



VILNIUS UNIVERSITY
BUSINESS SCHOOL

MASTER'S IN INTERNATIONAL PROJECT MANAGEMENT

Syed Imad Ali Shah

THE FINAL MASTER'S THESIS (PROJECT)

TITLE IN LITHUANIAN	TITLE IN ENGLISH
PROJEKTŲ VALDYMAS TVARIOS ENERGIJOS INOVACIJŲ SRITYJE	PROJECT MANAGEMENT IN SUSTAINABLE ENERGY INNOVATION

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Supervisor _____
(signature)

Dr. Eglė Terminė

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SUMMARY

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PROJECT MANAGEMENT IN SUSTAINABLE ENERGY INNOVATION

Supervisor – Dr. Eglė Terminė

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The FMTP described in brief:

The Final Master's Thesis Project (FMTP) ponders the adaptability of project management practices for the delivery of innovative and sustainable energy as well as projects that are highly uncertain and complex. The adoption of qualitative multiple case-study method gets the research done through the investigation of the real-world projects featuring geothermal, and bioenergy, tidal and wave energy as well as decentralized community-based systems. Key project stakeholders were the participants in the semi-structured interviews to collect the data supported by the document analysis, with the findings getting thematically analyzed through the lenses of Innovation Diffusion Theory (IDT) and Complex Adaptive Systems (CAS). The research work depicts the scenario that traditional project management methods are ineffective when used alone and asserts the usefulness of a hybrid project management model that fuses the elements of predicting control and adaptive learning. The findings affirm that

giving rise to the commercialization of new energy sources depending on the nature of the project, the dynamics of the stakeholders, the regulatory environment, and the organizational capability. Drawing on the results, the thesis recommends a flexible, contingency-based project management framework that connects project context, delivery approach, and multi-dimensional project outcomes, which provides practical guidance for the managers, organizations, and policymakers engaging in the transition to sustainable energy.

Problem, objective and tasks of the FMTP:

Involvement of empirical studies to a moderate extent has really lagged behind the emergence of innovative sustainable energy projects in very uncertain, stakeholder-relationship-complex, and regulatory-changing environments and the trail-blazing being done in the handling of such projects. Literature has so far been dominated by discussions of the technical side of things and thus has not offered much help in the way of suggesting project management methods that can be modified to be used in these conditions. Thus, the main aim of this Final Master's Thesis Project (FMTP) is to look into the different ways that the management of projects could be modified in order to get the delivery of these projects to be successful. To fulfil this aim, the research will indicate the major management and governance problem areas, take a closer look at and also contrast predictive, adaptive, and hybrid project management methodologies, carry out a study of the impact the stakeholder, regulatory, and organisational factors have on the project results, and finally work out a flexible, context-sensitive project management framework linking the project context, delivery approach, and multidimensional project outcomes.

Research methods used in the FMTP:

This Final Master's Thesis Project (FMTP) adopts one of the qualitative research designs and utilizes a multiple case-study approach to provide deep understanding of the project management practices applied in the area of innovative sustainable energy projects. Collection of primary data was done by conducting semi-structured interviews with the main stakeholders - project managers, technical experts, policy makers and community representatives - in addition to documentary analysis of project reports, feasibility studies and regulatory documents. Thematic analysis was used for the data analysis, which helped in identifying and bringing forth the different patterns and relationships across the cases. Innovation Diffusion Theory (IDT) and Complex Adaptive Systems (CAS) theory were used as the guiding frameworks for the analysis in order to explain the interrelations of project context, stakeholder dynamics, and adaptive governance on project delivery and outcomes.

Research and results obtained:

The research has discovered that the novel sustainable energy projects are continuously surrounded by technical, regulatory, and stakeholder uncertainties that cannot be completely eliminated by the traditional plan-driven project management methods. In all cases, the use of adaptive and hybrid project management practices resulted in enhanced project performance by allowing continuous learning, adapting, and being responsive to changing conditions. The findings also reveal that hybrid methods—predictive controls combined with iterative and feedback-driven practices—have improved forecasting accuracy, risk management, stakeholder engagement, and system reliability. At the same time, the project context, data and organizational readiness, stakeholder trust, and regulatory stability were mentioned as major influences on the effectiveness of these practices, signaling that successful project delivery depends on the appropriate management approach to the given context rather than a uniform methodology being applied.

Conclusions of the FMTP:

The study indicates that innovative sustainable energy projects must be managed in a way that is sensitive to their context, requiring project management approaches that go beyond the traditional predictive methods. Although drive- plan-based practices are still considered the most important for regulatory compliance, financial control, and accountability, they are not enough to deal with high uncertainty and complexity environments when used alone. The results indicate that hybrid project management approaches, which mix predictive control with adaptive and learning-oriented practices, are the most effective way to deliver such projects. These approaches' success depends on the factors such as project context, stakeholder engagement, organizational capability, and regulatory conditions. All in all, the FMTP indicates that matching project management practices with the volatile socio-technical nature of sustainable energy projects is crucial for obtaining resilient, sustainable, and long-term project outputs.

Information about the publication of FMTP results or adaptation for publication To the present moment, the outcomes of this Final Master's Thesis Project (FMTP) have not found publication. Nonetheless, the results are adaptable for a scholarly journal article or a conference paper dealing with management practices in innovation and sustainability in the energy sector. Besides, the research's chosen results can be communicated to professionals and policymakers through expert or policy-oriented publications, thus promoting knowledge transfer and making it possible for the sustainable energy sector to make informed decisions.

SANTRAUKA

VILNIAUS UNIVERSITETO VERSLO MOKYKLA

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SYED IMAD ALI SHAH

PROJEKTŲ VALDYMAS TVARIOS ENERGIJOS INOVACIJŲ SRITYJE

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FMTP trumpas aprašymas:

Baigiamajame magistro darbe (FMTP) nagrinėjamas projektų valdymo praktikų pritaikomumas įgyvendinant inovatyvius ir tvarius energetikos projektus, pasižyminčius dideliu neapibrėžtumu ir sudėtingumu. Tyrime taikomas kokybinis daugiavejų atvejų tyrimo metodas, analizuojant realius projektus geoterminės, bioenergetikos, potvynių ir bangų energijos srityse bei decentralizuotas bendruomenines energetikos sistemas. Duomenys buvo renkami atliekant pusiau struktūruotus interviu su pagrindiniais projektų suinteresuotaisiais asmenimis ir papildyti dokumentų analize, o gauti rezultatai analizuoti teminės analizės metodu, taikant Inovacijų sklaidos teorijos (IDT) ir Kompleksinių adaptyvių sistemų (CAS) teorijos perspektyvas. Tyrimas parodo, kad tradiciniai projektų valdymo metodai yra neefektyvūs, kai taikomi atskirai, ir pabrėžia hibridinio projektų valdymo modelio, jungiančio prognozuojamą kontrolę ir adaptyvų mokymąsi, naudą. Rezultatai patvirtina, kad naujų energijos šaltinių komercializavimo sėkmė priklauso nuo projekto pobūdžio, suinteresuotųjų šalių dinamikos, reguliacinės aplinkos ir organizacinių gebėjimų. Remiantis gautais rezultatais, darbe siūloma lanksti, sąlygų pagrindu sukurta projektų valdymo sistema, jungianti projekto kontekstą, įgyvendinimo metodą ir daugiamates projekto baigtis, bei teikianti praktines gaires vadovams, organizacijoms ir politikos formuotojams, dalyvaujantiems perėjime prie tvarios energetikos.

FMTP problema, tikslas ir uždaviniai:

Empirinių tyrimų įsitraukimas iki šiol iš esmės atsilieka nuo inovatyvių tvarių energetikos projektų plėtros itin neapibrėžtoje, sudėtingų suinteresuotųjų šalių santykių ir nuolat kintančios reguliacinės aplinkos sąlygomis, taip pat nuo naujų praktikų, taikomų valdant tokius projektus. Iki šiol literatūroje dominavo techninių aspektų analizė, todėl joje pateikiama mažai rekomendacijų dėl projektų valdymo metodų, kuriuos būtų galima pritaikyti minėtoms sąlygoms. Todėl pagrindinis šio Baigiamojo magistro darbo (FMTP) tikslas – ištirti, kaip projektų valdymas gali būti modifikuojamas siekiant užtikrinti sėkmingą tokių projektų įgyvendinimą. Šiam tikslui pasiekti tyrime nustatomos pagrindinės valdymo ir valdymo struktūrų problemos, išsamiai analizuojami ir lyginami prognozuojamieji, adaptyvūs ir hibridiniai projektų valdymo metodai, tiriami suinteresuotųjų šalių, reguliacinių ir organizacinių veiksnių įtaka projektų rezultatams bei kuriama lanksti, kontekstui jautri projektų valdymo sistema, jungianti projekto kontekstą, įgyvendinimo metodą ir daugiamates projekto baigtis.

FMTP taikyti tyrimo metodai:

Šiame Baigiamajame magistro darbe (FMTP) taikomas kokybinis tyrimo dizainas, naudojant daugiavejų atvejų tyrimo metodą, siekiant giliai suprasti projektų valdymo praktikas, taikomas inovatyvių tvarių energetikos projektų srityje. Pirminiai duomenys buvo renkami atliekant pusiau struktūruotus interviu su pagrindiniais suinteresuotaisiais asmenimis – projektų vadovais, techniniais ekspertais, politikos formuotojais ir bendruomenių atstovais – taip pat analizuojant projektų ataskaitas, galimybių studijas ir reguliacinius dokumentus. Duomenų analizei buvo taikyta teminė analizė, leidusi identifikuoti ir atskleisti dėsningumus bei ryšius tarp nagrinėjamų atvejų. Analizėje kaip pagrindinės teorinės gairės buvo taikomos Inovacijų sklaidos teorija (IDT) ir Kompleksinių adaptyvių sistemų (CAS) teorija, siekiant paaiškinti projekto konteksto, suinteresuotųjų šalių dinamikos ir adaptyvaus valdymo sąveiką projektų įgyvendinimui ir rezultatams.

Gauti tyrimo rezultatai:

Tyrimas atskleidė, kad inovatyvūs tvarios energetikos projektai nuolat susiduria su techniniu, reguliaciniu ir suinteresuotųjų šalių neapibrėžtumu, kurio neįmanoma visiškai pašalinti vien tradiciniais, planu grindžiamais projektų valdymo metodais. Visais nagrinėtais atvejais adaptyvių ir hibridinių projektų valdymo praktikų taikymas lėmė geresnius projektų rezultatus, nes sudarė sąlygas nuolatiniam mokymuisi, prisitaikymui ir greitam reagavimui į kintančias sąlygas. Rezultatai taip pat parodė, kad hibridiniai metodai, derinantys prognozuojamą kontrolę su iteracinėmis ir grįžtamuoju ryšiu grindžiamomis praktikomis, pagerino prognozavimo tikslumą, rizikų valdymą,

suireresuotujų Ŗalių įsitraukimą ir sistemos patikimumą. Kartu nustatyta, kad Ŗių praktikų veiksmingumui didelę įtaką daro projekto kontekstas, duomenų ir organizacinis pasirengimas, suireresuotujų Ŗalių pasitikėjimas bei reguliacinės aplinkos stabilumas, parodant, jog sėkmingas projektų įgyvendinimas priklauso nuo valdymo metodo pritaikymo konkrečiam kontekstui, o ne nuo vieningos metodikos taikymo.

