 37 projects financed through PF and 38 through CF, further ensures reliable coefficient estimates and reduces the risk of bias toward one class. The final model was chosen through a structured process, starting with a baseline model and sequentially adding predictors to assess their effects:

- Model 1: Includes *log(InstalledCapacity)* as the sole predictor to establish a baseline.
- Models 2 to 4: Incrementally add sponsor-related variables to examine their individual and combined effects on the likelihood of using project finance.
- Model 5: Introduces controls for technology and time to account for potential influences from project characteristics and temporal trends.
- Model 6: Incorporates all predictors and tests an interaction effect between project size and sponsor characteristics, providing the most comprehensive and interpretable results.

Model performance was evaluated using the Akaike Information Criterion (AIC) and McFadden's Pseudo R^2, which measure model fit and explanatory power, respectively (Dobson & Barnett, 2018, p. 165). While the Pseudo R^2 values were quite low, this is common in logistic regression models and does not necessarily indicate poor model performance (Hosmer et al., 2013, p. 185). Additionally, the Hosmer-Lemeshow test was conducted to assess the goodness-of-fit of the logistic regression model (Dobson & Barnett, 2018, p. 164). Results for all tested models (1–6), including the incremental inclusion of predictors and interaction terms, are presented and discussed in Section 9.

7.4 Ethical Considerations

This study relies exclusively on publicly available data, including financial statements and regulatory databases such as Proff.no (2024) and the Norwegian Water Resources and Energy Directorate (NVE). No personal or sensitive data are included, ensuring minimal ethical concerns. All sources are transparently cited, and the analysis was conducted responsibly to maintain the credibility and integrity of the research.

8. Empirical Analysis of Descriptive Tables

8.1 Analysis of Project Finance & Corporate Finance

This section analyzes the use of PF and CF in renewable energy projects in Norway, using a dataset we compiled from Proff.no (2024) and NVE, covering the period from 2010 to 2023. The analysis explores how financing preferences differ by project size, sponsor type, and technology, revealing distinct patterns that demonstrate the role of PF in managing risks and CF in leveraging sponsor balance sheets.

Distribution of Project Finance and Corporate Finance

The distribution of PF and CF shows notable differences between wind power and hydropower projects in Norway. To ensure an accurate comparison, the analysis normalizes the data by focusing on the proportion of PF and CF projects within each technology. This approach accounts for the difference in the total number of projects – 47 wind power projects compared to 28 hydropower projects – and emphasizes financing preferences rather than absolute numbers.

Figure 3: Financing Models in Wind- and Hydropower Projects

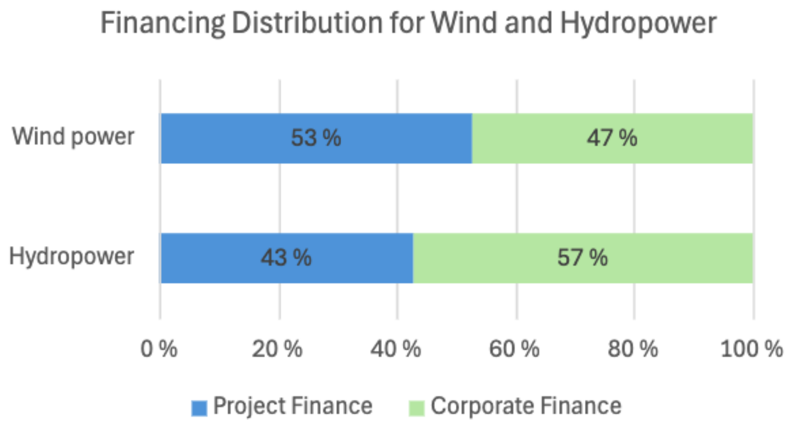


Figure 3 presents the distribution of financing models for wind- and hydropower projects in Norway, highlighting the differing use of project finance and corporate finance in each sector.

As illustrated in Figure 3, 53% of wind power projects are financed through PF, while 47% rely on CF. In contrast, 43% of hydropower projects use PF, while 57% are financed through CF. This shows a slight preference for PF in wind power projects, while CF is more common in hydropower. Across the entire dataset, CF remains the most common financing method, with 38 projects (51%) compared to 37 projects (49%) using PF. While CF dominates overall, these differences underscore how financing strategies are shaped by the distinct characteristics and risks of each energy source.

For wind power, the preference for PF lies in its ability to manage financial risks associated with weather dependency and market fluctuations. PF is well-suited to mitigate these challenges by isolating project-specific risks using SPVs and aligning debt repayment schedules with cash flows patterns (Whitelaw-Jones, 2024). Additionally, although wind power often benefits from relatively lower installation costs compared to other renewable technologies, its higher Levelized Cost of Electricity (LCOE) and intermittent production exacerbate revenue variability, further reinforcing the preference for PF (NVE, 2024 C).

In contrast, hydropower's stable revenues, longer asset lifespans, and lower risk profiles make CF the preferred option. CF leverages the financial strength and balance sheets of sponsors, allowing them to directly fund projects without the need to isolate risks. Equity-heavy financing is particularly advantageous for projects with predictable income streams, as equity offers greater flexibility in managing financial obligations compared to debt (Vernimmen et al., 2017, p. 609). This reflects hydropower's inherent stability and lower exposure to market volatility (Statkraft, n.d. E).

Project Size and Financing Preferences

The relationship between project size and financing preferences shows distinct patterns in the use of PF and CF. As illustrated in figure 4, PF is the dominant financing model for projects exceeding 100 MW, representing 58% of projects in this category. For projects in the 50-100 MW category, CF slightly outweighs PF, accounting for 54% of the projects. Medium-sized projects in the 20-50 MW category are primarily financed through CF (57%), while smaller projects (10-20 MW), exhibit a notable preference for PF, which is used in 56% of the projects. This distribution reflects how financing models adapt to the specific characteristics of different project sizes.

Figure 4: Financing Models Across Different Project Sizes

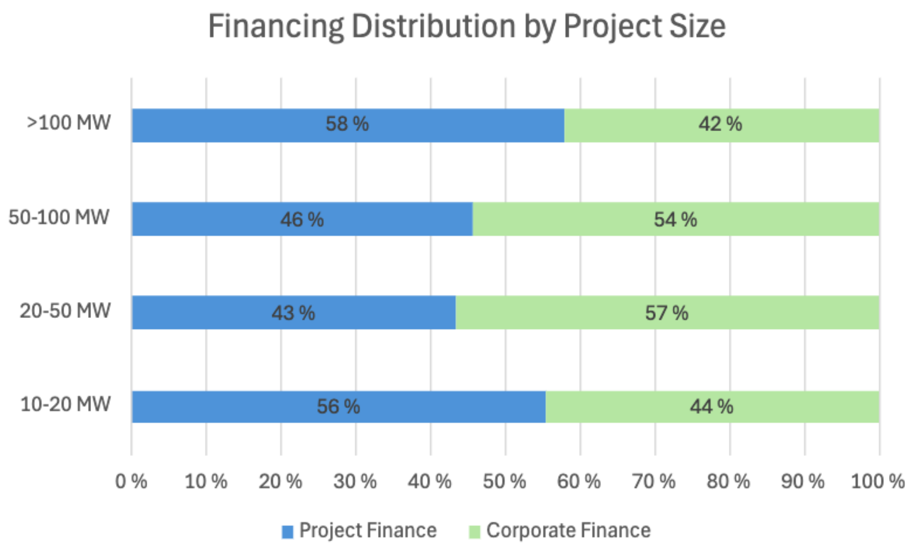


Figure 4 shows the distribution of project finance and corporate finance across various project size categories, ranging from 10-20 MW to over 100 MW. The figure demonstrates the variation in financing choices based on installed capacity.

PF’s dominance in larger projects can be attributed to its ability to address the challenges associated with substantial upfront costs, longer development timelines, and greater market uncertainties. By isolating project-specific risks within an SPV and securing external financing, PF provides a robust framework for managing the complexities of large-scale investments (Steffen, 2018, p. 281). Additionally, PF enables risk-sharing between lenders and sponsors, reducing the strain on corporate balance sheets – an essential factor for capital-intensive projects. Conversely, CF is more common in medium-sized projects, where lower risks and predictable revenue streams make this financing model a practical choice (Vernimmen et al., 2017, p. 209). Sponsors of such projects often leverage their strong balance sheets to directly fund these projects, avoiding the complexities and external oversight associated with PF. This reliance on CF reflects its suitability for stable, medium-sized investments, where equity-heavy structures provide the flexibility and cost-efficiency needed to manage financial obligations effectively.

Project Size Distribution by Technology

The distribution of project size also varies significantly between hydropower and wind power, reflecting the distinct characteristics of these technologies. Figure 5 shows that across both technologies, medium-sized projects dominate, with the 20-50 MW and 50-100 MW categories representing the largest shares. Larger projects (>100 MW) are also common, however smaller projects (<20 MW) are less frequent, but remain critical components of Norway's renewable energy landscape.

Figure 5: Project Size Distribution for Wind and Hydropower

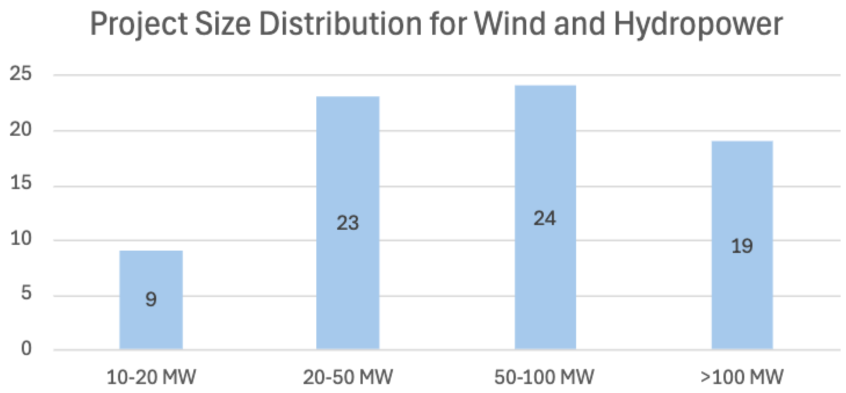


Figure 5 illustrates the number of wind and hydropower projects distributed different size categories, ranging from 10–20 MW to projects exceeding 100 MW.

Hydropower projects (Figure 6) are predominantly medium-sized, with 20–50 MW accounting for the majority, followed by 50-100 MW. Smaller projects (10-20 MW) are also relatively common, while projects exceeding 100 MW are rare. This distribution reflects the mature and stable nature of hydropower development in Norway, where medium-sized projects dominate due to their manageable scale and predictable revenue streams.

Figure 6: Project Size Distribution for Hydropower

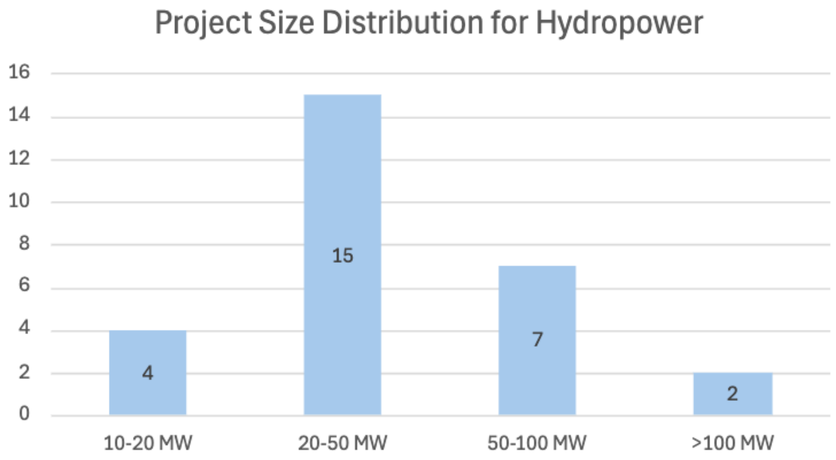


Figure 6 presents the distribution of hydropower projects across various size categories, ranging from 10–20 MW to projects over 100 MW. It highlights a concentration of projects in the 20-50 MW category, with fewer projects in both the smallest and largest size categories.

In contrast, wind power projects (Figure 7) are generally larger in scale. Most projects fall into the 50-100 MW and >100 MW categories, noting the capital-intensive nature of wind power. Smaller projects (10–20 MW) are less common, indicating a developer preference for larger installations to manage revenue variability and achieve economies of scale.

Figure 7: Project Size Distribution for Wind Power

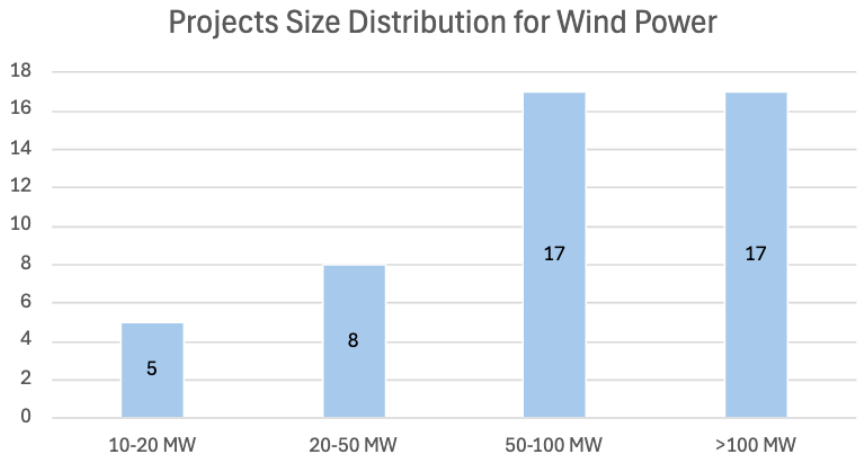


Figure 7 illustrates the distribution of wind power projects across different size categories, ranging from 10–20 MW to over 100 MW. It highlights the concentration of projects in the 50-100 MW and >100 MW categories, with fewer projects in the smaller size categories.

Sponsor Types and Financing Preferences

Sponsor types play a significant role in shaping financing preferences in Norwegian renewable energy projects. The four sponsor types exhibit distinct tendencies toward PF or CF, reflecting differences in financial strategies, risk tolerance, and operational objectives. Sponsors requiring structured risk management are more inclined to use PF, as it provides access to external funding while isolating financial exposure through SPVs. In contrast, larger and more established sponsors often favor CF due to its lower costs and ability to leverage their robust balance sheets.

Figure 8: Sponsor Types in Hydropower and Wind Power Projects

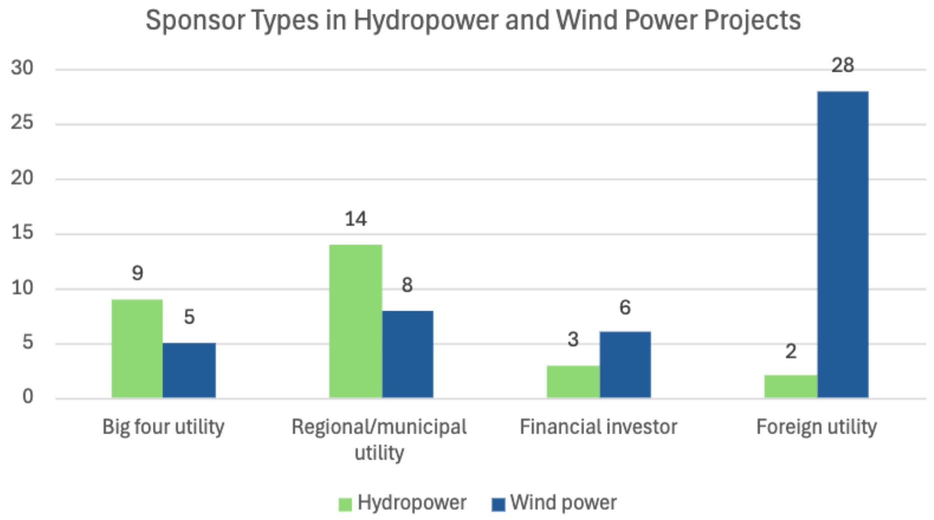


Figure 8 illustrates the distribution of sponsor types across hydropower and wind power projects, including Big Four utilities, regional/municipal utilities, financial investors, and foreign utilities. The figure highlights the dominance in wind power projects and the significant role of regional/municipal utilities in hydropower.

Figure 8 provides an overview of sponsor types across hydropower and wind power projects. Foreign utilities dominate wind power projects, with 28 wind projects compared to just 2 hydropower projects. Regional/municipal utilities have a more balanced portfolio, with 14 hydropower projects and 8 wind projects, reflecting their broader involvement in both technologies. Financial investors and the Big Four utilities demonstrate narrower engagement, with financial investors favoring wind projects and the Big Four utilities focusing primarily on hydropower. This distribution underscores the alignment between sponsor characteristics and project types, as well as the distinct financial strategies tailored to the risks and scales associated with each technology.

The distinct financing preferences among sponsor types are evident in figure 9 (below). Foreign utilities and financial investors predominantly rely on PF, reflecting their focus on isolating project-specific risks and addressing information asymmetry. Foreign utilities finance 63% of their projects through PF, reflecting its strategic role in managing uncertainties such as regulatory unfamiliarity and markets risks (Steffen, 2018, p. 281). Financial investors exclusively use PF, underscoring their emphasis on limiting liabilities and employing SPVs to achieve optimal risk-sharing.

In contrast, regional/municipal utilities and the Big Four utilities demonstrates a preference for CF. Regional/municipal utilities finance 59% of their projects through CF, capitalizing on their stable financial positions to avoid the complexities associated with PF. The Big Four utilities exclusively use CF, leveraging their substantial financial resources and operational stability to directly fund projects. These financing strategies align with their lower risk tolerance and preference for straightforward financial management.

Figure 9: Distribution of Project Finance and Corporate Finance by Sponsor Types

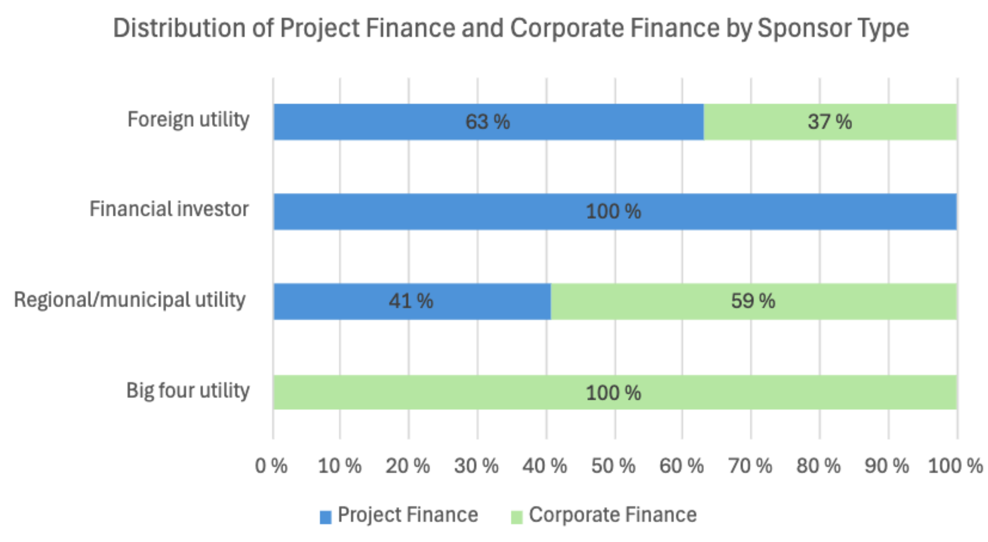


Figure 9 illustrates the distribution of project finance and corporate finance among sponsor types, showcasing the varying financing preferences of foreign utilities, financial investors, regional/municipal utilities, and Big Four utilities.

Key Findings from the Analysis

The analysis reveals distinct and consistent patterns in financing preferences, shaped by technology type, project size, and sponsor characteristics. PF is predominantly used for larger and more capital-intensive projects, particularly within the wind power sector, where higher risks such as revenue variability, market price fluctuations, and weather dependency necessitate robust financial mechanisms. The data illustrates that most wind power projects exceed 50 MW, aligning well with PF's capacity to manage such uncertainties through risk isolation and access to external financing (Yescombe, 2014, p. 8).

Conversely, CF dominates in medium-sized projects, particularly within hydropower, which is characterized by its lower risk profile, predictable revenue streams, and longer operational lifespans. These attributes make CF an optimal financing choice for regional/municipal utilities and the Big Four utilities, who leverage their strong balance sheets and financial stability to directly fund projects without relying on external debt. Hydropower's inherent stability allows these sponsors to avoid the complexity and risk-sharing structures associated with PF, instead focusing on cost-efficient, equity-heavy financing models that align with their operational strategies.

Sponsor characteristics further reinforce these financing patterns. Foreign utilities and financial investors, operating in higher-risk environments and often facing challenges like information asymmetry and regulatory unfamiliarity, overwhelmingly rely on PF for large-scale wind power projects. PF enables these sponsors to isolate project-specific risks withing the SPV, protecting their corporate balance sheets while attracting external capital. Conversely, regional/municipal utilities and the Big Four utilities consistently favor CF, reflecting their financial strength and a preference for streamlined financing structures that directly integrate with their broader asset portfolios.

In sum, the analysis confirms that PF has been of great importance for renewable energy projects put to operation in Norway during 2010–2023, particularly for large-scale wind power projects that have increased in frequency as Norway expands its renewable energy capacity. CF and PF play complementary roles, with PF primarily addressing the risks and financial demands of high-capital wind power investments. Conversely, CF dominates the financing landscape overall, especially in medium-sized, lower-risk projects such as hydropower. Its prevalence reflects the financial strength and stability of sponsors like the Big Four utilities, who leverage their balance sheets to avoid the complexity of external financing. These patterns highlight how financing strategies in Norway are tailored to project size, technology, and sponsor characteristics, ensuring adaptability and resilience in the country's renewable energy sector.