FMTP išvados:

Tyrimas rodo, kad inovatyvūs tvarios energetikos projektai turi būti valdomi atsiŖvelgiant į jų kontekstą, todėl reikalingi projektų valdymo metodai, perŖengiantys tradicinius prognozuojamuosius sprendimus. Nors planu grindžiamos praktikos išlieka itin svarbios reguliacinei atitikčiai, finansinei kontrolei ir atskaitomybei užtikrinti, jos nėra pakankamos, kai taikomos atskirai aplinkoje, pasiŖyminčioje dideliu neapibrėŖtumu ir sudėtingumu. Rezultatai parodė, kad hibridiniai projektų valdymo metodai, derinantys prognozuojamą kontrolę su adaptyviomis ir mokymuisi orientuotomis praktikomis, yra veiksmingiausias būdas tokiems projektams įgyvendinti. Ŗių metodų sėkmė priklauso nuo tokių veiksnų kaip projekto kontekstas, suireresuotujų Ŗalių įsitraukimas, organizaciniai gebėjimai ir reguliacinės sąlygos. Apibendrinant, FMTP parodo, kad projektų valdymo praktikų suderinimas su kintančia tvarių energetikos projektų sociotechnine prigimtimi yra būtinas siekiant atsparių, tvarių ir ilgalaikių projektų rezultatų.

Informacija apie FMTP rezultatų publikavimą ar pritaikymą publikavimui:

Iki Ŗiol Ŗio Baigiamojo magistro darbo (FMTP) rezultatai nėra publikuoti. Tačiau gauti rezultatai gali būti pritaikyti rengiant mokslinį straipsnį arba konferencijos pranešimą, skirtą inovacijų ir tvarumo projektų valdymo praktikoms energetikos sektoriuje. Be to, atrinkti tyrimo rezultatai gali būti pristatyti specialistams ir politikos formuotojams per ekspertines ar politikai skirtas publikacijas, taip skatinant Ŗinių sklaidą ir sudarant prielaidas priimti pagrįstus sprendimus tvarios energetikos sektoriuje.

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND AND RATIONALE

The world is transitioning rapidly to low-carbon energy solutions, which are supported by various factors including climate change commitments such as net-zero pledges, technological innovations and the pressing issue of energy security caused by the recent geopolitical tensions and supply chain disruptions. Moreover, Deloitte anticipates that more emphasis will be placed on improving infrastructure and reducing the gap between the demand and supply of clean energy in the next few years (Fagarasan et al., 2023). The International Renewable Energy Agency (IRENA), too, mentions that the solar and wind sectors will be, without a doubt, the core of a decarbonized future as they are still the most economical and flexible energy sources (ElHamahmy, n.d.)

On the other hand, the world has been witnessing a super-fast development of renewable energy systems that are cheap and effective—solar and onshore wind power, for instance which are already on the grid. The simple deployment of these effective systems has, however, concealed some deep-rooted problems related to project delivery. The technologies have built over time on the common practices of the respective industries for example predictable supply chains, contract templates, stakeholder frameworks and risk management mechanisms have become mainstream. Commercial nuclear power is one case in which this has happened; however, one generation has been able to implement diverse and exciting sustainable energy projects—community-scale bioenergy, tidal and wave power, EGS and remote micro-hydro—which confront an alternate reality. Their uniqueness, location-specific effects, ecosystem vulnerabilities, and policy fragmentation mean that traditional service delivery models are completely unfit (Tetty et al., 2025).

The technologies in question are complicated from a technological standpoint and have weak points in the organization: the process includes the coming together of several subsystems, which are mechanical, civil, biological and digital, and besides, it traverses through the difficult layers of regulations around environment, water usage and grid interconnection. Studies have

shown that such factors as supply-chain bottlenecks, the tolerance for delays and its causes, regulatory uncertainty are among the principal impediments to the provision of low-cost planting and timely deployment (Liu et al., 2025; Mohtasim et al., 2025). A case in point is the U.S., where ambiguous regulations (40%^C), overlapping duties and lack of communication have resulted in delays for many renewable projects that are already in the permitting stage (Andriollo et al., 2021).

Moreover, the “last mile”—the transition from a prototype or a pilot to mass production—remains a chronic problem. The technological feasibility may be there but it does not guarantee that the project can be executed in reality (community opposition, financial terms, ecology protections) (Breslin et al., 2021). Thus, the major hurdle in the process is not the technological development in itself but rather getting it done in uncertain environments.

The creativity and ambiguity in the use of new technologies, together with the changing and uncertain stakeholder environments project management-wise, make traditional plan-driven methods unfit for use. The existing predictive models assume base levels and linear progressions that will hardly ever be faced in such cases. On the contrary, adaptive feedback and hybrid governance systems (merging a predictive control approach with an agile responsiveness) are becoming more and more recommended in practice (Aaltonen & Kujala, 2016).

Recent literature emphasizes these challenges. Site selection, grid integration and storage coupling are also common barriers found in the 2025 engineering review (*World Energy Transitions Outlook 2024: 1.5°C Pathway*, n.d.). A systematic review also finds that institutional and organizational barriers are a greater limitation to net-zero implementation compared with technical factors (Liu et al., 2025). Studies on sustainable project-management also show that there is a continued challenge of the alignment of stakeholders and regulations and cost-overruns in projects involving renewable infrastructure (Rani et al., 2024).

Hence, this research fills an important void; to know what project-management delivery methods — predictive, agile or hybrid are most effective under different contextual factors. The research aspires to optimise the reliability, efficiency and sustainability of transition new energy initiatives through well-aligned governance structures, learning cycles and stakeholder strategies.

In short, as the world rapidly decarbonizes, delivery capacity – not just technological innovation – will prove to be the difference. Mature renewables have developed delivery

ecosystems; immature ones do not. The bridge between these two fields is inherently a project management issue, and this research specifically addresses that demand.

1.2 PROBLEM STATEMENT

The academic and technical literature is full of accounts as to how these technologies can be engineered and optimised, but much less on how they are managed and delivered in situated organisational, social, regulatory worlds—let alone outside a handful of well chronicled situations (e.g. Icelandic geothermal). As a result, practitioners do not have guidelines for how to adjust planning, governance and control to the uncertainty profiles of innovative sustainable energy projects. This gap is addressed in the research presented herein, which describes delivery challenges that emerge from such projects and assesses what project management practices are most appropriate for a range of conditions associated with novelty, complexity, and change.

1.3 RESEARCH QUESTIONS

Grounded in brief and slides, the study pursues the following questions:

1. What management issues arise in novel energy innovation projects?
2. How do project managers deal with risks and changing conditions?
3. Which PM practices (traditional, agile, hybrid) work best?

1.4 AIM AND OBJECTIVES

Aim:

To explore how project management practices can be adapted to support the successful delivery of innovative, sustainable energy projects.

Objectives:

1. Investigate challenges in delivering small- to mid-scale innovative projects (e.g., geothermal, wave energy).
2. Compare traditional vs. adaptive PM methods in real-world clean energy implementations.
3. Study successful case examples (e.g., Iceland's geothermal PM system, Denmark's biogas integration).
4. Propose a flexible project management framework suitable for managing innovation in diverse contexts.

1.5 SIGNIFICANCE OF THE STUDY

This study is significant both practically and theoretically in advancing the management and successful delivery of innovative sustainable energy projects.

1.5.1 Practical Significance

The practical contribution of the study is that it offers a data-informed framework for project sponsors, managers and policy stakeholders to choose and adapt project delivery methodologies – using predictive or agile (or their hybrids) approaches – according to the contextual complexity of each individual project. By coupling the governance structures, planning cadence, stakeholder engagement with project characteristics like new technology introduction risk, regulatory uncertainty and site-specific limitations, the framework is intended to enhance on-time delivery on budget as well as sustainability performance (Fagarasan et al., 2023).

Hybrid Methods have been implemented in different ways and at the same time used in renewable infrastructure (Apaolaza et al., 2020), where a combination of structured supervision and adaptive learning cycles proved to be beneficial for both performance and resilience. Such flexibility can be a risk-mitigating factor for the supply-chain and regulatory delay-related risks that usually cause cost overruns in sustainable energy projects (Mohtasim et al., 2025). Thus, the research gives concrete recommendations for celebrities who aim at changing the rules of the game in the clean-energy sector with the help of innovative governance practices, which are sensitive to the local context.

1.5.2 Theoretical Significance

The study theoretically increases the output of literature through the unification of Innovation Diffusion Theory (IDT) and Complex Adaptive Systems (CAS) theory. IDT clarifies the influence of stakeholders' faith on benefits, compatibility, and complexity through the adoption/trialling (Liu et al., 2025) while CAS regards at projects as shifting techno-social interconnectedness demanding emergent management practice (Breslin et al., 2021). This combination makes it possible for us to know about and the ways in which delivery must change because of technology scaling and the co-evolution of stakeholder ecosystems.

Theoretical innovation management and project delivery theory connection is what the study does, it also extends the understanding of context-driven adaptability. Moreover, it brings the concept of a field of sustainable project management development closer in time. Besides that, it is interconnected to global sustainability targets, particularly, SDG 7 (Affordable and Clean Energy) and SDG13 (Climate Action) as, on the whole, it lifts the credibility of clean energy transitions.

1.6 THEORETICAL PERSPECTIVE

The research utilizes two combined theories—Innovation Diffusion Theory (IDT) and Complex Adaptive Systems (CAS)—to analyze the selection of the most effective project delivery method for innovative sustainable energy projects in the context of the factors that influenced the choice and the manner of it. Combined, the two theories provide a deep understanding of the various ways through which the new technology and the complexity of the system affect the realities and the outcomes in project management..

1.6.1 Innovation Diffusion Theory (IDT)

(Rogers, 1983) Innovation Diffusion Theory (IDT), which has been extensively applied in the studies of energy and technology, outlines the process of a new idea's spread through the social system using five main features of that idea: relative advantage, compatibility, complexity, and observability. These limitations have an impact on the pace and extent of adoption of renewable energy sources among the key players such as policy-makers, communities, and investors who support the movement towards sustainable energy (Liu et al., 2025).

Initiatives showcasing significant relative advantages (like lower emissions and community gain) and strong integration with the present infrastructure are the ones that get the green light faster. In contrast, the perception of complexity and lack of trials can act as barriers to adoption. By combining IDT, this research conceptually analyses the stakeholder perceptions of a decision-making model, its risk profile and which delivery methods—predictive, agile or hybrid—they support in order to define how communication and demonstration strategies can positively influence its acceptance and implementation.

1.6.2 Complex Adaptive Systems (CAS)

The CAS theory identifies a project as a dynamic, complex network of agents (such as firms technologies and communities) who have iteratively interacted and fed back to each other for learning, evolving over time (Breslin et al., 2021). In the novel energy systems, non-linear dynamics result from uncertainties such environmental variations, changes in policy and attitude of stakeholders. CAS focuses on self-organization and emergence, and the “understanding of how work is really accomplished” in order to resist simple (and naive) solutions to complex issues.

CAS enabled PMs can develop feedback-driven governance mechanisms, foster iterative learning and adapt the delivery strategies to keep up with an evolving ecosystem. This is consistent with the modern trend towards hybrid methods that combine predictiveness-controller and agile-adaptive approaches (Aaltonen & Kujala, 2016).