8.2 Analysis of Debt Structure

This section analyzes variations in debt structures between PF and CF, using total debt, debt ratio, long-term debt, short-term debt, and debt to credit institutions. Data were compiled from Proff.no (2024) and NVE as part of the overall dataset from 2010-2023. The aim is to illustrate how risk profiles, capital requirements, and technology influence financing choices and debt distribution. All debt values are reported in millions NOK (*1000).

Distribution of Sum Debt

The analysis reveals significant variations in total debt between PF and CF, with clear differences emerging across technologies (see Figure 10). CF projects, particularly in hydropower, carry notably higher total debt compared to PF, while PF projects exhibit higher total debt in wind power. These differences reflect the specific risk profiles, capital requirements, and financial strategies associated with each technology.

Figure 10: Average Sum Debt by Financing Model and Technology Type

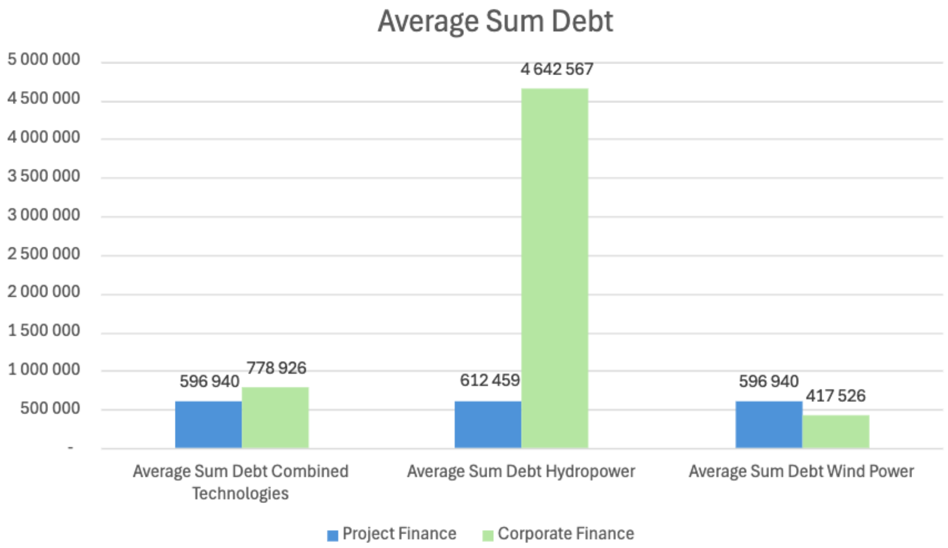


Figure 10 illustrates the average sum debt across renewable energy projects in the dataset, divided into three categories: combined technology, hydropower, and wind power. The chart compares the debt levels associated with project finance and corporate finance.

For hydropower, CF projects demonstrate significantly higher total debt, averaging NOK 4,642,567, compared to NOK 612,459 in PF. This can be attributed to the robust financial position of large sponsors, such as Statkraft and other major utilities, who leverage their strong balance sheets and stable revenue streams to secure substantial loans for long-term infrastructure investments like dams and turbines. CF projects often strike a balance between debt and equity contributions to optimize their capital structure and minimize the weighted average cost of capital (WACC) (Vernimmen et al., 2017, p. 593). This dual reliance enables sponsors to finance large-scale projects effectively while maintaining financial control and minimizing overall risk. Additionally, the ability to deduct interest expenses from taxable income provides a tax incentive for CF companies to utilize debt financing over equity (Vernimmen et al., 2017, p. 602). Unlike dividends, which are paid post-tax, debt repayments occur pre-tax, making debt an attractive and cost-effective option for financing projects. These tax advantages, combined with favorable loan conditions enabled by CF sponsors' high creditworthiness, contribute to the higher total debt levels observed in CF hydropower projects.

In contrast, wind power projects display higher total debt in PF, with an average of NOK 596,940 compared to NOK 417,526 in CF. This reflects the higher capital intensity and greater risks associated with wind power, including weather dependency, price fluctuations, and intermittent income streams (Statkraft, n.d. E). PF structures are specifically designed to manage these risks by isolating project-specific liabilities within an SPV. This allows repayment schedules to be aligned with the project's cash flow patterns, ensuring that debt service is prioritized even when revenues fluctuate (Whitelaw-Jones, 2024). The high debt-to-equity ratios characteristic of PF make it particularly suitable for capital-intensive wind projects, as debt financing is generally cheaper than equity (Yescombe, 2014, p. 22). Foreign sponsors, heavily involved in wind power, also rely on PF to mitigate risks related to information asymmetry and local market uncertainties. By isolating liabilities, PF enables sponsors to limit exposure while facilitating large-scale investments (Finnerty, 2013, p. 1).

The observed differences between PF and CF underline how financing strategies align with the risk and financial characteristics of the respective technologies. In hydropower, CF dominates due to its stability and predictability, allowing sponsors to access large loans without the need for risk isolation. The combination of equity contributions and strong credit ratings ensures sustainable capital structures for CF projects. Conversely, PF emerges as the preferred choice for wind power due to its ability to address higher financial risk and revenue variability while leveraging debt to minimize upfront equity contributions. Overall, these findings underscore that CF is more suited for low-risk, stable technologies like hydropower, while PF is strategically used for managing risks and capital demands in wind power. This alignment reflects the distinct roles played by each financing model in addressing technology-specific financial needs.

Debt Ratio

The analysis reveals that PF projects have a significantly higher average debt ratio (85%) compared to CF projects (43%) across both hydropower and wind power technologies (see figure 11). This distinction underlines the fundamental difference in financing strategies between the two models: PF prioritizes high debt utilization to minimize upfront equity contributions, while CF relies more on a balanced capital structure supported by substantial equity.

Figure 11: Average Debt Ratio by Financing Model and Technology Type

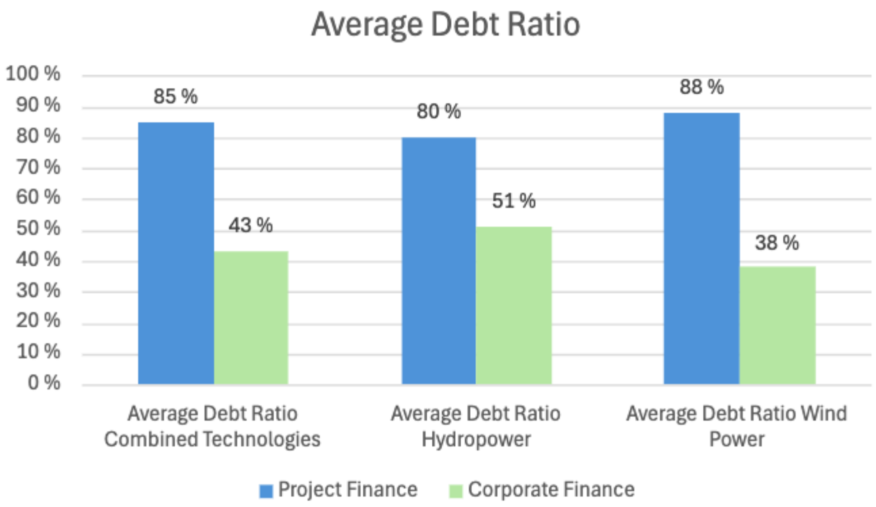


Figure 11 presents the average debt ratio across renewable energy projects, divided into combined technologies, hydropower, and wind power, while distinguishing between project finance and corporate finance.

In the PF model, projects are predominantly financed through loans, with equity contributions intentionally kept low to reduce the sponsors' financial exposure and minimize the overall cost of capital (Yescombe, 2014, p. 22). This approach allows risks to be isolated at the project level, ensuring that liabilities remain tied to the project's cash flows rather than the sponsor's broader balance sheet (Steffen, 2018, p. 281). The tax deductibility of interest expenses further enhances the attractiveness of debt financing, as it lowers taxable income and improves cash flow (Yescombe, 2014, p. 24). For wind power, which is characterized by weather dependency, price volatility, and intermittent revenues, PF's high debt ratio is particularly advantageous. By aligning debt repayment schedules with project cash flows and implementing mechanisms such as cash flow waterfalls and reserve accounts, PF effectively manages these risks while limiting equity contributions (Whitelaw-Jones, 2024). Additionally, PF allows sponsors, including foreign investors, to mitigate risks associated with information asymmetry and unfamiliar market conditions, enabling them to undertake capital-intensive projects without jeopardizing their broader financial stability (Finnerty, 2013, p. 1).

For hydropower, PF projects also display relatively high debt ratios despite the technology's stable revenues. This can be attributed to PF's ability to isolate project-specific risks and ensure that debt repayment is directly linked to the project's predictable cash flows (Yescombe, 2014, p. 8). However, PF remains less common in hydropower compared to CF, as the risk isolation provided by PF is often unnecessary for such low-risk projects.

In contrast, CF projects exhibit lower debt ratios due to their reliance on equity contributions. Large companies like Statkraft and regional/municipal utilities leverage their strong balance sheets, equity reserves, and predictable revenue streams to secure favorable loan terms for hydropower investments. By combining equity with long-term debt, CF sponsors maintain financial flexibility and achieve a stable capital structure that minimizes risk over time (Vernimmen et al., 2017, p. 593). The reliance on equity also ensures greater adaptability, as equity does not require fixed repayments or interest, providing a buffer during financial downturns or crises (Vernimmen et al., 2017, p. 609). This approach makes CF particularly sustainable for hydropower projects, where revenue streams are stable and predictable.

However, for wind power, the heavy reliance on equity in CF becomes less viable due to revenue variability and higher financial risks. Equity demands a higher return compared to debt, making it less attractive for capital-intensive wind power projects (Vernimmen et al., 2017, p. 609). Consequently, PF emerges as the more suitable option for managing the unique risks of wind power, as it maximizes debt utilization while isolating liabilities at the project level.

Overall, the higher debt ratio in PF reflects its ability to optimize debt financing and manage risks through project-specific structures, particularly in wind power projects with higher uncertainty and capital intensity. In contrast, CF's lower debt ratio reflects its reliance on strong equity contributions and stable revenues, making it a more sustainable option for low-risk technologies like hydropower. These differences underscore how financing strategies align with the financial and risk profiles of renewable energy technologies.

Long-Term Debt

The analysis reveals that when combining hydropower and wind power, long-term debt is higher for PF (NOK 507,481) than for CF (NOK 344,497) (see Figure 12). This combined average reflects PF's reliance on external debt to finance capital-intensive projects, particularly in cases where risk profiles and cash flows are less predictable (Yescombe, 2014, p. 8). However, this overall trend masks significant variations across technologies: PF carries higher long-term debt in wind power, while CF dominates in hydropower with substantially higher long-term debt.