Integration and Application

IDT and CAS provide a wholistic perspective: IDT describes how innovations spread among stakeholder systems, whilst CAS describes how projects act as developing ecosystems. The merging of these elements forms the foundation of a project delivery model that is very active and comes at the cost of environmental uncertainty, stakeholder dynamics, and innovation diffusion paths, which in turn leads to an overall increase in projects' deliverability and sustainability.

1.7 METHODOLOGICAL OVERVIEW

The qualitative study approach has been adopted for the research to find out the changing project management practices in innovative sustainable energy projects, which possess high uncertainties and complexities. A qualitative method is suitable because of the exploratory

character of the research and the necessity of getting context-specific insights from professionals involved in project delivery.

In the study, comparative case studies are conducted at both national and community levels, concentrating on geothermal, bioenergy, tidal, wave, and decentralized energy projects. Collection of data takes place through semi-structured interviews with key stakeholders such as project managers, technical experts, policy actors, and community representatives, which are also verified by project and policy materials document analysis.

Thematic analysis is the method for analyzing the data with the help of qualitative software NVivo which will assist in identifying the patterns related to the project context, delivery approaches (predictive, agile, hybrid), governance mechanisms, and outcomes. The results are interpreted using the perspectives of Innovation Diffusion Theory (IDT) and Complex Adaptive Systems (CAS) as a means to understand the impact of context and adaptive practices on project delivery.

1.8 SCOPE AND DELIMITATIONS

The study focuses on new or early-commercial projects in which delivery approaches are not well established. Note: we are not strongly focused on mature utility-scale solar/wind, unless they have an interesting integration (e.g., complex storage or hybridization). Cases are geographically focused on Iceland, Denmark and a number of Asian community settings selected for their diversity of contexts and data availability. The findings are meant to be transferable, rather than universally generalizable to all energy sectors.

1.9 STRUCTURE OF THE THESIS

- **Chapter 1** introduces the problem, aims, significance, and approach.
- **Chapter 2** reviews relevant studies and develops the conceptual framework.
- **Chapter 3** details methodology.
- **Chapter 4** presents findings.
- **Chapter 5** concludes with contributions, limitations, and future research.

CHAPTER 2

LITERATURE REVIEW AND CONCEPTUAL FRAMEWORK

2.1 OVERVIEW

This chapter has embedded the research within three intersecting literatures, (1) project management under uncertainty, (2) innovation diffusion and adoption in infrastructure-heavy sectors and (3) sustainable-energy project delivery. It maintains that these emergent energy projects act as complex adaptive systems, negating linear planning logics and favouring adaptive, feedback based governance. The chapter ends by presenting a provisional context-dependent framework connecting project: context → delivery approach → outcomes which are the analytical kernel that is to be tested in this thesis.

2.2 PROJECT MANAGEMENT FOR INNOVATIVE INFRASTRUCTURE

Innovative infrastructure projects require techniques that go beyond standard project management methodologies to keep pace with rapidly changing technological advancements - particularly in renewable and sustainable energy sectors. Traditional PM, based on the waterfall and plan-driven methods, focuses on front-end loading, baseline management and variance reduction (Shahzad et al., 2023). These techniques are appropriate for stable, clearly-defined systems such as traditional power plants or known civil works projects where scope, requirement and risks are relatively predictable. However, novel infrastructure technologies such as geothermal plants, tidal energy converters, community biogas systems or floating micro-hydro units imply dynamic requirements and site-specific uncertainties and emergent risks that frequently conflict with fixed upfront planning (Arena & Uhl-Bien, n.d.).

As such initiatives evolve; underground behavior, resource diversity, regulatory impediments and social acceptance dynamics are ongoing redefining constraints and products. Meanwhile, there is a growing support in the literature for adaptive, action-learning based management approaches that combine control with autonomy. Such researchers recommend

hybrid delivery models and suggest a combination of stage-gate governance to satisfy sponsor assurance and safety requirements with agile or iterative cycles on sub-systems where there is uncertainty (Azizi et al., 2022).

2.2.1 Front-End Loading with Iterative Learning

FEL is a prerequisite for successful delivery; an FEL approach with significant pioneering, scenario planning and risk assessment activities conducted in the early stages of project development (Landis, 2024). For novel energy projects, FEL is especially critical as technical viability, stakeholder support and permitting pathways need to be determined prior to a commitment of substantial capital investment. Yet, it is increasingly acknowledged that static FEL models are incapable of fitting emergent learning—a critical characteristic in projects involving novel technologies or geographies (Mohtasim et al., 2025).

In order to address this, some recent studies recommend the use of “FEL with learning loops”, this includes adaptive cycling between planning and execution (Malik et al., 2023). For example, drilling methods used in geothermal projects may be improved after every confirmation well and bioenergy feedstock planning might go back to the start after a pilot scale implementation. This dual-loop mechanism offers a gradual approach to model validation, thus reducing systemic risk while allowing for manageable oversight.

Nevertheless, proponent group considers that iterative FEL is the key to enhancing the resilience of a project and its decision-making process (Liu et al., 2025); while opponents hold the view that excessive iteration of FEL can lead to scope changes and budget escalation if not controlled by proper governance. Therefore, hybrid FEL suggests that there should be decision points determined by the quality of information available and not merely by scheduling milestones.

2.2.2 Progressive Elaboration and Adaptive Contracts

The modern project management literature often points to the fact that the gradual maturing of the definition is a step that naturally takes place as we go from one phase of the project to the next (Rafique et al., 2024). The infrastructure demand is so groundbreaking that the requirements cannot be specified in advance, so contract flexibility is a must.

Recent research indicates that fixed-price contracts with strict terms and conditions result in more conflicts when applied to high-uncertainty situations (Daniel & Daniel, 2019). On the other

hand, the establishment of a type of contract where the parties work collaboratively to determine the scope is gaining popularity (Cano et al., 2022). Such partnerships reinforce trust-based governance and the risk-sharing pools, which in turn lead to changes with less disorder.

Importantly, there is emerging evidence from offshore wind and tidal energy projects that this type of adaptive contracting enhances partner alignment and the uptake of innovative solutions, although it can also introduce transaction costs and potentially involve mature client capability (Felix et al., 2019). It follows, then, that project sponsors need to invest in capabilities in contract management and governance transparency if they are going to realize the benefits of progressive elaboration.

2.2.3 Information Flow as a Control Variable

Information, not time or cost in volatile projects the key control variable is information –not time, and money (Lacerda & Van Den Bergh, 2014). Modern methodologies focus on data-driven governance, using dashboards and decision support to measure the burn-down of uncertainty in technical/regulatory/social dimensions.

Recent advances in digital twins, AI based forecasts, and risk dashboards allow real time sensing of deviations, ultra quick emerging risks (Malik et al., 2023). For instance, in current adaptive geothermal projects Bayesian updating of realization models is utilized to update predictions of the subsurface after each well section has been drilled. Likewise, the social license markers that community feelings and stakeholder engagement metrics have become part of integrated reporting mechanisms (Felix et al., 2019).

On the downside, visibility can become burdensome and decisions paralyzing when the information is not organized through stacked dashboards and defined decision rights (Zhang & Xi, 2023). Its successful implementation also entails the necessary technological backbone and an overall readiness to take decisions supported by data.

2.2.4 Hybrid Delivery and Governance

How hybrid project management is becoming the new norm in innovative infrastructure. It takes predictive (for controlling costs, for compliance) and mixes it with agile (for learning and adapting). Hybrid: Hybrid models use stage-gate reviews for large investment decisions and

sprints or iterations for subsystems (e.g., control systems, stakeholder pilots) that are more complex to develop (Filippov & Mooi, n.d.).

Case studies of wave energy and community microgrid projects demonstrate that hybrid delivery improves schedule compliance, responsiveness to risk and stakeholder trust (Ilin et al., 2023). Agile methods - daily stand-up meetings, retrospect, incremental prototyping - are designed to support learning together with predictive components that maintain strategic alignment.

Yet, hybridization requires cultural dexterity and a richness of leadership. Lack of strong coordination can lead to methodological conflict in dual-mode systems – i.e. teams covering different cadence or priorities (Shahzad et al., 2023). Therefore, governance mechanisms – such as meta-scrum boards and integrated PMOs – are necessary to harmonize predictive and agile paths.

2.2.5 Critical Synthesis

Explicit throughout the literature is that innovative infrastructure projects cannot be managed using classical PM alone. (Aaltonen & Kujala, 2016) insists on the stupidity of deterministically planning, Biesenthal and Hartmann (2023) are calling for sense-making in dynamics, and (Samset & Volden, 2016) are demanding that companies regard hybrid agility as a strategy. The empirical evidence indicates that adaptive governance improves performance in uncertainty (Azizi et al., 2022; Liu et al., 2025).

But there are still huge holes in the picture. Many models are conceptually thick yet empirically wanting--the few available longitudinal data provide a modest window into hybrid performance across developmental states. Furthermore, there is limited research on contextual moderators: institutional evolution, regulatory stability and organizational culture. (Adebayo et al., 2025) posit that methodological sophistication can become secondary to socio-political complexity, especially if stakeholders are not fully aligned. Hence, while hybrid transnationality models are a step forwards, they have to be relativized, not generalized.

Future studies should pursue comparative analysis across technologies and geographies, combining performance measures with learning. This meets the aim of the present study to elaborate a 'contingency' based framework that maps context variables onto channels and outcomes.

2.3 INNOVATION DIFFUSION IN ENERGY SYSTEMS (IDT PERSPECTIVE)

The theory of the Diffusion of Innovations (IDT), as it was originally introduced by Rogers, is one of most popular ideas, in respect to how innovative technologies are integrated in social systems. It suggests that five characteristic traits--relative advantage, compatibility, complexity, trainability and observability--influence the rate and degree of adoption. In terms of energy systems, these traits are modulated by technological development, institutional structure, policy incentives and stakeholder attitudes (Liu et al., 2025).

Although IDT traditionally assumes that its focus is on individual user adoption, more contemporary research has extended IDT to consider user organizations and infrastructures as well, acknowledging that energy projects—whether community-owned microgrids, wave power generation or geothermal installations—are embedded in complex socio-technical systems. Thus the trend of ICT adoption in this sector cannot be only explained by technical feasibility but also by policy support, market readiness, social acceptance and project management intervention (Setyadi et al., 2025).

2.3.1 Relative Advantage and Perceived Value

Relative advantage that is the extent, to which an innovation is perceived as better than its predecessor, has been identified as a key issue for adoption. In energy systems, such impact can mean efficiency improvements or is equivalent to emission reductions, cost savings and resilience bonus (Zhang & Xi, 2023). Literature indicates the spreading of innovative technology and energy sources is accelerated when renewable technologies offer economic benefits and is backed by policies such as feed-in tariffs or carbon credit supports (Filippov & Mooi, n.d.).

But what seems advantageous isn't always bent on engendering real results. For instance, wave has a well-established sustainability profile but is perceived to be expensive and unproven, constraining its uptake (Adebayo et al., 2025). Project organizers may additional increase perceptual value by cost-benefit analysis, life cycle assessment and demonstrate projects of the operation facticity (Brunet, 2019a).

Critically, as (Liu et al., 2025) overall, for example there is need to communicate the relative advantage across varied stakeholder groups—investors, regulators and local communities—who assign value to different outputs (profitability, compliance, socio-

environmental benefit). Therefore, strategic communication is an institutional building block for diffusion and serves to bolster the agency Project Management (PM) in authoring adoption trajectories.

2.3.2 Compatibility with Existing Systems

Compatibility is the degree to which an innovation can be assimilated and integrated into existing infrastructures, markets, and cultural practices. Compatibility issues in energy transitions: the barriers posed by grid integration, policy contexts and community acceptance (Raygoza-Limón et al., 2025). Technologies that fit more easily with the existing energy mixture or social systems—such as grid-connected solar PV—they also tend to diffuse quickly relative to technologies requiring systemic overhaul (e.g. hydrogen microgrid).

One example is bioenergy projects that are successful when agricultural residues are plentiful and culturally accepted but fail when there is competition for feedstock or social resistance (Wang & Witlox, 2025). PM activities, e.g. early stakeholder mapping, context analysis and policy alignment workshops improve compatibility by identifying local constraints and act on them accordingly.

As (Assad et al., 2022) pointed out, it is dynamic in the sense that it can be engineered or learned to underlie. Thus, teams must embrace ‘iterative feedback loops’ in their projects to (re)develop design and participation strategies that resonate with innovations and contexts-in-the-making.

2.3.3 Complexity and Perceived Effort

Complexity (relative advantage), which is the degree of difficulty associated with understanding and using an innovation, is inversely related to adoption (Rogers, 1983). Energy systems are complex due to technological complexity, interfaces between disciplines and regulatory complexities. For example, EGS face technological challenges (advanced drilling and uncertain subsurface knowledge) and high capital costs that would discourage early entrants (Okafor et al., 2025).

Approaches to simplify (close to the customer) service interactions and processes that are modularification, standardization of interfaces as well as operational protocols that are easy to handle can counteract perceived complexity (Alam et al., 2025). Additionally, the institutional

readiness is facilitated by capacity building and knowledge transfer mechanisms to reduce learning curves.

Most importantly, the PMs are also (in a way) translators – they translate technical complexity into things other humans can understand and use, and plain english for non-technical humans. (Peyravi et al., 2022; Shah et al., 2024) emphasize that ineffective communication of complexity often results in stakeholder depoliticization or policy lag, pointing to the sense-making and educational function of PM.

2.3.4 Trialability and Demonstration Effects

Trialability—being able to try out an innovation on a small scale before committing entirely—is enormously important for diffusion, especially in high-risk industries like energy. Farms as a service, pilot projects, living labs and experimental zones provide opportunities for stakeholders to witness the projects in action and decrease uncertainty (Abdessadak et al., 2025).

Microgrid pilots in South Asia and community biogas programs in Africa provide examples that demonstrate how trust and knowledge spillovers are created when people are given the opportunity to test product functionality without a considerable commitment (Algburi et al., 2025). PM can incorporate trialability in phased introduction, prototyping, and iterative evaluation that correspond with agile delivery approaches to emphasize learning cycles.

However, there is still the danger of getting stuck in “pilot traps”, which would result in the development of innovations that would remain at the demonstration stage forever (Assad et al., 2022). Therefore, the effective scaling approaches have to accompany the trials in such a way that they are linked with the policy incentives and financial models that are promoting mainstreaming.

2.3.5 Observability and Social Learning

Observability, or the extent to which the benefits are available for others to see, promotes diffusion via social learning and peer influence. Celerity of visible systems tends to enhance their imitation; on the other hand, inaccessible technologies (mainly those underground) “suffer” from low levels of observability (Yan et al., 2025).

Project managers have different ways of enhancing observability through the promotion of public exhibitions, open data sites, and community engagement activities. Nonetheless, as (Xiang et al., 2025) caution: “visibility without interpretive capacity may lead to” symbolic adoption- when organizations adopt the visible artifacts of the approach while rejecting its core practice. Therefore, it is not only about observability, but also education and capacity building that is needed.

2.3.6 Critical Synthesis and Application to Project Management

The growing number of studies on the subject indicate that the determinants for IDT to succeed or their opposite are mainly due to the characteristics of IDT. However, diffusion is not a magical process; it is progress that is made by the project management that does the tests, builds the compatibility and markets the benefits during the course set by the project.

(Min et al., 2023) maintain that, in general, the institutional inertia and policy mismatch are the main contributors, while the technical merits are the least ones, thus requiring the PMs to be facilitators who are always involved. (Ansong et al., 2025) point out COC and stakeholder engagement as methods for overcoming social impediments, while (Xiang et al., 2025) argue against the linearity of IDT, thus calling for embedding in Complex Adaptive Systems (CAS) to learn through the feedback and development of new knowledge.

In line with this critique, in this paper we turn to IDT as the diagnostic tool to, on the one hand, identify the set of factors conducive to the acceptance of SST and RL and, on the other hand, use CAS to take into account the adaptive dynamics of the emergence of complexities. The integration unveils that the successful delivery platforms are to be built not only for the technical work to be managed but also for the work to be perceived, made legitimate, and learned from to be shaped.

The project management approach is at the heart of the transition of IDT concepts from vertical to horizontal adoption, where passive spread turns into active adoption management. This will ensure that the innovative and sustainable energy initiatives will not remain at the pilot stage, but rather be transformed into a change that affects the whole system.

2.4 COMPLEX ADAPTIVE SYSTEMS (CAS) AND PROJECT DELIVERY

The CAS viewpoint (Cuesta et al., 2025) views projects -among which are innovative public infrastructure and energy systems- as ever-changing networks of interacting agents that modify their behavior based on feedback received. Besides, CAS, unlike traditional linear systems, places uncertainty, nonlinearity, and emergence as inherent factors in the case of complex environments. The placement of sustainable energy projects that are technologically new and complex in nature at the heart of changing legislation, environmental interdependencies, and multiple stakeholders makes the application of CAS theory particularly powerful in understanding and dealing with system evolution and performance.

2.4.1 The Nature of Projects as Complex Adaptive Systems

In CAS, projects are considered open systems, consisting of elements, such as organizations, technologies, communities and regulatory bodies, which interact with one another—as a response—adapt to internal and external stimuli (Li et al., 2021). Each actor is designed for autonomy, but there emerges the overall behavior through feedback and co-evolution. In the case of a tidal energy project, for example, engineering teams adapt designs with respect to environmental conditions, regulatory agencies adapt standards from observed impact and communities adjust perception as reactions are visible.

Recent research has alerted us to the presence of these signature CAS properties within novel energy projects; ‘The properties that were identified as CAS fell into three categories: distributed control, path dependence and emergence’ (Alam et al., 2025). Such projects hardly ever develop along predetermined trajectory but result from adjustments of interactions between actors. Hence the project's success relies on little in static planning and more in adaptive capability to, feedback integration and learning (Khanum et al., 2025).

Key to this concept is the notion of explaining things, yet its abstractness means that it also causes implementation issues. As (Toolib et al., 2023) observes, managers frequently find it difficult to convert systemic complexity into actionable practices and there is a need for frameworks that strike a balance between systemicity and operativity.

2.4.2 Adaptive Governance and Decision-Making

Drawing on CAS thinking, adaptive governance focuses on flexibility, participatory decision-making and learning-based modification (Raju et al., 2025). In renewable energy

projects, governance mechanisms need to be able to respond to changing environmental information, interests of stakeholders and technology developments.

For instance, bioenergy systems are characterised by dynamic feedstock availability and emission regulations. Adaptive governance enables project teams to update their design criteria, risk responses and contractual scopes without losing sight of overall goals (Abdessadak et al., 2025). Rating Rate... Perfect Good Average Not that bad Very Poor There is evidence to suggest that adaptive governance is associated with a higher degree of resilience and trust among stakeholders which are fundamental long-term success factors (Ba et al., 2025).

Critics, though, are quick to point out that too much adaptability can lead to scope ambiguity and decisions paralysis (Ba et al., 2025). Hybrid governance is therefore frequently advocated as a balance of adaptive mechanisms with strategic drivers (e.g., milestone reviews, clear objectives).

2.4.3 Feedback Loops and Learning Mechanisms

Feedback is central to CAS. Double loop learning —revisiting both actions and governing assumptions—allows for ongoing improvement (Wang & Witlox, 2025). Drilling information provides vital technical data, but also key strategic intelligence about how to sequence exploration in a geothermal project.

Current PM Tools, including digital twins, AI-driven dashboards and real-time sensing improve feedback integration by translating data to actionable knowledge (Khanum et al., 2025). These technologies realize CAS in that they can sense environment continually, make preparations ahead of time and are able to decide according to condition.

However, empirical evidence proves that feedback loops are frequently broken due to organizational silos and information overload (Lacerda & Van Den Bergh, 2014). Papers that have successfully employed CAS require information governance – ensuring transparency, prioritization and common understanding among actors within the project.

2.4.4 Stakeholder Networks and Co-Evolution

CAS focuses on relationships between actors in project ecosystems. Success in innovative energy systems requires alignment among multiple actors—developers, financiers, regulators and communities.

Research has it that the tempo and stability of innovation diffusion is a function of co-evolution, a mutual adaptation between actors (Setyadi et al., 2025). For example, early engagement of stakeholders and participative planning generate a sense of ownership that decreases opposition and increases social licence to operate (Arena & Uhl-Bien, n.d.).

Critically, (Raygoza-Limón et al., 2025) warn that when co-evolution is not synchronised (e.g., policy change slower than technological one), friction can be generated, suggesting the need for enabling mechanisms for such synchronization through proactive PM interventions such as roadmapping, policy dialogues and multi-level coordination.

2.4.5 CAS and Hybrid Project Management

Hybrid project management (PM) methodologies – that combine predictive planning for stability with agile iterations for adaptation – are in accordance with the CAS perspective. CAS is the theoretical rational of hybridization: it recognises that both positions structure (to handle interdependencies) and flexibility (to cope with unforeseen issues).

Hybrid models that utilise governance based on CAS are a better fit, producing earlier time-to adoption, greater stakeholder satisfaction and risk management in tidal energy and microgrid pilots than simple linear models (Toolib et al., 2023). Such systems with modular experimentation and learning-based pivoting are also advantageous in terms of CAS nature.

However, CAS approach requires an agile organizational structure, leadership support and learning culture factors that are not often based in traditional infrastructure organizations (Abdessadak et al., 2025). Yet somehow, without them, while CAS seems to be more than a theory, it might not have succeeded transforming people.

2.4.6 Critical Synthesis and Research Gaps

With a CAS approach, we can include and provide valuable perspectives and pathways to handle uncertainty and emergence in novel sustainable energy projects. Its focus on feedback, adaptation and co-evolution is well suited to the dynamics of energy transitions, which involve closely linked technological, institutional and social processes.

Nonetheless, critical reviews have identified three major voids:

Operationalization Gap – Although the CAS is conceptually very descriptive, but practical tools to implement it on projects are still limited.

Measurement Gap -There is a gap in the literature with regard to quantification of CAS-induced practices that have an impact on outcomes such as cost, schedule or stakeholder satisfaction.

Context Gap – Roll-out across regulatory, cultural and technical contexts is uneven and requires comparative studies.