Figure 12: Average Long-Term Debt by Financing Model and Technology Type

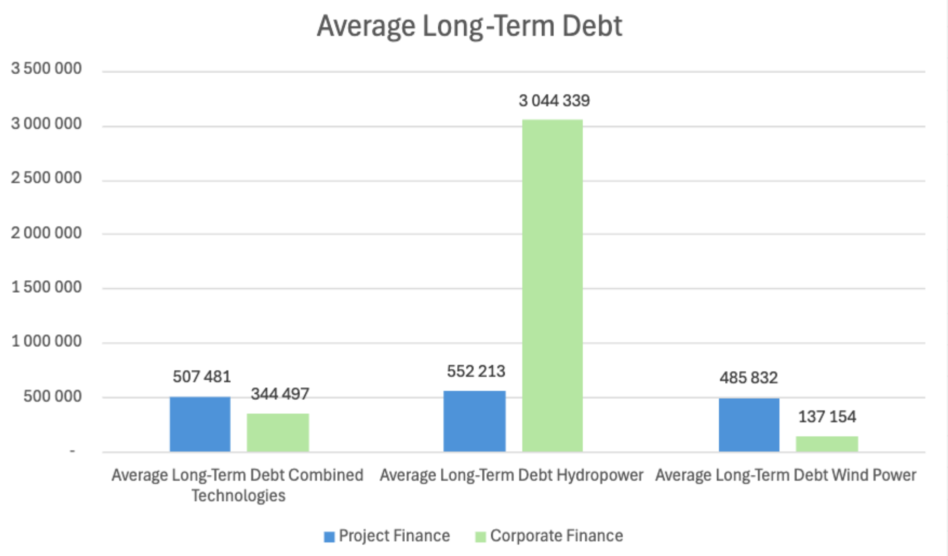


Figure 12 illustrates the average long-term debt for across renewable energy projects, divided into combined technologies, hydropower, and wind power, while distinguishing between project finance and corporate finance.

In hydropower, CF projects display notably higher long-term debt, averaging NOK 3,044,339, compared to NOK 552,213 for PF. This disparity illustrates hydropower's stability and predictability, which enable CF sponsors, such as Statkraft and regional utilities, to leverage strong balance sheets and creditworthiness to secure favorable loan terms. The low-risk profile of hydropower reduces the necessity for risk isolation provided by PF. Instead, CF sponsors combine long-term debt with significant equity contributions to achieve a balanced and stable capital structure. Additionally, tax advantages associated with interest expenses make debt a cost-effective financing strategy, further supporting profitability (Vernimmen et al., 2017, p. 602).

In contrast, wind power projects exhibit higher long-term debt under PF, with an average of NOK 485,832 compared to NOK 137,154 in CF. This is primarily driven by the capital-intensive nature of wind power and its higher financial uncertainty due to weather dependency and price volatility. Wind power's dependency on weather conditions and exposure to market price fluctuations make PF a suitable model for managing financial risks associated with this technology. Moreover, lenders are willing to provide substantial loans to PF projects because the structure prioritizes debt repayment directly from project revenues. While wind power cash flows can be variable, PF ensures that operational expenses and debt service are covered first, offering lenders a degree of stability in repayments (Whitelaw-Jones, 2024).

Additionally, the project's status as a separate legal entity isolates financial risks, ensuring that lenders' exposure is limited to the project's assets and revenues rather than the sponsor's overall financial situation (Steffen, 2018, p. 281). This separation of liabilities, combined with the collateral value of project assets, reduces lender risk and makes it possible to secure long-term financing even for higher-risk projects like wind power. Furthermore, tax deductions on interest expenses lower the effective borrowing costs, enhancing the financial feasibility of PF for capital-intensive projects (Yescombe, 2014, p. 24).

Short-Term Debt

Figure 13 illustrates distinct variations in short-term debt between PF and CF, particularly when comparing hydropower and wind power. While CF projects overall carry higher short-term debt (NOK 162,715) compared to PF projects (NOK 93,152), this general trend conceals key differences: CF projects dominate short-term debt in hydropower, whereas PF projects exhibit a small dominance in wind power.

Figure 13: Average Short-Term Debt by Financing Model and Technology Type

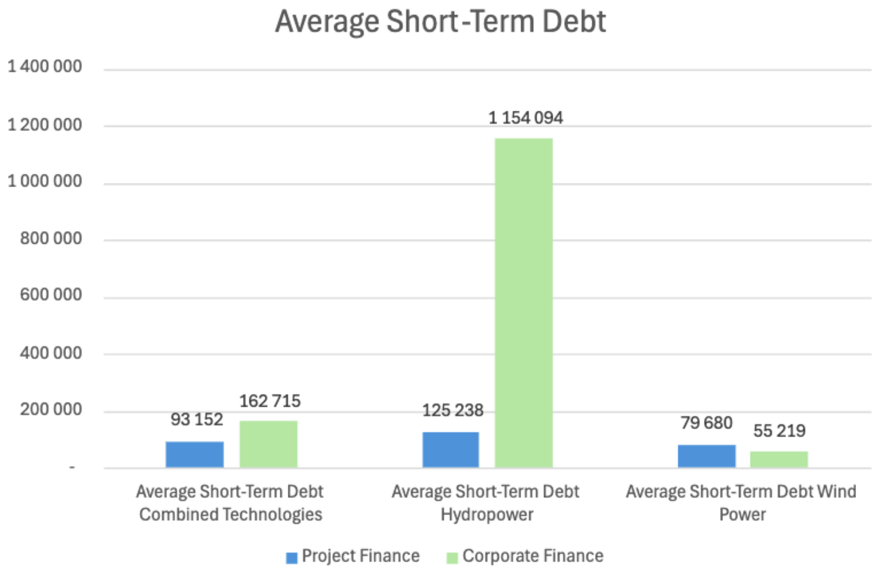


Figure 13 illustrates the average short-term debt across renewable energy projects, categorizing into combined technologies, hydropower, and wind power, while distinguishing the differences between project finance and corporate finance.

In hydropower, CF projects display significantly higher short-term debt, averaging NOK 1,154,094, compared to NOK 125,238 for PF. This discrepancy reflects the stability and predictability of hydropower revenues, which reduce default risk and make short-term financing readily accessible and cost-effective for CF sponsors. Banks are more inclined to offer favorable credit terms, enabling CF sponsors such as Statkraft and regional/municipal utilities to efficiently address operational and maintenance expenses. Additionally, tax advantages associated with interest deductions further improve liquidity, making short-term debt an attractive and flexible financing option (Vernimmen et al., 2017, p. 602).

Conversely, in wind power, PF projects exhibit higher short-term debt, averaging NOK 79,680 compared to NOK 55,219 in CF. This reflects wind power's greater financial uncertainty due to weather dependency, price fluctuations, and intermittent revenues. PF's project-specific structure allows sponsors to use short-term debt to address immediate financial needs, such as maintenance costs, grid connection fees, or unexpected disruptions, without placing undue pressure on the sponsors' broader finances. The relatively high leverage in PF, combined with lower equity requirements, makes it an effective financing strategy for capital-intensive wind projects (Yescombe, 2014, p. 24). By aligning short-term debt with project cash flows, PF ensures operational continuity, particularly during periods of low production.

Debt to Credit Institutions

As illustrated in Figure 14, PF projects report a higher average debt to credit institutions (NOK 121,452) compared to CF projects (NOK 86,374). This trend reflects PF's reliance on external funding to finance capital-intensive projects, particularly in cases with higher risk and less predictable cash flows. As independent entities, PF projects secure loans directly from credit institutions, with liabilities strictly tied to the project's assets and cash flows (Finnerty, 2013, p. 1; Yescombe, 2014, p. 8). This project-specific structure not only isolates risk but also enhances lender confidence by offering clear collateral and prioritizing debt repayment.

In contrast, CF projects leverage the financial strength and balance sheets of their sponsors, leading to lower external debt per project. These findings align with earlier observations, underscoring CF's suitability for stable, lower-risk projects like hydropower, while PF is better positioned to accommodate the higher risks and substantial capital requirements of technologies like wind power.

Figure 14: Average Debt to Credit Institutions by Financing Model

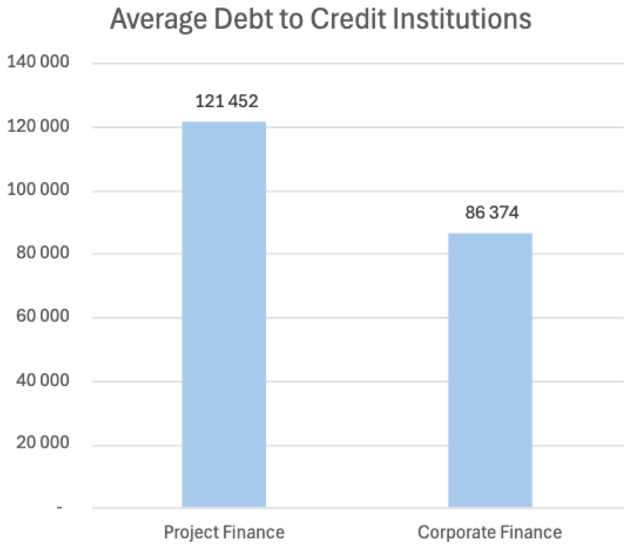
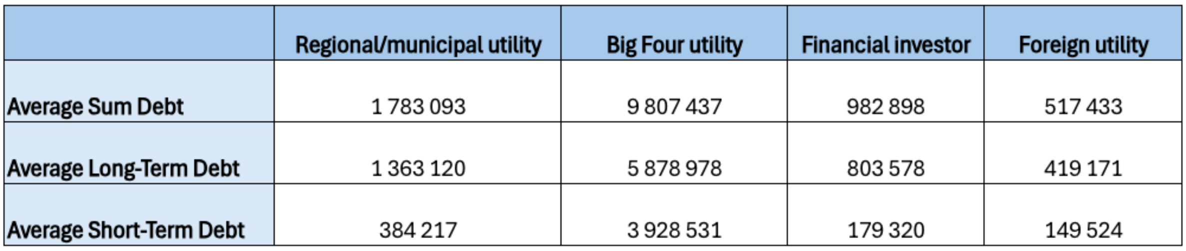


Figure 14 illustrates the average debt levels owed to credit institutions, comparing projects financed through project finance and corporate finance.

Sponsors Distribution of Debt

The analysis also shows significant variations in debt levels across sponsor types, reflecting differences in financing strategies and risk profiles (see Table 7).

Table 7: Debt Distribution by Sponsor Type



	Regional/municipal utility	Big Four utility	Financial investor	Foreign utility
Average Sum Debt	1 783 093	9 807 437	982 898	517 433
Average Long-Term Debt	1 363 120	5 878 978	803 578	419 171
Average Short-Term Debt	384 217	3 928 531	179 320	149 524

Table 7 presents the average sum debt, long-term debt, and short-term debt for different sponsor types, including regional/municipal utilities, Big Four utilities, financial investors, and foreign utilities. All values are in NOK.