To fill this gap, researchers propose merging the CAS approach with PMMM and Learning Organisation theory to transfer systemic complexity into manageable competences. CAS provides, in this study, a complementary focus with IDT where we are unable to explain such dynamism of adoption processes and how delivery mechanisms themselves need to be dynamic to fit evolving contexts. Collectively, IDT and CAS form the contingency- based hybrid model which emphasizes adaptive governance, feedback integration and stakeholder co-evolution as cornerstones of effective delivery.

2.5 DELIVERY APPROACHES: PREDICTIVE, AGILE, AND HYBRID

Efficient delivery of innovative sustainable energy systems projects demand approaches that can manage control, adaptability and learning in presence of uncertainty. Traditional predictive (plan-driven) models, commonly found in infrastructure projects, focus on the front-end definition of work performance measurements for estimating uncertainty and baselining estimates and variances (Peyravi et al., 2022). On the other hand, agile approaches derive from software development and emphasize iteration, stakeholder involvement and adaptable planning (Khanum

et al., 2025). However, neither approach in isolation provides a complete means to consider such multiple interrelated aspects associated with unique energy projects (e.g., linear dependencies, such as regulatory compliance and safety; non-linear influences driven by technology evolution and community acceptance). Therefore, hybrid delivery models that combine predictive discipline with agile adaptability are increasingly recognized as the most appropriate project delivery paradigm to use for managing such projects (Gemino et al., 2021).

2.5.1 Predictive (Plan-Driven) Approach

The waterfall based PMBOK driven predictive model is based on a linear progression: initiation, planning, execution, monitoring and closure. The method is grounded on extensive preliminary planning and baseline management to maintain scope, timetable and cost adherence (Aaltonen & Kujala, 2016). For traditional infrastructure, the certainty of delivery guarantees compliance with regulations, clarity on contractual terms and safety. For projects like utility-scale solar and transmission grids, standardized equipment and established engineering processes warrant extensive upfront planning (Tetty et al., 2025). Predictive methods additionally provide traceability and risk transparency, which are mandatory to secure financing and build trust with stakeholders.

On the other hand, researchers are challenging the neo-principled approach more and more through different ways. (Setyadi et al., 2025) argue that innovation contexts are learning-based and therefore static reference points do not apply. (Felix et al., 2019) also postulate that plan-driven frameworks limit creativity and flexibility which often leads to a situation where the project is outdated or the market is already cooled for the technologies like geothermal or wave energy. In this way, control from prediction-based means is given but still, they are surrounded by the volatility and uncertainty that come with the innovative sustainable energy systems.

2.5.2 Agile (Iterative and Adaptive) Approach

Agile methodologies, like Scrum, Kanban, and Adaptive Project Frameworks, prefer brief cycles (sprints), feedback loops and co-creation of stakeholders. Agile is most suitable when the specifications are changing constantly and quick learning and changing direction are a must.

In the renewable energy innovation the application of agile methods means the carrying out of experiments, getting prototypes tested and adapting to the surrounding circumstances. A good example is microgrid community projects which rely heavily on frequent interactions with the

stakeholders and fast track design iterations. The application of agile principles is to a great extent in line with the Innovation Diffusion Theory (IDT) as it shows the support of trialability and observability and the facilitating of stakeholder acceptance (Ba et al., 2025).

There are a number of studies done that show that agile has a positive impact on the ability to adapt, speed of innovation and the level of satisfaction among the stakeholders (Khanum et al., 2025). (Cuesta et al., 2025) point out the performance improvement in energy R&D through iterative planning and cross-functional teams. Nevertheless, in a strict regulatory and capital-intensive sector, such as chemical manufacturing, agile methods alone may not suffice for the compliance, safety and investment predictability requirements which necessitate control by forecasting.

Importantly, (Yan et al., 2025) point out that in global projects, the decentralized decision-making process of agile can lead to the occurrence of gaps in the coordination and lack of clarity concerning the scope of the project. Therefore, agile practices might be able to hasten the learning process and the recovery but could completely lose track of what a complex engineering masterpiece is all about.

2.5.3 Hybrid Approach: Balancing Flexibility and Control

Hybrid models provide an interesting meeting ground between the need and value for structured planning and the flexible favoring of iterative learning. It used stage-gate governance for strategic control and regulatory mile-stones, with use of agile cycles for innovation-intensive subcomponents (Azizi et al., 2022).

Hybridization enables dual-mode management:

- Forecast elements to secure policy enforcement, budget control, and safety.
- The Agile practices support experimentation, learning on behalf of stakeholders, and the progressive processors.

It is critical to this duality in the new forms of energy. Geothermal, for example, needs predictive control in drilling and safety keeping - but agile learning in reservoir modelling or community's engagement. Likewise, tidal power or bioenergy projects require rapid response to environmental information whereas being constrained by fixed regulatory gates.

Recent researches confirm the hybrid over classic: (Wirkus, 2016) reveal that project schedule performance and stakeholder satisfaction are significantly better in hybrid compared to singular approaches. (Alam et al., 2025) find that hybrid teams are more learning agile and responsive to risk. (Mohtasim et al., 2025) also point out how the advent of digital tools (AI dashboards, predictive analytics), has enabled hybrid governance in real time resulting from planned intervention and adaptive feedback.

However, hybridization has its limitations. (Malik et al., 2023) describe tensions between predictive and agile teams, contradictory rhythms and logics of decision making. The meta-governance mechanisms (for example, integrated PMOs, shared measures) and the culture of working together is necessary for successful integration.

2.5.4 Critical Perspectives and Emerging Trends

As hybrid management gains prevalence within the academia and industry, scholars warn against “methodological eclecticism”—utilising hybrid labels without any substantial fusing (Svejvig & Geraldi, 2023). Useful hybrids need clear separation of roles, common cadences and learning based governance (Adebayo et al., 2025).

New research is studying AI-enabled hybrid PMOs, digital twins and adaptive stage-gates whose criteria change over time. Furthermore, PM that is sustainability-focused combines ESG metrics in hybrid supply synergies as well: SDG 7 and SDG 13 are apparently compatible with that (Ghezzi & Cavallo, 2020)

More fundamentally, there are methodological gaps: relatively little longitudinal research measures the impact of hybrids on innovation diffusion, cost resilience or social license. In addition, the context moderators—organisational maturity, stakeholder complexity and organisational culture—are based on little empirical evidence.

The purpose of this paper is to fill these gaps by creating a context model aligning project attributes (novelty, complexity) and delivery method effectiveness and then by testing the model with empirical data.

2.6 SUSTAINABLE-ENERGY PROJECT CONTEXTS AND TYPICAL CHALLENGES

The development of sustainable-energy projects, especially nascent technologies like EGS (enhanced geothermal systems) tidal and wave power, bioenergy, and micro-hydro are thus key enablers of the world's energy transition. But their project delivery meets a unique set of soft-context challenges completely different than those of mature renewables like solar PV and onshore wind. The projects are complicated due to factors like site, technology, regulation, and different interest groups (Ansong et al., 2025).

The authors will critically reflect on the context, four categories of sustainable energy projects, and common challenges faced by project stakeholders in the field. They will also assess the impact of project management approaches, especially the hybrid frameworks developed from IDT and CAS, in reducing delivery risks and improving adoption success.

2.6.1 Geothermal Energy Projects

Context

Geothermal schemes such as Enhanced Geothermal Systems (EGS) involve deep-well drilling and reservoir stimulation plus subsurface risk management. They provide reliable baseload power but they exhibit great capital investment and exploration risk.

Challenges

Key delivery challenges include:

- Uncertainty of resources (temperature, flow rate) constraining feasibility;
- Drilling cost over-run and wrestling technical failures caused by unforeseen sub-surface conditions;
- Allowing for delays and changing regulations related to environmental restrictions;
- Stakeholders have little understanding of risks and benefits of geothermal.

Critical Analysis

According to (Adebayo et al., 2025), the complex adaptive character of geothermal systems requires feedback-rich modes of governance, so that learning in relation to each well is fed back into next-stages designs. IDT's "complexity" and "trialability" dimensions are of particular relevance—stakeholders that find it hard, and there are a lack of demonstration projects which decreases the rate at which adoption occurs (Ba et al., 2025).

An alternative split-hybrid delivery model consisting of predictive planning (for regulatory adherence and cost containment) in combination with agile iterations (during drilling and modeling) is becoming increasingly popular (Azizi et al., 2022). But, as (Assad et al., 2022) warn, unfocused iteration is a possible cause of budget upheaval if it remains undisciplined with stage-gate reviews.

2.6.2 Tidal and Wave Power Projects

Context

Tidal and wave technologies are in early commercialization, providing predictable marine energy but subject to unfriendly conditions and uncertain business models.

Challenges

- Lack of maturity of technology and reliability issues in components;
- Red tape due to bureaucracies of multiple marine permit taking authorities;
- Grid integration in islands and coastal systems;
- High CAPEX costs and uncertain revenue streams are making investors hesitant.

Critical Analysis

The relative advantage is low in diffusion studies since the cost is high and there are uncertainties for expandability (Zhang & Xi, 2023). From an IDT point of view, poor observability (no visible close offshore line on the subsoil) is a factor limiting social acceptance. CAS-thinking points to the presence of non-linear interdependencies – weather conditions, ecological sensitivities, and regulatory feedback loops impact performance in unpredictable ways (Li et al., 2021).

Hence, the core matter is adaptive governance with feedback loops: continuous environmental monitoring and stakeholders' communication not only assist government but through these measures the whole society has the ability to manage risk. Hybrid PM ensures the predictive anchoring of compliance and safety while at the same time enabling the agile cycles to iteratively test technology and engage stakeholders improving both learning and rest.

2.6.3 Bioenergy Projects

Context

Bioenergy involves linked actions between agriculture, industry, and society that interact in its work, such as biogas, biomass, and biofuel systems. Projects frequently promise co-benefits like less waste and more rural employment.

Challenges

- Seasonal feedstock supply volatility;
- Land-use and resource utilization conflict among stakeholders;
- Emission and smell issues leading to resistance within the community;
- Incoherence of policy in agriculture, energy and environment.

Critical Analysis

IDT compatibility is really a critical dimension—matching the nature of projects as to directives, on-farm practices and policies determine whether they are successful or not. CAS-informed PM highlights co-evolution with community ecosystems to match local resource flows, and cultural circumstances (Raygoza-Limón et al., 2025).

(Xiang et al., 2025) report that by facilitating trust and observability, participatory design encourages the use of technology. However, overly decentralized control may lead to inefficiency and as such hybrid governance—structured supply chain planning with loosely couple follow-up in the local environment—is proposed (Ghezzi & Cavallo, 2020).

2.6.4 Micro-Hydro and Decentralized Systems

Context

It is through micro hydro and the community based decentralized systems that a localised form of power can be provided to far remote or hilly areas where these solutions often compliment rural electrification.

Challenges

- Variability in hydrology and the implications for resource reliability with respect to climates;
- Low manpower for operations and Maintenance;
- Financial restrictions resulting from small size and scattered users;
- Coordination of stakeholders, including community, NGO's and agencies.

Critical Analysis

From an IDT perspective, high trialability and visibility support diffusion, but low institutional commitment and operational constraints inhibit the scaling (Ba et al., 2025). CAS points on self-organization and feedback learning of the community actors. Empirical results (Toolib et al., 2023) indicate that participatory governance and iterative learning cycles re-enforce resilience but over autonomy may lead to fractured responsibility. Hybrid PM helps strike a balance between stakeholder ownership and predictive control, to guarantee availability as well as consistency.

2.7 SUMMARY

Innovative sustainable-energy projects face patterns of uncertainty which stretch the linear approach of planning. Delivery mode hybridizations as orchestrated by stage-gate governance and driven with iterative learning just where uncertainty is dense are lent by the literature. The integration of IDT (adoption dynamics) with CAS (system adaptiveness) explains coherently method tailoring and adjustment in governance. This synthesis provides motivation for the empirical approach in subsequent chapters and the concept of a generic project-delivery model for sustainable-energy innovation.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 INTRODUCTION

This chapter presents the method that was used for the analysis of how the project management techniques were applied and adjusted in the case of innovative sustainable energy projects where uncertainties were very high, there were new technologies, and there were complicated stakeholder relationships. The chapter, based on the theoretical foundations laid down in Chapter 2—Innovation Diffusion Theory (IDT) and Complex Adaptive Systems (CAS)—theory outlines the qualitative research design, the research strategy and methods are explained, and the data collection, analysis, and validation procedures are described in detail.

3.2 RESEARCH PHILOSOPHY

This research study has been built on the foundation of an interpretivist approach, which holds that the social reality is made up of the meanings and experiences of people who are in specific organizational, institutional and cultural contexts. Interpretivism is particularly suitable for a study that tries to find out how project managers and stakeholders interpret uncertainty, adapt governance mechanisms, and understand the changing project conditions (Abdessadak et al., 2025).

Innovative and sustainable energy projects have no controlled or stable environments to operate; rather, they are a part of complex socio-technical systems that get affected by regulatory changes, environmental uncertainty, and the negotiation among the stakeholders. An interpretivist position not only permits to a large degree these different subjective interpretations and the contextual dynamics but it also strongly aligns with the CAS viewpoint which regards projects as living systems that change over time rather than simple linear processes (Breslin et al., 2021).

3.3 RESEARCH APPROACH

The research utilizes an inductive approach, where the theoretical insights are derived from the empirical observations and not through predefined hypotheses. Although the IDT and CAS served as the theoretical backdrop for the study, these concepts were applied as sensitizing lenses, and not as deterministic models, thereby permitting the data to reveal the patterns and relationships naturally (Ansong et al., 2025).

An inductive approach is particularly appropriate for nascent domains where empirical support is still patchy and the existing theories need to be adjusted according to the context—especially in the case of pioneering sustainable energy projects that are being delivered in the context of large-scale wind or solar installations, which have been extensively studied (Andriollo et al., 2021).

3.4 RESEARCH DESIGN

3.4.1 Qualitative Multiple Case Study Design

This research utilizes a qualitative multiple case study approach which allows for an in-depth examination of project management practices across various technologies, governance scenarios, and geographical locations. According to (Yin, 2014), case studies are very useful when it comes to the analysis of modern-day phenomena under the microscope and in contexts where the lines between the phenomenon and context are significantly blurred.

The cases are drawn from the areas of innovative sustainable energy, such as:

- Geothermal and enhanced geothermal systems (EGS)
- Bioenergy and biogas projects
- Tidal and wave energy initiatives
- Decentralised and community-based energy systems (e.g., micro-hydro)

This type of study allows for comparison across cases and enables the identification of the influence of contextual factors on the delivery approaches and outcomes in the different institutional and technological environments.

3.5 CASE SELECTION AND SAMPLING STRATEGY

3.5.1 Sampling Technique

A purposive sampling strategy was utilized to identify participants that were rich in information, and who had a direct experience in the planning, governance, or delivery of innovative sustainable energy projects. A total of 20 participants were involved in the research, which consisted of project managers and technical and engineering specialists as well as sustainability or environmental experts, policy or regulatory actors and community or organizational representatives depending on the project context. This sample size was considered suitable for qualitative inquiry, as it allowed the in-depth exploration of different perspectives while achieving the thematic saturation at the same time. Participants were recruited from various project types and geographic locations to improve the analytical transferability and to make sure that there was a difference in the institutional, regulatory, and socio-technical conditions. The focus of the sampling was thus not on statistical representation, but on the depth, relevance, and experiential knowledge necessary to meet the research aim and objectives. Purposive sampling is suitable when the goal is to attain analytical depth instead of getting a statistical representation (Brunet, 2019b).

3.5.2 Case Selection Criteria

In the case selection process, purposive criteria were applied with the aim of including not only information-rich but also analytically relevant examples. To be more precise, cases under consideration are connected with the adoption of innovative or early-commercial sustainable energy technologies and are subject to technical, regulatory, or stakeholder uncertainty (which is the main point of the research) thus they are very much relevant to the purpose of the study. On the one hand, projects using non-traditional or adaptive project management practices like hybrid or iterative governance were preferred as they are likely to provide more insights through interviews with knowledgeable participants and adequate project documentation for thorough qualitative analysis. On the other hand, the cases were selected from Iceland, Denmark, and certain Asian community contexts, which allowed the research to take into account the differences in regulatory maturity, institutional capacity, and socio-cultural settings, thus enhancing the comparison between cases and the transferability of the analysis.

3.6 DATA COLLECTION METHODS

3.6.1 Semi-Structured Interviews

The primary data gathering technique is made up of semi-structured interviews with significant stakeholders such as:

- Project and deputy project managers
- Heads of technical and engineering departments
- Specialists in sustainability and environment
- Policy and regulatory workers
- Community or cooperative members (if needed)

Semi-structured interviews offer the possibility to engage with the predetermined themes while at the same time letting the interviewees bring forward unexpected insights from their points of view (Kvale & Brinkmann, 2023). The questions in the interviews are directed towards the research queries and supported by the IDT constructs (like perceived complexity, compatibility, trialability) and by the CAS concepts (such as feedback loops, adaptation, emergence).

Interviews are either virtual or face-to-face, and the content is written down word-for-word in order to guarantee the correctness of the analysis.

3.6.2 Document Analysis

In order to reinforce the use of different methods in the study, document analysis was used to provide support based on interviews to the other data source. The scrutinized papers consisted of such things as project feasibility studies and progress reports, regulatory and policy documents, environmental impact assessments, and public consultation records and technical briefs. The researcher was able to understand the context and history of project development as well as decision-making processes through these documents. The analysis of documents may provide evidence to corroborate the findings of interviews and facilitate the comprehension of governance structures, policy impacts, and the evolution of adaptive mechanisms over time which would further enhance the study's credibility and depth of analysis (Lima et al., 2022).

3.7 DATA ANALYSIS PROCEDURE

3.7.1 Thematic Analysis

Thematic analysis is done to make sense of the data and it adheres to the six-phase model proposed by (Raygoza-Limón et al., 2025). The very first action is to familiarize oneself with the data through the constant reading of transcripts and documents, then to the initial coding. The codes undergo a detailed examination and are organized into broader themes, which are verified against the research questions and theory. The final phase of interpretation and synthesis takes place thereafter where the themes are linked to the research questions and theoretical framework. The coding is achieved through a hybrid method consisting of a deductive approach based on Innovation Diffusion Theory (IDT) and Complex Adaptive Systems (CAS) alongside an inductive approach that allows for the emergence of new, context-specific themes. This technique ensures strong theoretical alignment while at the same time being able to capture insights that are very much embedded in the experiences of the participants.

3.7.2 Use of Qualitative Data Analysis Software

Qualitative data analysis and annotation are accomplished with NVivo, which promotes the systematic and open handling of the analytical process. It is NVivo that enables the comparison of cases, the examination of nearly identical codes, and the provision of audit trails—thus adding to the methodological rigor (Rand & Hoen, 2017).

3.8 TRUSTWORTHINESS AND RESEARCH QUALITY

The research project is based on Lincoln and Guba's (1985) criteria for qualitative trustworthiness, which have been the pillars of qualitative research and even more in today's world, to be precise, to improve the systematicity and quality of research. Credibility is constructed among other factors through the usage of data triangulation which is composed of interviews and document analysis, reflective participation during interviews, and prolonged engagement with both the empirical material and relevant literature. Rich and thick descriptions of the research contexts and cases are provided to support transferability thus enabling analytical rather than statistical generalisation. Dependability is guaranteed via the open and clear documentation of the data collection and analysis processes along with the uniform application of the coding

protocols throughout the study. Finally, confirmability comes into the picture by being constantly aware of the biases that might come from the researcher and having an audit trail that is clear and is backed up by systematic data management and coding outputs from NVivo.

3.9 ETHICAL CONSIDERATIONS

The study received ethical approval as per the research guidelines of the institution. The main ethical issues were getting the informed consent of all the participants ahead of the data collection, the anonymization of both the participants and the organizations, and the very secure storage of the recordings, transcripts, and documents related to the interviews. The participants were told about their right to leave the study at any point with no punishment. In the case of sustainable energy projects, it is especially necessary to maintain ethical standards as the stakeholders, the regulators, and the commercial parties involved the often complex and sensitive spheres of information and so, the keeping of confidentiality and responsible research conduct becomes a must (Ghezzi & Cavallo, 2020).

3.10 LIMITATIONS OF THE METHODOLOGY

Despite the qualitative case study method allowing for deep contextual insight, it carries certain restrictions. The results cannot be applied to the whole population statistically, and the confidentiality or the commercial sensitivity may restrict the access to the participants. On the other hand, the limitations of qualitative research may be overcome by selective case selection, triangulation, and theory-driven interpretation.

3.11 SUMMARY

The chapter outlined a qualitative, interpretivist methodology that aimed to provide insights into the adoption of project management techniques in the innovative sustainable energy sector. By utilizing multiple case studies, conducting semi-structured interviews, analyzing documents, and applying thematic analysis grounded in IDT and CAS, the research aspires to generate

insights that could be analytically shifted into context-oriented delivery methods. The methodological choices make a solid foundation for the presentation and analysis of the results in Chapter 4.

CHAPTER 4

FINDINGS AND ANALYSIS

4.1 INTRODUCTION

This chapter provides a revealing discussion of the empirical results from the qualitative part of the study. It applies semi-structured interviews and document analysis to demonstrate how project management practices are implemented, transformed and coalesce during the uncertainty and complexity situation across different innovative sustainable energy projects. The findings are presented thematically and organized in direct alignment with the research questions and the corresponding theoretical frameworks of Innovation Diffusion Theory (IDT) and Complex Adaptive Systems (CAS).

4.2 OVERVIEW OF CASES AND PARTICIPANTS

The study is acquiring qualitative data from different types of project stakeholders involved in geothermal, bioenergy, tidal and wave energy, and decentralized community-based systems in Iceland, Denmark and chosen Asian areas, among others. The people who took part in this study are project managers, technical leads, environmental specialists, regulatory actors, and community representatives. In this regard, the projects were at different levels of development in different case studies, from feasibility and pilot phases to early-commercial deployment.

No matter how different the technology and geography were, the participants always pointed out that the operating environment had a massive uncertainty factor, multi-level governance, and a strong relationship between the technical and social systems, which in turn made it easier for the CAS to be seen as an analytical lens.