The table reveals that Big Four utilities and regional/municipal utilities, which predominantly rely on CF and invest in hydropower, hold the highest levels of average total, long-term, and short-term debt. This can be attributed to their established financial positions, strong balance sheets, and stable income streams, which enable them to secure favorable loan terms for capital-intensive projects. Specifically, the Big Four utilities, as large and creditworthy entities, are well-positioned to leverage their financial strength to fund significant hydropower investments. Similarly, regional/municipal utilities, though smaller in scale, benefit from their stable operations and community backing, which provide lenders with confidence to extend substantial debt financing for long-term infrastructure projects.

In contrast, financial investors and foreign utilities, which are more commonly associated with PF, display lower average debt levels. This disparity stems from PF's project-specific financing structure, where debt is directly tied to project assets and cash flows, rather than the sponsor's broader financial position. For financial investors, the reliance on PF reflects their focus on isolating risks while minimizing equity contributions. Meanwhile, foreign utilities often use PF as a strategy to manage risks associated with entering unfamiliar markets. Although PF allows these sponsors to limit their financial exposure, it also restricts the total amount of debt that can be tied to each project, particularly when sponsors have smaller balance sheets or limited access to internal capital.

Key Finding from the Analysis

PF projects are characterized by higher debt ratios, greater reliance on long-term debt, and larger amounts of debt to credit institutions. These features reflect PF's emphasis on isolating project-specific risks and leveraging external financing, particularly for wind power projects, where income streams are variable, and capital needs are higher. PF's lower equity requirements enable sponsors such as foreign utilities and financial investors to participate in large-scale projects while limiting their financial exposure.

In contrast, CF projects hold higher total debt across categories, despite having lower debt ratios due to their strong reliance on equity. Sponsors like the Big Four utilities and regional/municipal utilities leverage their financial strength and high creditworthiness to secure significant loans to fund renewable energy projects. The stability and predictability of hydropower revenues further enable these sponsors to manage larger debt effectively while maintaining financial stability.

These findings embrace the strategic alignment between financing models and project characteristics. PF's debt-driven, project-specific approach suits high-risk, capital-intensive technologies like wind power, while CF's equity-driven structure supports the financial stability and long-term investment needs of hydropower.

8.3 Elcertificates: Their Impact on Renewable Energy Financing in Norway

The Norwegian-Swedish elcertificate scheme, introduced in 2012, has likely played a significant role in shaping financing decisions for renewable energy projects in Norway (Energifakta Norge, 2024). By providing an additional revenue stream for every megawatt hour (MWh) of electricity generated, elcertificates enhanced project profitability and reduced financial uncertainty (NVE, 2023 A). This impact is visible in both CF and PF models, though in different ways.

For CF, the stabilizing effect of elcertificates strengthened cash flow and reduced financial risk, particularly for hydropower projects with predictable production. These stable income streams made it easier for large domestic sponsors, such as the Big Four utilities and regional/municipal utilities, to finance projects internally. The resulting reduction in reliance on external debt reinforced CF's dominance in Norway, even for projects with substantial capital requirements. For larger and riskier projects, particularly wind power projects exceeding 50 MW, elcertificates improved economic feasibility by mitigating financial risk. Wind power, characterized by variable production and uncertain revenues, benefited from the additional income provided by elcertificates. This increase in profitability boosted banks and investors' confidence in future cash flows, making it easier to secure external loans. Consequently, PF emerged as a preferred financing option for capital-intensive wind power projects.

In summary, elcertificates have had a clear influence on financing strategies for renewable energy projects in Norway. By enhancing cash flow stability and reducing financial risk, CF became a preferred option for hydropower projects, where stable revenues allowed large sponsors to leverage equity and limit external debt. At the same time, PF became more viable for large wind power projects, where elcertificates improved profitability, reduced financial uncertainty, and increased lender confidence. Although the scheme ended for new projects in 2021, elcertificates continue to support projects initiated before the deadline, significantly shaping financing decisions for the 2010–2021 period (Energifakta Norge, 2024). This analysis focuses on projects within this timeframe, highlighting how elcertificates played a pivotal role in reducing financial risk and improving economic feasibility, enabling sponsors to choose financing models best suited to their project characteristics and needs.

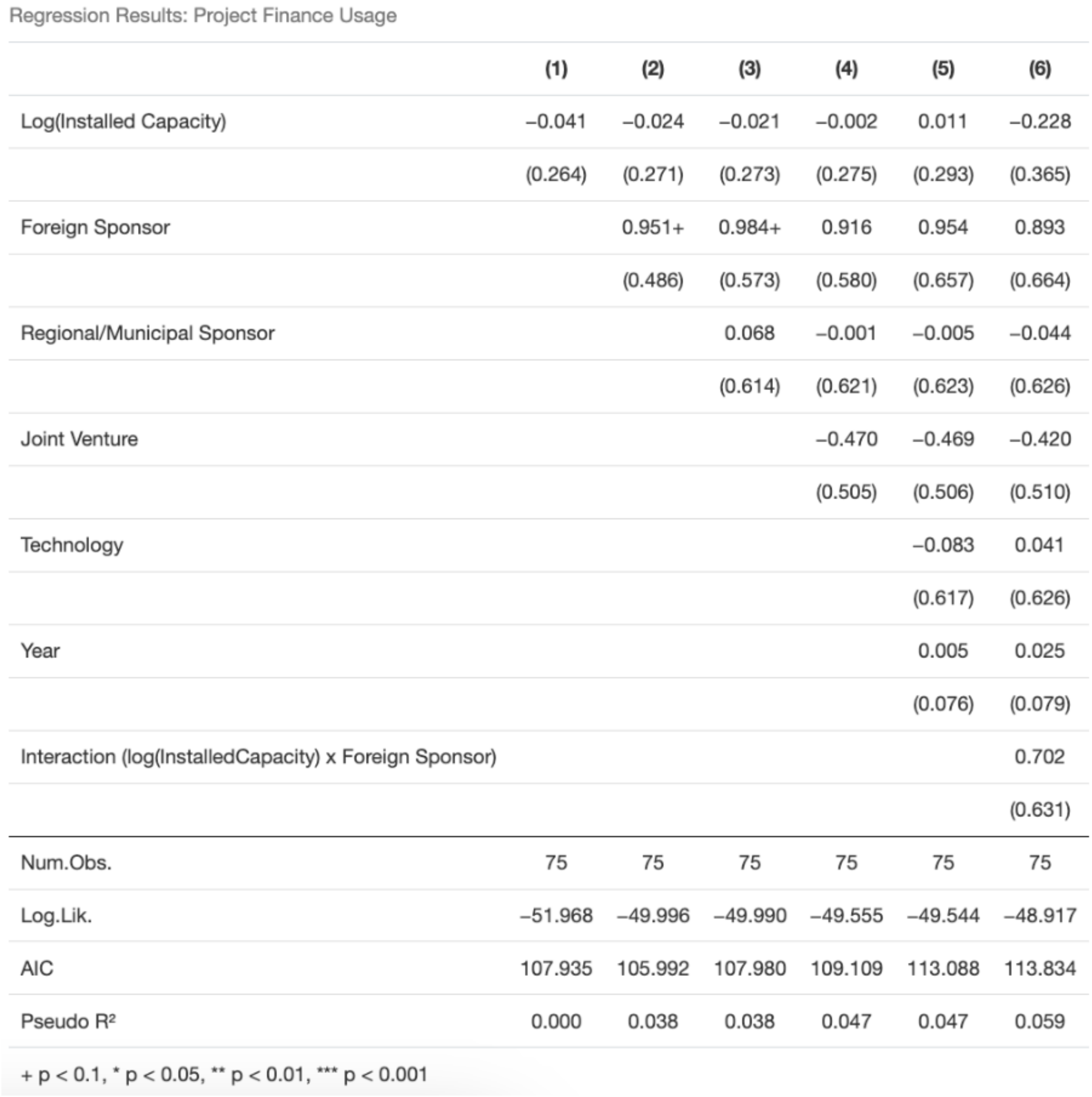
9. Empirical Analysis of Regression Results

This section presents the regression analysis results, aiming to identify the key drivers behind the use of PF in Norwegian renewable energy projects. The models are directly tied to the theoretical framework outlined in the literature review and test our hypotheses. Following a stepwise regression approach inspired by Steffen (2018), variables are incrementally introduced to isolate their individual and combined effects on the likelihood of using PF. This approach notes how project size, sponsor type, and ownership structure interact with financing decisions. By situating these results within the unique context of Norway's energy sector, the analysis sheds light on whether theoretical drivers of PF apply in a market characterized by strong sponsor balance sheets, low-risk projects, and established financial practices.

9.1 Regression Model and Key Findings

The regression models test the hypotheses by progressively adding variables, allowing an evaluation of their impact on the likelihood of PF usage. Table 8 summarizes the logit regression results, revealing the relationship between PF usage and the explanatory variables. The stepwise approach ensures a systematic assessment of key drivers, including contamination risk, information asymmetry, and agency conflicts, and their relevance in the Norwegian energy market.

Table 8: Regression Results for Project Finance Usage



Regression Results: Project Finance Usage

	(1)	(2)	(3)	(4)	(5)	(6)
Log(Installed Capacity)	−0.041	−0.024	−0.021	−0.002	0.011	−0.228
	(0.264)	(0.271)	(0.273)	(0.275)	(0.293)	(0.365)
Foreign Sponsor		0.951+	0.984+	0.916	0.954	0.893
		(0.486)	(0.573)	(0.580)	(0.657)	(0.664)
Regional/Municipal Sponsor			0.068	−0.001	−0.005	−0.044
			(0.614)	(0.621)	(0.623)	(0.626)
Joint Venture				−0.470	−0.469	−0.420
				(0.505)	(0.506)	(0.510)
Technology					−0.083	0.041
					(0.617)	(0.626)
Year					0.005	0.025
					(0.076)	(0.079)
Interaction (log(InstalledCapacity) x Foreign Sponsor)						0.702
						(0.631)
Num.Obs.	75	75	75	75	75	75
Log.Lik.	−51.968	−49.996	−49.990	−49.555	−49.544	−48.917
AIC	107.935	105.992	107.980	109.109	113.088	113.834
Pseudo R²	0.000	0.038	0.038	0.047	0.047	0.059

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001

*Table 8 displays the regression results for the determinants of Project Finance Usage. The table includes coefficient estimates, standard errors (in parentheses), and key model statistics such as the Akaike Information Criterion (AIC), Log-Likelihood, and Pseudo R^2. Significance levels are denoted by +, *, **, and *** for $p < 0.1$, $p < 0.05$, $p < 0.01$, and $p < 0.001$, respectively.*

Hypothesis 1: Project Size

Larger renewable energy projects (measured by installed capacity) are more likely to use project finance than smaller projects due to higher levels of risk and extensive funding requirements.

This hypothesis is grounded in the assumption that contamination risk – the potential for project failure to harm the parent company's financial stability – encourages the use of PF to isolate liabilities (Steffen, 2018, p. 282). Larger projects, with their higher capital intensity and risks, are expected to benefit from PF structures that limit financial exposure (Steffen, 2018, p. 282).

Model 1 tests the effect of project size, represented by log(Installed Capacity), as the sole explanatory variable. The coefficient is negative (-0.041) but statistically insignificant, indicating no clear relationship. As additional variables are introduced in Models 2–4, the coefficient for project size remains negative but fluctuates slightly in magnitude. In Model 5, the coefficient turns marginally positive (0.011) but reverts to a larger negative value (-0.228) in Model 6 when the interaction term is included. Importantly, the statistical insignificance persists across all models ($p > 0.05$), suggesting no systematic relationship between project size and PF usage.

The results reject the hypothesis that larger renewable energy projects are more likely to use PF in this dataset. Despite traditional theoretical expectations, larger project size and contamination risk remains insignificant across all models, and the interaction term offers no additional explanatory power. This suggests that larger project size and contamination risk, a key driver in other contexts, may be less relevant in Norway. Instead, Norwegian energy projects, particularly those in hydropower, rely on CF due to their robust financial health, access to low-cost funding, and the stable nature of their projects.

Hypothesis 2: Foreign Utilities

Projects sponsored by foreign utilities are more likely to use project finance due to increased risk and capital requirements.

This hypothesis assumes that foreign utilities face greater information asymmetry and contamination risk when operating in unfamiliar markets like Norway. PF can address these challenges by isolating liabilities through an SPV, providing transparency to lenders, and protecting the parent company's financial stability.

The foreign sponsor variable is introduced in Model 2 and has a positive coefficient (0.951) that is statistically significant at the 10% level ($p < 0.1$). This significance persists in Model 3 (0.984*) but diminishes in Models 4–6 as additional control variables (Technology, Year) and the interaction term are added. The coefficient remains positive but loses statistical significance, suggesting that the relationship between foreign sponsorship and PF usage weakens when accounting for additional factors. This pattern indicates that while foreign sponsorship aligns with theoretical expectations in simpler models, other unobserved factors – such as regulatory conditions or market-specific risks – may influence financing decisions.

The hypothesis is partially supported. Foreign utilities show a significant preference for PF in simpler models, aligning with theoretical expectations that they use PF to mitigate information asymmetry and contamination risk. However, this effect diminishes as more controls are added, highlighting the complex interplay of factors influencing financing decisions in the Norwegian energy market.

Hypothesis 3: Regional/Municipal Utilities

Regional/municipal utilities are more likely to use project finance compared to other sponsor types due to independence and ownership structure.

This hypothesis builds on the fact that regional/municipal utilities are theoretically expected to favor PF to isolate project-specific risks and maintain financial independence.

The regional/municipal sponsor variable exhibits an interesting trend across the models. In Model 2, the coefficient is slightly positive (0.068) but not statistically significant. However, as additional variables are added in Models 3–6, the coefficient turns negative, reaching -0.044 in Model 6, and remains consistently insignificant ($p > 0.05$). The shift in the coefficient suggests that once other project characteristics are controlled for, these utilities are systematically less likely to use PF. The findings align with the descriptive analysis, which notes several dynamics specific to Norway's energy market. Regional/municipal utilities benefit from strong financial stability, low-cost public financing, and access to government guarantees. These advantages make CF a simpler and more cost-effective option. Furthermore, hydropower projects, which dominate their portfolios, are perceived as low risk and naturally suited to corporate financing methods.

The hypothesis is rejected. Regional/municipal utilities do not favor PF and instead often rely on CF due to their financial strength, access to low-cost public funding, and low-risk hydropower portfolios. The results underscore the unique financing dynamics in Norway, where CF remains dominant among regional and municipal utilities.

Hypothesis 4: Joint Ventures

Joint venture projects are more likely to use project finance compared to single-owner projects, particularly due to shared risks and agency conflicts.

This hypothesis builds on the premise that joint ventures are expected to benefit from PF's ability to isolate risks and liabilities at the project level, particularly in horizontal partnerships where multiple stakeholders collaborate. By limiting each partner's exposure solely to project-specific risks, PF provides a mechanism to manage shared risks effectively. Additionally, it addresses agency conflicts by enforcing transparency and accountability through contractual agreements.

The Joint Venture variable is introduced in Model 4 and exhibits a consistently negative coefficient across all models, ranging from -0.470 to -0.420. However, the coefficients are not statistically significant ($p > 0.05$). This finding contradicts theoretical expectations, suggesting that joint ventures are not more likely – and perhaps even less likely – to adopt PF compared to single-owner projects. Several factors may explain this result. First, joint ventures in Norway likely benefit from the strong financial stability of their partners, making CF a simpler and less costly option. Second, the administrative complexity of PF, combined with its rigorous oversight requirements, may deter joint ventures in favor of corporate loans. Additionally, the relatively low-risk profile of many Norwegian energy projects, particularly hydropower, further diminishes the need for risk-isolating mechanisms.

The hypothesis is rejected, meaning that joint ventures do not demonstrate a significant preference for PF in this dataset. Instead, CF dominates, reflecting the simplicity and cost-effectiveness of this approach in a market characterized by strong financial stability and low project risk. This aligns with the broader observation that CF remains the primary financing method in the Norwegian energy market, regardless of ownership structure. These findings emphasize the limited influence of shared risks and agency conflicts on financing decisions in this context.

Control Variables and Interaction Term

Control variables, including Technology and Year, were introduced in Model 5 to account for differences in project characteristics and temporal effects. However, neither variable is statistically significant ($p > 0.05$), and their inclusion did not substantially alter the coefficients of the main explanatory variables. This suggests that technology type (e.g., hydropower or wind power) and project timing do not significantly influence the likelihood of using PF in this dataset.

Model 6 incorporates an Interaction Term between log(Installed Capacity) and foreign sponsor to examine whether project size moderates the relationship between foreign sponsorship and the likelihood of using PF. The coefficient for the interaction term is positive (0.702) but statistically insignificant, indicating that project size does not amplify or diminish the effect of foreign sponsorship on PF usage. The findings suggest that foreign sponsorship influences PF decisions independently of project size, and the interaction term provides no additional explanatory power. Model 6 closely resembles Steffen (2018) by including the key project characteristics and sponsor variables, while also accounting for interaction effects specific to the Norwegian market.

Key Metrics for Regression Models

The regression models exhibit low Pseudo R^2 values, ranging from 0.0 in Model 1 to 0.059 in Model 6. While these values suggest limited explanatory power, such results are typical for logistic regressions applied to small datasets and can still yield meaningful insights into the relationships between variables. AIC values vary across the models, reflecting their relative fit. Between Models 1 and 3, AIC decreases, indicating an improved model fit with the inclusion of sponsor characteristics. However, AIC increases again in Models 4 through 6 as additional control variables and interaction terms are introduced. This pattern suggests that the added complexity in the later models does not meaningfully enhance the explanatory power and may instead dilute the model’s clarity. Residual diagnostics revealed no major issues with the models, supporting their validity despite the small dataset and limited predictive strength. While the models' explanatory power is modest, they provide a foundational understanding of the factors influencing the likelihood of PF usage in the Norwegian renewable energy sector.

9.2 Interpretation of Findings

The regression analysis offers valuable insights into the factors influencing PF usage in Norway’s renewable energy market, although it reveals deviations from theoretical expectations. These deviations showcase the unique financial and operational dynamics of Norway’s energy sector.

Project Size and Project Finance Usage

Contrary to theoretical expectations, larger high-risk project does not significantly influence the likelihood of using PF in our dataset. Larger projects, with higher capital requirements and contamination risks, were hypothesized to benefit from PF as a mechanism to isolate liabilities. However, the results reveal no systematic relationship between large high-risk projects and financing choices, challenging contamination risk as a decisive factor in Norway’s context.

Norwegian energy companies, particularly those involved in hydropower, benefit from stable market conditions and strong financial health. Sponsors such as the Big Four utilities and regional/municipal utilities dominate the market, leveraging their robust corporate structures and well-established lender relationships to secure financing without isolating liabilities through PF. Hydropower, which constitutes a significant share of the Norwegian energy portfolio, is perceived as low risk and well-suited to CF due to its stable cash flows and predictable risk profile. Even for wind power projects, which carry higher risks, sponsors often rely on their financial stability to secure corporate loans, bypassing the complexity of PF. Norway’s reliance on CF reflects the unique dynamics of its energy market. The country’s long-standing focus on renewable energy and the dominance of hydropower have fostered a financing culture that prioritizes simplicity and cost-effectiveness over the additional complexity of PF. These characteristics distinguish Norway from markets where contamination risk and larger project size play a more significant role in financing decisions. Instead, factors such as the market’s financial stability, strong sponsor balance sheets, and access to low-cost financing outweigh the theoretical drivers of PF.

Foreign Sponsors and Project Finance Usage

Foreign sponsors demonstrate a positive relationship with PF usage in simpler models, aligning with theoretical expectations that they rely on PF to address information asymmetry and contamination risk. Foreign utilities entering the Norwegian energy market face challenges such as limited familiarity with local regulatory frameworks and market risks, which increase lenders' perceptions of risk. PF provides tools to mitigate these concerns by isolating liabilities within an SPV, enhancing transparency, and shielding parent companies from project-specific risks. This dual role of managing informational gaps and protecting corporate balance sheets underscores the strategic importance of PF for foreign sponsors.

However, as additional control variables such as technology type, year, and interaction terms are introduced, the significance of the foreign sponsor variable diminishes. This indicates that while foreign sponsorship may initially increase the likelihood of PF, this effect is not robust across more complex models. The diminishing significance suggests that other factors, such as regulatory frameworks, market dynamics, or project-specific risks, may also play a critical role in financing decisions. These findings highlight that while information asymmetry and contamination risk contribute to foreign sponsors' preference for PF, these factors alone do not fully explain their financing decisions. The limited explanatory power of the regression models underscores the need for further research to capture a more comprehensive picture.

Regional/Municipal Utilities and Project Finance Usage

Regional and municipal utilities exhibit a clear preference for CF, as indicated by the consistently negative and statistically insignificant coefficients for the regional/municipal Sponsor variable. These utilities rely on CF due to their strong financial positions, access to low-cost public financing, and the predictable nature of hydropower projects, which dominate their portfolios. Hydropower's low risk and stable cash flows make it particularly well-suited to corporate financing methods. Additionally, regional and municipal utilities benefit from public guarantees and low-cost funding mechanisms, further reducing the need for risk-isolating structures like PF. The reliance on CF reflects the unique characteristics of Norway's energy market, where simplicity, cost-effectiveness, and robust financial stability are prioritized over the complexity of PF.

The findings suggest that regional/municipal utilities' preference for CF aligns with their operational realities and the established financial culture of Norway's renewable energy sector. While the hypothesis proposed that regional/municipal utilities would favor PF to maintain independence and isolate risks, the results reveal that these utilities rely on their financial stability to efficiently fund projects through corporate financing methods. The widespread reliance on CF among these utilities also reflects several unique dynamics of Norway's energy market. First, the dominance of hydropower, a well-established and low-risk energy source, naturally aligns with corporate financing methods. Second, the availability of low-cost public financing and guarantees further diminishes the attractiveness of more complex financing structures like PF. Additionally, mechanisms like elcertificates may incentivize straightforward financing approaches, allowing utilities to bypass the administrative and financial complexities of PF.