4.3 THEME 1: PERVASIVE UNCERTAINTY AS A DEFINING FEATURE OF INNOVATIVE ENERGY PROJECTS

The qualitative analysis reveals a dominant and cross-cutting theme which is the uncertainty of innovative sustainable energy projects all over the world. In all the cases, uncertainty was not considered a temporary state that could be removed by better planning, but saw as a root and lasting feature of project realization. This conclusion concurs with previous studies that claim new energy technologies are developing in an environment where technical knowledge, institutional arrangements, and stakeholder expectations are changing at the same time ((Landis, 2024; Rafique et al., 2024).

4.3.1 Technical and Environmental Uncertainty

Participants pointed out consistently that technical and environmental uncertainty were the most important issues to the project management decisions. In geothermal projects, there was a very frequent reference to the uncertainty about the subsurface conditions like, for example, the reservoir permeability, the temperature gradients, and the induced seismicity, which could never be completely foreseen before drilling. One project manager remarked:

“No matter how excellent your feasibility studies are, you still get surprises from the ground. You see, learning starts only with the drilling.”

This remark backs up very well the assertions of (Yan et al., 2025), who consider geothermal systems to be non-linear and hence not predictable through front-end loading alone. In like manner, tidal and wave energy projects were marked out by the uncertainty of the marine environment is being very rugged, equipment losing efficiency and long-term performance data being non-existent. Participants pointed out that one of the major environmental variability factors was wave intensity, which, together with corrosion and accessibility constraints, often led to the original design assumptions being invalidated.

Respondents did not accept the idea that the uncertainties mentioned could be "designed out" by way of conventional predictive planning. On the contrary, they characterised acquiring knowledge as a process that is ongoing and iterative and that is inside execution rather than being restricted to the early project phases. This goes against the traditional project management viewpoint that uncertainty reduces steadily with time and backs up the arguments based on CAS that uncertainty may vary or even increase as the systems come into contact with the realities of the world (Cuesta et al., 2025).

4.3.2 Regulatory and Institutional Uncertainty

The uncertainty surrounding regulators, alongside the technical risks, was, however, the biggest discriminating factor. Depending on the area, the participants drew a picture of the whole thing being very complicated, with issuing permits taking a long time, several regulatory bodies having the same or overlapping authority, and unstable environmental standards that very often changed the project in terms of the scope, the order of what was done, and the time it took. One of the interviewees working on a tidal energy project put it this way:

“We were compliant at the start, but midway through the project the rules changed. Suddenly we were redesigning not because the technology failed, but because policy moved.”

The mention of regulatory instability as a barrier to innovation diffusion in energy technologies that are just getting to the market was one of the findings (Matthews & Smith, 2024). From the IDT standpoint, this kind of instability affects negatively the two main characteristics of an innovation that are considered irresistible—compatibility and trialability—as the players in the game of innovation find it difficult to match their innovations with the changing unpredictable institutional expectations. On the other hand, the CAS approach sees the regulatory systems as being flexible actors and not just as obstructions that are fixed in place. The regulations had adapted to the new environmental facts, political considerations, or public protests and were often the cause of the project’s delayed delivery in a roundabout way.

(Breslin et al., 2021) view is that projects and institutions get to interact and that governance frameworks themselves are subjected to feedback and learning is further validated by these findings. The main point made by the data is that regulatory uncertainty is not something that can only be managed through a compliance-oriented control measure. On the contrary, the projects that were successful had in place adaptive governance mechanisms such as ongoing regulatory conversations and sequencing of approvals that is flexible. This finding adds to the existing literature that is in support of hybrid governance systems that are able to balance the formal control with the institutional change responsiveness (Andriollo et al., 2021).

4.4 THEME 2: STAKEHOLDER COMPLEXITY AND SOCIAL DYNAMICS

The second major theme that arises from the results is the multifaceted nature of the stakeholder environments, as well as the crucial influence of the social dynamics on project

delivery outcomes. Project managers in all the cases reported their engagement in multi-stakeholders' ecosystems with regulators, investors, technology providers, local communities, NGOs, and technical consultants. Each of the stakeholders had their own specific priorities, risk perceptions, and norms which led, in most cases, to the formation of new conflicting expectations that changed over the course of the project. This is in line with the findings of the previous research arguing that the development of innovative infrastructure projects involves the participation of a lot of stakeholders rather than just the two parties in the client–contractor relationship (Wang & Witlox, 2025).

4.4.1 Multi-Stakeholder Environments

Stakeholders' alignment was, participants remarked repeatedly, a process requiring continuous asking, compromising and adapting, and not a one-off planning exercise. Among the stakeholders, the regulators put compliance and environmental protections first, the investors were concerned with the viability of the project and risk containment, and the local community talked mainly about social and environmental impacts. A project manager who had a hand in a bioenergy project said,

"People will feel left out even if the technology is working and the project will fail. It will take time to build trust, and it is not given at the beginning."

The statement is in line with the studies conducted recently which say that one of the prime reasons for delay and resistance to renewable energy projects is stakeholder conflict and misalignment (Brady et al., n.d.). Community projects, especially in Asia, put a lot of emphasis on the social license to operate, and acceptance was based on trust, transparency, and local benefits in the form of jobs or improved infrastructures. Technical performance was not enough to confer legitimacy.

The findings point to the increased stakeholder complexity as the projects transition from the pilot to the full-scale deployment, which conflicts with the linear assumption that uncertainty diminishes over time. That enhances the literature on socio-technical transitions, which considers stakeholder involvement as a lively and rewindable process instead of a mere prolongation of one phase (Cuesta et al., 2025).

4.4.2 IDT Constructs: Compatibility, Observability, and Trust

The results have a strong impact on the main ideas of Innovation Diffusion Theory, especially on the aspects of their compatibility, visibility, and reliability. When the projects considered the local culture, governance, and livelihoods, the adoption was less problematic. For instance, bioenergy projects that were linked to agricultural waste already being used by communities faced practically no opposition compared to those that were viewed as imposed from outside.

Visibility was another factor that came out to be very important alongside compatibility. Participants thought that using visible demonstrations, pilot plants and site tours were effective ways to deal with uncertainty and scepticism. One of the interviewees from a community energy project said:

“People's perceptions changed totally after they saw the system working and realized its benefits for them.”

This is in line with the lately conducted research that has shown the factors of demonstrability and transparency to be accelerating the rate of acceptance owing to the social learning and peer influence which are made possible (Landis, 2024). On the other hand, there was a situation where the technologies were regarded dark and too complicated, thus trust was eroded even though the technical feasibility was strong.

The most significant finding of the study is the role played by project managers as boundary spanners. Project managers often represented both sides—the technical experts and the non-technical stakeholders—by converting hard-to-understand technical terms into easy-to-understand narratives and allowing trialability through staging the pilots. Such a conclusion is also drawn by (Flyvbjerg et al., 2025), who highlight the skills of sense-making and communication as key in complex project environments.

Moreover, the results have indicated that trust was not merely a byproduct of efficient delivery but rather a prerequisite for nurturing other areas of production. It was observed that the absence of the initial trust-building strategies in the projects caused a bottleneck situation for subsequent steps.

4.5 THEME 3: LIMITATIONS OF PURELY PREDICTIVE PROJECT MANAGEMENT

The third main issue that was identified through the analysis is the insufficiency of predictive (plan-driven) project management techniques as the sole method for innovative sustainable energy projects. The respondents emphasized the necessity of front-end planning particularly in the areas of funding, regulatory approval, and political legitimacy—but yet, there was a lot of consensus that conventional predictive techniques were inadequate unless they were supported by another method. This conclusion is in line with the increasing criticism in the management literature that deterministic models are hardly applicable in situations where technological innovation and uncertainty about the system are the main characteristics (Lacerda & Van Den Bergh, 2014).

4.5.1 Front-End Planning Constraints

Front-end planning was seen as a crucial practice by most participants in the industry. It helped to clarify project objectives, set the ground for safety and compliance requirements, and at the same time, meet the needs of investors and regulators. But, at the same time, the participants reported that standard baselines and strict constraints very soon became irrelevant as fresh technical data came through or the regulatory environment changed. For instance, one geothermal project manager said:

“We had a very solid plan on paper, but once drilling started, the assumptions behind that plan just didn’t hold. Updating it became more work than the plan itself.”

Such a viewpoint is in accordance with the findings of recent studies which indicate that front-end planning in innovative infrastructure projects sometimes depends on sketchy or temporary knowledge especially where underground or ecological conditions are involved (Samset & Volden, 2016). In such cases, early commitment to detailed baselines can cause the projects to remain in suboptimal positions and create a feeling of certainty by the use of false assumptions.

A number of participants recounted instances when sticking to inflexible plans resulted in more work being done over again and the delay in making the right decision since the teams had to prove the necessity of the changes instead of simply reacting to the new information in a practical manner. Thus, the viewpoint of (Setyadi et al., 2025) that putting too much emphasis on upfront precision can lead to loss of responsiveness and hence increase overall project risk rather than reduce it finds support in the arguments presented here.

4.5.2 Control versus Learning Tension

The results additionally show that there is a basic contradiction between controlling and learning that is inherent in predictive project management methods. On the one hand, predictive methodologies lay stress on stability, predictability, and the guaranteeing of those things—characteristics that are greatly appreciated by the sponsors, lenders, and regulatory bodies surrounding the project. The industry insiders recognized the existence of these traits as a means of gaining trust and being accountable, especially in the case of pricey energy projects involving millions of dollars.

On the other hand, the same measures that were in control often placed in the corner the learning and adaptation, particularly during the phases of the project when the uncertainty was at its peak. One of the people interviewed involved in the tidal energy project told us:

“Every change was interpreted as a failure because the whole system was built to reject change rather than to be modified through it.”

This effect is in line with what recent studies say that predict control systems will frequently consider deviation as a problem that needs to be resolved instead of a source of insight (Ghezzi & Cavallo, 2020). In the case of innovative energy projects, where learning from failure and iterations are crucial, such an attitude can limit the scope of the experiments to be done and also lead to the non-reporting of the risks that are just beginning to emerge.

The evidence has starkly pointed out that the issue is not the planning itself but rather the weighing of control over learning which is an assumption. Participants mentioned that there was a need for delivery methods that would be a combination of the regulations and the ability to adapt. This is aligned with the position taken by (Raygoza-Limón et al., 2025) that contemporary project governance should be capable of both guarantees and emergence instead of treating them as opposites.

4.6 THEME 4: EMERGENCE OF HYBRID PROJECT MANAGEMENT APPROACHES

This study has a main empirical result that hybrid project management approaches have emerged as a practical necessity instead of merely a methodological choice. In all instances case, delivery models were reported by participants that incorporated the features of both predictive

and adaptive practices as a reaction to ongoing uncertainty, huge number of stakeholders, and changing regulations. A mixture of techniques and methods was not based on theoretical devotion to either agile or predictive systems but rather on the actualities of administering innovative sustainable energy projects where neither strategy was sufficient on its own.

4.6.1 Hybridisation as a Practical Necessity

Participants throughout the study pointed out the application of combining stage-gate governance mechanisms—applied for financing, regulatory approvals, and strategic oversight—with iterative cycles for tech development, stakeholder engagement, and environmental monitoring. The comment of one senior project manager was as follows:

“Investors and regulators need stage gates, but we have to experiment, learn, and adjust between those gates. Otherwise, the project simply gets stuck.”