Joint Ventures and Project Finance Usage

Joint ventures are theoretically well-suited to PF due to its ability to isolate risks at the project level and manage agency conflicts among multiple stakeholders. In horizontal joint ventures, where partners with diverse interests collaborate, PF offers mechanisms to limit exposure to project-specific risks and ensure liabilities remain confined to the project. However, contrary to theoretical expectations, the findings suggest that these advantages do not significantly influence financing decisions in the Norwegian renewable energy market. Across all models, the coefficient for Joint Venture is negative and statistically insignificant. This indicates no substantial evidence that joint ventures are more likely to adopt PF compared to single-owner projects. In fact, the negative coefficient implies that single-owner projects may be more inclined to use PF, though this relationship lacks statistical significance and cannot be confidently established.

The findings may reflect the unique characteristics of the Norwegian energy market. Joint ventures in Norway likely benefit from the strong financial stability of their partners, making CF a simpler and less costly alternative. Established relationships with lenders and sufficient internal capital further reduce the necessity for complex PF structures. Additionally, the complexity of coordinating multiple stakeholders in a joint venture may prevent the use of PF, which involves rigorous oversight and extensive contractual agreements.

Moreover, the relatively low-risk profile of many Norwegian energy projects, particularly hydropower, diminishes the need for risk-isolating mechanisms traditionally associated with PF. CF enables joint ventures to leverage their collective financial resources without incurring the added costs and oversight required by PF. These dynamics, combined with strong sponsor balance sheets and stable market conditions, reduce the theoretical appeal of PF in this context. In a market characterized by strong financial positions, established lender relationships, and low project risks, the advantages of PF – such as risk isolation and agency conflict mitigation – play a minimal role in financing decisions. These findings suggest that project type and sponsor strength have a greater influence on financing choices than ownership structure.

Summary of Findings

The findings challenge traditional drivers of PF, such as contamination risk and agency conflicts for larger high-risk projects, in Norway's renewable energy market. Instead, the strong financial capacity of sponsors, stable market conditions, and public financing mechanisms favor CF. Hydropower projects, in particular, benefit from the low-risk nature of their operations and the financial robustness of Norwegian sponsors, including the Big Four utilities and regional/municipal utilities. These sponsors often rely on CF, leveraging strong balance sheets and access to low-cost capital to directly absorb risks without the need for complex PF structures. While contamination risk may still influence financing decisions for certain projects, such as wind power ventures sponsored by foreign utilities, it is not a decisive factor overall. Foreign sponsors show some initial association with PF, likely due to information asymmetry and the need to isolate liabilities, but this effect diminishes as additional variables are introduced. The analysis also suggests that market conditions, risk profiles, and institutional frameworks may play a more critical role than project size, sponsor type, or ownership structure. The limited data set constrains the analysis, emphasizing the need for future research to explore these dynamics with larger and more comprehensive data. These results underscore the unique characteristics of Norway's renewable energy market, where CF dominates due to its simplicity, cost-effectiveness, and alignment with the financial and operational strengths of sponsors.

10. Conclusion

This thesis has examined the factors influencing the use of PF in Norway's renewable energy sector, with its unique characteristics as a low-risk, renewable-dominated market. Through the lens of economic and financial theory, the study identifies the conditions under which PF and CF are utilized. While hydropower projects typically rely on CF due to the financial capacity of domestic utilities, PF remains a strategic option for wind power projects involving higher risks and foreign sponsors. The findings highlight the nuanced role of PF in Norway, offering valuable insights into its selective application in stable, well-established markets.

Using our combined dataset of renewable energy projects in Norway, this thesis demonstrates that the classical "contamination risk" explanation does not hold. PF is not widely used for large, high-risk projects but is selectively applied to large-scale wind power developments, particularly those involving foreign utilities and financial investors. CF dominates the financing landscape, driven by the financial strength, experience, and substantial balance sheets of the Big Four utilities and regional/municipal utilities. These entities favor CF for its simplicity and efficiency, particularly in hydropower projects, which are medium-sized and low-risk. CF is also used in wind power projects by these sponsors, as their expertise and strong balance sheets allow internal funding without requiring PF's risk-mitigation mechanisms.

PF is instead used strategically for large high-risk wind power projects, reflecting its traditional role in managing uncertainty and shielding sponsors' core operations. Foreign utilities, the largest sponsors in Norway's wind power sector, face challenges related to information asymmetry and contamination risk, which are key drivers for PF usage. By isolating liabilities within an SPV, PF provides transparency to lenders, mitigates risks, and protects sponsors' broader operations. While the significance of these drivers diminishes with additional variables, they remain relevant for foreign sponsors navigating the uncertainties of large-scale wind developments. Moreover, financial investors are also drawn to PF for its high returns and structured risk-sharing, further emphasizing its selective but critical role in Norway's renewable energy sector.

These findings highlight the nuanced role of PF in Norway's renewable energy sector, demonstrating its value in high-risk wind power projects and contributing to the broader understanding of financial structures in renewable energy investments.

11. Thesis Limitations

Our thesis provides valuable insights into financing decisions in Norway’s renewable energy sector; however, certain limitations have shaped the scope and interpretation of our findings. One of the primary limitations is the relatively small sample size of 75 projects, which poses challenges, particularly when analyzing smaller subgroups such as specific sponsor types or technologies. This limitation reduces statistical power and the ability to detect nuanced effects, potentially impacting the robustness and generalizability of the results. It also increases the risk of overfitting in the regression models, which could affect the reliability of predictive outcomes.

While the geographic focus on Norway provides a stable and unique context for studying financing decisions in renewable energy projects, it is important to note that the findings are intentionally tailored to this specific setting. Norway’s well-established regulatory framework and mature renewable energy market make it an ideal case for this analysis. However, the results may not directly apply to countries with different market conditions or regulatory environments. Another notable limitation lies in the manual classification of financing structures (PF vs. CF) and sponsor types, which relied on our predefined criteria. Although efforts were made to ensure accuracy and consistency, this process inevitably involves a degree of subjectivity, particularly in cases where classification were less straightforward.

Despite these challenges, the study provides a strong foundation for examining financing decisions in Norway’s renewable energy projects. The insights contribute to a deeper understanding of the factors influencing the choice between PF and CF, offering valuable perspectives on renewable energy financing in a mature and stable energy market. These limitations also highlight areas where further research could enhance the robustness and applicability of the future findings.

Declaration on the use of AI tools in the work on this master's thesis

Name (and version) of the AI tool: ChatGPT, 4.0.
Purpose of using the tool: We have used ChatGPT 4.0 for organizing data, assisting with data analysis (including support with R programming), generating ideas, and refining language in written sections. Additionally, the tool has been used for formatting references and creating APA citations.

We are aware that we are responsible for all content of this master's thesis, including the parts where AI tools are used. We are responsible for ensuring that the thesis complies with ethical rules for privacy and publication.

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Appendices

Appendix A: Explanation of Coefficients in the Regression Equation

The regression model estimates the probability of a renewable energy project using PF, with various factors influencing this decision. The constant term (β_0), represents the baseline log-odds of using PF when all other factors are held at zero, providing a starting point for understanding PF adoption (Hosmer et al., 2013, p. 16). One of the most important drivers in the model is project size, measured through the log-transformed installed capacity (β_1). This coefficient captures how changes in project size influence the likelihood of PF adoption. A positive coefficient suggests that larger projects are more likely to use PF, reflecting economies of scale or higher financing requirements. The log-transformation ensures that percentage changes in project size yield a linear effect on the log-odds, making the relationship straightforward to interpret (Woolridge, 2019, p. 746).

The type of sponsor is another critical factor in the model. The Foreign Sponsor Dummy (β_2) shows whether foreign sponsors influence the decision to use PF. A positive coefficient implies that foreign-sponsored projects are more likely to adopt PF, potentially reflecting greater capital requirements or risk-sharing needs. Similarly, the Regional/municipal Sponsor Dummy (β_3) assesses the impact of regional or municipal sponsors. A positive value indicates a higher likelihood of PF adoption, whereas a negative value points to a reduced preference for this financing structure among these sponsors. In addition, ownership structure is reflected in the Joint Venture Dummy (β_4), where a positive coefficient suggests that shared ownership increases the attractiveness of PF compared to single-owner projects. The model also accounts for differences in technology type through the Technology Dummy (β_5), which distinguishes between wind power and hydropower projects. A positive coefficient implies that wind power projects are more likely to use PF, reflecting higher capital costs or size compared to hydropower.

Temporal trends are captured by the Year variable (β_6), where a positive coefficient indicates increased PF adoption over time. Additionally, the interaction term (β_7) between log(Installed Capacity) and the Foreign Sponsor Dummy examines the combined effect of project size and foreign sponsorship. A positive value suggests that larger, foreign-sponsored projects are particularly inclined towards PF. Finally, the error term (ε) accounts for unobserved factors or random variation, ensuring the model's robustness (Woolridge, 2019, p. 848). Together, these coefficients offer valuable insights into the factors shaping PF usage in renewable energy projects, providing a detailed framework for analyzing financing decisions in this sector.

Appendix B: Variable Transformation

To improve interpretability and ensure the regression model met key assumptions, specific transformations were applied to the dataset. The variable InstalledCapacity, representing project size in megawatts (MW), exhibited substantial skewness due to the wide variation between small-scale hydropower plants and large wind farms. A log-transformation was applied, producing log(InstalledCapacity). This transformation reduced skewness, stabilized variance, and improved the linear relationship between project size and the log-odds of the dependent variable ProjectFinanceDummy, enhancing both model fit and predictive accuracy (Woolridge, 2019, p. 746). The log-transformation also allows for an intuitive interpretation of coefficients as proportional changes in the likelihood of using PF.

For categorical variables, such as SponsorType, dummy variables were manually created. Manual creation allowed for explicit control over the reference category, ensuring avoidance of perfect multicollinearity (the "dummy variable trap") (Woolridge, 2019, p. 236). By excluding one category as the reference, the coefficients for the remaining categories represent their effect on the likelihood of PF relative to the reference group (Woolridge, 2019, p. 236). This approach also facilitated targeted hypothesis testing, such as evaluating the impact of foreign sponsors compared to other sponsor types.

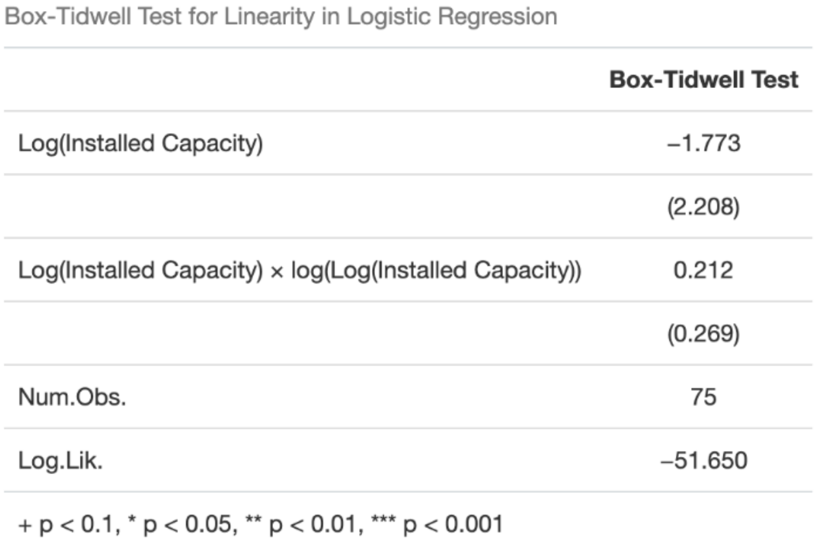
Appendix C: Testing the GLM Assumptions

For the final regression model (Table 8), several diagnostic tests were conducted to validate the assumptions of logistic regression and ensure the robustness of the results.

1. Linearity Between Continuous Predictors and Log-Odds

To validate the assumption of linearity between continuous predictors and the log-odds of the binary outcome, the Box-Tidwell procedure was employed. This test evaluates whether a significant interaction exists between the continuous predictor and its log-transformed value, which would indicate non-linearity (Shrestha, 2019, p. 18). For the primary predictor log(InstalledCapacity), the Box-Tidwell test produced the following results:

Table 9: Box-Tidwell Test for Linearity in Logistic Regression



Box-Tidwell Test for Linearity in Logistic Regression

	Box-Tidwell Test
Log(Installed Capacity)	−1.773
	(2.208)
Log(Installed Capacity) × log(Log(Installed Capacity))	0.212
	(0.269)
Num.Obs.	75
Log.Lik.	−51.650

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001

Table 9 presents the results of the Box-Tidwell test for assessing the linearity assumption in logistic regression. The table includes coefficients and standard errors (in parentheses) for the interaction term between the predictor (log(InstalledCapacity)) and its logarithmic transformation. Key statistics such as the number of observations (Num. Obs) and Log-Likelihood (Log.Lik.) are also provided.

The interaction term (InstalledCapacity × log(InstalledCapacity)) is non-significant ($p = 0.429$). This confirms that the relationship between log(InstalledCapacity) and the log-odds of using PF is linear. As a result, no further transformations or adjustments are necessary. Hence, the linearity assumption is satisfied for log(InstalledCapacity) in the logistic regression model.

2. Absence of Multicollinearity

Multicollinearity among the independent variables was assessed using the Variance Inflation Factor (VIF), which is a standard diagnostic tool in regression analysis (Dobson & Barnett, 2018, p. 119). High multicollinearity can lead to unstable coefficient estimates and reduced model interpretability (Dobson & Barnett, 2018, p. 119). The VIF values were computed using the car package in R, which supports both linear regression and generalized linear models, including logistic regression.

Table 10: Variance Inflation Factor (VIF) Values for Predictors

Predictor	VIF value
log(InstalledCapacity)	1.75
Foreign Sponsor	1.81
Regional/Municipal Sponsor	1.43
Joint Venture	1.03
Technology Type	1.61
Year	1.07
Interaction Term	1.59

Table 10 presents the Variance Inflation Factor (VIF) values for predictors included in the regression model, assessing potential multicollinearity.

A VIF value above 10 generally indicates problematic multicollinearity (Woolridge, 2020, p. 98). In this analysis, all VIF values are well below 5, confirming that multicollinearity is not a concern in the final model (Table 8). These results ensure the stability and reliability of the regression coefficients, allowing for robust interpretation of the effects of each predictor (Woolridge, 2020, p. 98).

3. Independence of Observations

The dataset consists of 75 unique renewable energy projects, each representing distinct developments in hydropower or wind power. Projects vary in ownership structure, financing arrangements, and technical specifications. The data were collected independently from reliable sources, such as company financial reports and regulatory databases. Hence, there is no evidence of systematic dependencies between the observations, satisfying the assumption of independence (Woolridge, 2020, p. 728).

4. Sufficient Sample Size

While the dataset contains a relatively modest sample of 75 projects (37 financed through PF and 38 through CF), it provides sufficient variation to explore key relationships. The balanced distribution of the dependent variable further reduces the risk of bias and ensures stable coefficient estimates. Nonetheless, the small sample size remains a limitation and may impact the statistical power and generalizability of the results. However, the dataset is considered representative of the renewable energy sector in Norway, capturing a diverse range of projects across both wind and hydropower technologies.

5. No Autocorrelation in the Data

Autocorrelation is primarily a concern for time-series data, where observations may exhibit temporal dependencies (Woolridge, 2020, p. 353). Since this study is based on cross-sectional data, the assumption of no autocorrelation is inherently satisfied, and no further testing is required.

6. Goodness-of-Fit

The Hosmer-Lemeshow test was conducted to evaluate the goodness-of-fit of the logistic regression model. The test assesses whether the observed outcomes (actual values) differ significantly from the predicted probabilities. It divides the data into deciles of predicted probabilities and compares the observed frequencies with the expected frequencies in each group (Dobson & Barnett, 2018, p. 164-165). A non-significant p-value ($p > 0.05$) indicates that the model fits the data adequately, as there is no significant difference between the observed and predicted probabilities.

In this analysis, the test yielded a chi-squared statistic of 6.8712 with 8 degrees of freedom ($p = 0.5506$). Since the p-value is well above 0.05, we fail to reject the null hypothesis of no difference between observed and predicted probabilities. This confirms that the model provides an adequate fit to the data.

7. Residual Analysis

To evaluate the model for potential issues related to outliers or systematic patterns, deviance residuals were analyzed (Dobson & Barnett, 2018, p. 166).

Deviance Residuals vs Observations

The figure of deviance residuals plotted against observation numbers shows that residuals are symmetrically distributed around zero, with a slight concentration near ±1. This is a typical pattern in logistic regression models due to the bounded nature of the residuals (Dobson & Barnett, 2018, p. 166). Importantly, there are no discernible trends or clustering that suggest systematic errors, supporting the adequacy of the model.

Figure 15: Deviance Residuals for Model 6

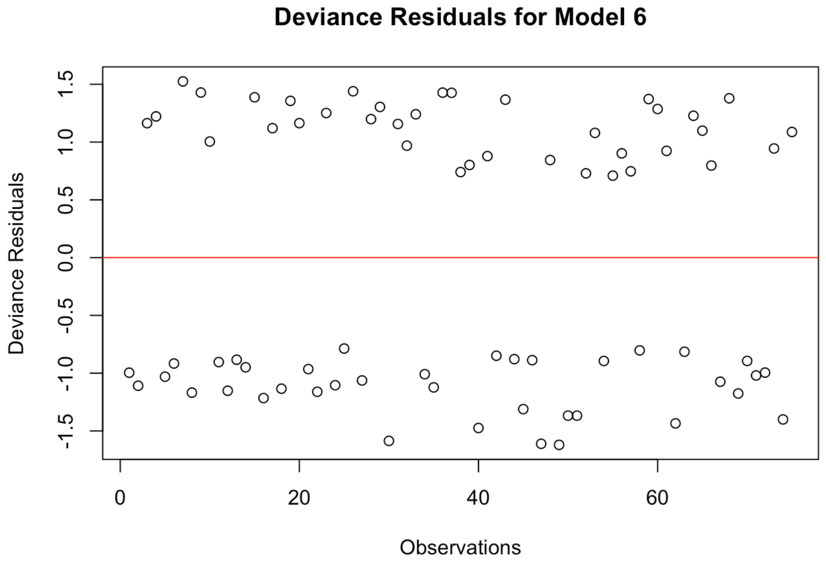


Figure 15 visualizes the deviance residuals for Model 6, assessing the model's goodness-of-fit. Deviance residuals represent the difference between observed and predicted values, helping to detect outliers or systematic patterns that may indicate model misspecification (Dobson & Barnett, 2018, p. 166). The red horizontal line represents the residual mean, providing a baseline for comparison.

Residuals vs Predicted Probabilities

The residuals plotted against the predicted probabilities (Figure 16) show a clear symmetry around the zero line. There are no evident trends or signs of heteroskedasticity (variation in the spread of residuals), confirming that the model provides stable and unbiased predictions (Woolridge, 2019, p. 849).

Figure 16: Residuals vs Predicted Probabilities for Model 6

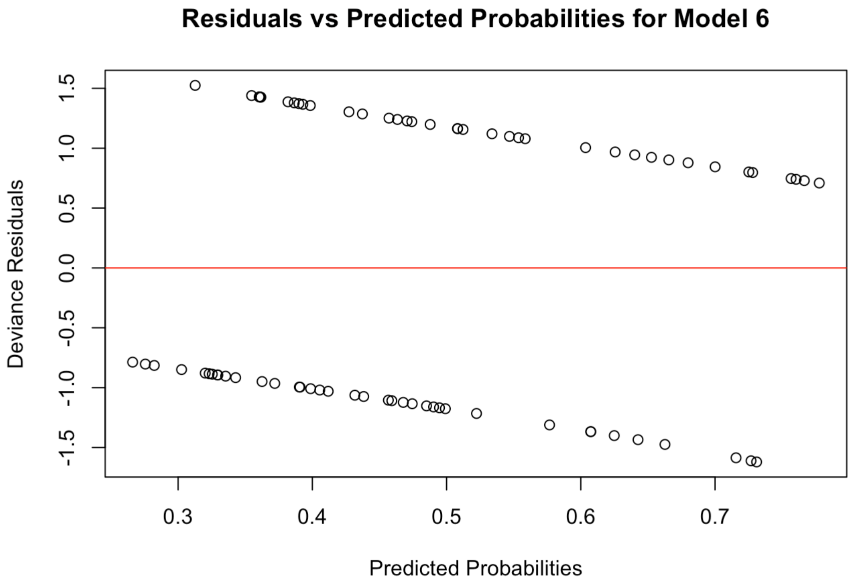


Figure 16 presents the relationship between deviance residuals and predicted probabilities for Model 6. This plot is a diagnostic tool to identify potential issues such as heteroskedasticity or non-linearity in the model fit (Woolridge, 2019, p. 849). The red horizontal line indicates the mean of the residuals, serving as a visual reference for any deviations.

8. Summary of Diagnostic Results

Table 11 provides a summary of diagnostic tests conducted to validate the assumptions of the logistic regression model. Overall, the model satisfies all necessary assumptions for logistic regression, which strengthens the reliability of the estimated effects and results.

Table 11: Summary of Diagnostic Results

Diagnostic Test	**Method Used**	**Result**
Linearity of Log-Odds	Box-Tidwell Test	Satisfied
Multicollinearity	Variance Inflation Factor (VIF)	No significant issues (VIF < 5)
Independence of Observations	Review of Dataset	Satisfied
Sufficient Sample Size	Evaluation of Data	Modest, but sufficient
No Autocorrelation	Cross-Sectional Data	Satisfied
Goodness-of-Fit	Hosmer-Lemeshow Test	p > 0.05 (adequate fit)
Residual Analysis	Deviance Residuals	No significant patterns observed

Table 11 summarizes the diagnostic tests performed on the regression models.