This observation concurs with the latest empirical research indicating that hybrid models grow naturally in complex infrastructure projects as the actors try to reconcile the restraints of institutional control with the flexibility they need for operations (Gemino et al., 2021). In reality, the stage gates came through as the sources of legitimacy and accountability, whereas the iterative practices made it possible to react to the technical data and the social feedback coming up.

Participants, however, were critical in pointing out that the hybridisation was most successful when it was actively modeled, not when it was informally done. Projects with no clear indication of where the need for predictability was and where flexibility was allowed faced misunderstandings, overlapping labor, and governance conflicts. This is in line with the claims of (Misbahuddin & Maarif, 2024) that hybrids which are poorly articulated are likely to become fragmented rather than integrative.

4.6.2 CAS Perspective: Feedback Loops and Adaptation

From the viewpoint of Complex Adaptive Systems (CAS), the hybrid delivery procedures allowed the unbroken feedback to loop among project subsystems that are interconnected. Henceforth, technic data of performance, i.e., reactions of stakeholders and signals of regulation, were not considered single inputs and were rather treated as feedback that is in constant motion shaping the decisions on the way. One participant from a community energy project stated:

“Every review meeting changed something—sometimes the design, sometimes the engagement plan, sometimes the timeline. The project went along with the system’s evolution.”

This statement is a very strong affirmation of CAS theory, which depicts projects as living systems undergoing changes characterized by emergence, non-linearity, and co-evolution between the different actors involved (Xiang et al., 2025). Hybrid governance models provided formal or Institutional learning spaces—such as adaptive review forums and cross-functional workshops—where learning could be institutionalised rather than remaining informal or tacit.

One of the essential things revealed by the research findings is that the company culture was the crucial factor that determined whether hybrid approaches paid off or not. Participants indicated that hybrid models were most efficient in organizations that allowed learning, transparency, and decentralized decision-making within the established governance boundaries. Oppressive environments that were hierarchical in nature would not facilitate the use of hybrid mechanisms so they only existed in name, and not in practice.

This accentuates the recent writings that claim that hybrid project management is not only a structural configuration but also a socio-organisational capability demanding trust, psychological safety, and leadership support (Reiff & Schlegel, 2022). According to the CAS perspective, these cultural attributes allow the occurrence of positive emergence whereas the rigid control methods hinder the capacity for adaptation.

4.7 THEME 5: PROJECT OUTCOMES AND PERCEIVED EFFECTIVENESS

One of the main aspects that came out of the research is the way project results and effectiveness are understood and measured in the case of new sustainable energy projects. In all the cases the participants were of the same opinion that project success should not be defined only in terms of time and cost, they rather promoted a more comprehensive and multi-dimensional view of effectiveness. This is indicative of a trend in project management literature to abandon the traditional “iron triangle” and to the other side of the spectrum, to outcome-oriented and sustainability measures (Min et al., 2023).

4.7.1 Performance Beyond Time and Cost

All project types' participants assert that environmental performance, system reliability, stakeholder satisfaction, and long-term adaptability are indicators of success equal to, or even more than, adherence to the original schedules or budgets. One project manager who worked on a geothermal project expressed:

“The system reliability, community acceptance, and future adaptation mean nothing but learning even if a few months delay occurs.”

This view is in agreement with the recent research by (Raju et al., 2025) that short-term efficiency metrics often ignore the long-term value creation in innovation and sustainability projects. Participants specifically indicated that deviating from the plan usually led to better environmental protection, more powerful systems, or even better stakeholder connections—all of which were seen as more strategically important than adhering to the timetable strictly.

It was generally believed that the hybrid project management approach would be the way to resilience and sustainability performance because it allows for the technical, environmental, and social risks to be identified much earlier. The iterative process of monitoring and the gradual improvement of the project let the teams modify designs, operational methods, and stakeholder engagement before the emergence of major failures. This conclusion is in line with the findings from (Sabini et al., 2019) who argued that delivery approaches which can adapt to the prevailing situation enhance not only learning-based performance but also long-term reliability in infrastructure projects.

The findings also indicate that the application of performance measurements that are not flexible can wrongly label adaptive behavior as inefficient, thus, learning-driven improvements will not gain the proper value. At this point the researchers' calls for the reevaluation of the performance measuring systems to be congruent with the innovations in the area re-emphasized.

4.7.2 Contextual Contingency

The results of the study also imply that there is no one project management technique that could be considered the best in all cases. Rather, the project's context was a key factor for the perceived effectiveness and these included the technical maturity, regulatory stability, the complexity of the stakeholders, and the capacity of the organization. The participants kept on

saying that the delivery methods used in one context were sometimes not only ineffective but also counterproductive if transferred without changing to another context. A certain interviewee noted:

“Agile works well when you can experiment, but if the regulator isn’t ready for that, you need more structure. It’s about fit, not fashion.”

This remark greatly reinforces the contingency theories of project management that assert that effectiveness is attained through the alignment of context and governance structure rather than methodological purity (Shah et al., 2024). In situations of technological immaturity or where there are social sensitivities, hybrid methods are considered to be quite effective as they provide a good mix of assurance and flexibility.

The most critical aspect is that the outcomes of the research give empirical support to the delivery approach proposed in the study: context → delivery approach → outcomes. The project outcomes were not only dictated by the choice of the methodology but also by how well that methodology was matched with the contextual demands. This is in contrast to universalism claims that are associated with both predictive and agile paradigms and it strengthens the argument for tailoring to the situation.

4.8 CROSS-CASE SYNTHESIS

Analyzing the different cases together shows that there were huge one and the same patterns across the various technologies (such as geothermal, bio, tidal/wave energy, and decentralised ones) and different the places, although there were some variations in the conditions under which they operated such as regulatory regimes, institutional capacity, and social-culture. This strong similarity indicates that the difficulties and the respective solutions that are mentioned are not anomalies of the individual technologies but are rather characteristics of the whole class of new sustainable energy projects.

When looking back at all cases that were subject to a high degree of uncertainty, it is noticed that the projects which made use of adaptive governance structures and iterative learning showed more resilience and were perceived as more effective. These projects managed to incorporate flexibility within the formal control systems, thus enabling the teams to react in a positive manner to the new technical data, stakeholder feedback, and regulatory changes. On the

other hand, cases that were marked by strict regulations, top-down decision-making, and lack of flexibility within the organisation found it difficult to implement hybrid practices even in situations where such approaches were officially approved.

One of the conclusions drawn from the analysis was that hybrid project management is not synonymous with adaptive outcomes. Rather, its effectiveness is dependent on the prevailing institutional and organizational conditions. In some instances, hybrid structures were only on paper, but the control over making decisions still was upon the central and acting outside the plan was not allowed. Such projects experienced slowness in response, more ongoing work, and stakeholder dissatisfaction increased. This result is in line with the recent critique that posits that using the hybrid approach methodologically without having culture and governance alignment will lead to “ceremonial agility” instead of real adaptability.

The synthesis not only confirmed but also strengthened the idea that ICT and CAS theories had a complementary explanatory power. Stakeholder perceptions, in particular concerning compatibility, observability, and trust, are seen as major factors that determined the adoption of technologies in these cross-case patterns, showing that from an IDT point of view. The projects that treated technology and local practice as one and got the most benefits seen through pilot testing and demonstrations experienced over all faster diffusion and fewer delays. On the other hand, where technology was considered not suitable for local practices or not sufficiently clear in its benefits, resistance continued no matter how good the technology was.

IDT, however, is not able to account for the technological revamping of projects over time by continuing to be the sole theory applied. In this respect, CAS offers the much needed depth of explanation. Over all cases, the projects were similar to systems that get their structure through the interaction of technical, institutional, and social factors, which in turn influence each other through feedback loops. A change in regulations would lead to design changes in the project; the project would change the engagement strategy in response to the stakeholders' reactions; and a technical breakthrough would force the adjustment of the governance structure. These interactions were often non-linear, resulting in outcomes that could not be forecasted through the use of linear planning models.

It is to be noted that the synthesis points out that adaptation itself turned into a performance capability. The projects that institutionalised learning—by means of regular reflective reviews, cross-functional forums and flexible decision thresholds—were more capable of

absorbing shocks and changing delivery strategies. This is in support of CAS-based arguments that success in complex environments becomes less dependent on initial optimization and more on ongoing system responsiveness.

The cross-case synthesis viewed from different angles, on the whole, validates the proposed subject matter → means of communication → results framework of the study. The results of the project were determined not by the nominal selection of predictive, agile, or hybrid methodology, but by the compatibility between the delivery method and the contextual conditions. High uncertainty, fragmented regulation, and dense stakeholder networks called for hybrid and adaptive governance; stable contexts were able to accept greater predictability. This result contradicts universalist claims in project management and strengthens the case for contingency-based approaches.

4.9 DISCUSSION IN RELATION TO RESEARCH QUESTIONS

RQ1: What management issues arise in novel energy innovation projects?

The study brings to light the fact that management of uncertainties, stakeholder issues and regulatory fragmentation are the major problems across the board in the management of the new sustainable energy projects. The projects are carrying out in novel infrastructure sectors and facing incomplete tech knowledge, evolving regulatory frameworks, and continuously changing stakeholder expectations. Uncertainty was on the contrary the case in the earlier stages of planning, it was through the project lifecycle which meant challenging the common view that risk can be progressively diminished through front-end loading alone.

These were the main reasons why and stakeholder complexity also added to these problems. The projects concerned different players with different priorities— regulators focusing on compliance, investors trying to control risks, and communities thinking about social and environmental impacts and implicitly asking for their participation. This competition of expectations was not solved once and for all but needed continuous negotiation as the project went on. Hence, this finding has given a new perspective to the project management literature by arguing that engagement with the stakeholders in energy projects has to be seen as a continuous governance function rather than a discrete activity.

Among the three management issues, regulatory fragmentation was the one that most frequently caused problems. The project scope and sequencing were often changed mainly because of overlapping authorities, changes in standards and policy unclear meaning, which could have happened completely independently of the state of the technology readiness. So, management issues in the case of novel energy innovation projects are not just scattered or isolated, they are systemic which means reinforcing the assumption that such projects are very complex socio-technical systems just like the engineers have to control them.

RQ2: How do project managers deal with risks and changing conditions?

The results show that mainly by means of the adaptive practices, the feedback loops, and the hybrid governance arrangements project managers dealt with the risks and the changes in the environment. The effective managers did not try to remove the uncertainty, they rather concentrated on absorbing and responding to it. This was done through embedding learning mechanisms in the project execution such as iterative reviews, phased pilots, and cross-functional coordination forums.

The feedback loops were the central factor that made adaptation possible. Many things such as technical data, stakeholder responses, and regulatory signals were constantly being monitored and unintentionally influenced the decision-making processes. This is consistent with the Complex Adaptive Systems view that sees risk management as an emergent and iterative activity rather than a predictive exercise. However, the findings indicate that adaptability was not spontaneous but rather institutionalized, and the successful projects formed formal spaces for reflection and recalibration.

Project managers were also crossing the boundaries and translating the complexity among the technical, social, and institutional domains. The clarity that this making sense role provided was very helpful in keeping stakeholders' trust and preventing fragmentation. Therefore, the findings overturn the traditional risk management models and place project managers within the role of adaptive leaders who are working through changing systems.

RQ3: Which project management practices work best?

The researcher concluded that the use of hybrid project management methods in the combination of predictive control with agile learning is the best way to go in the complex and unsure circumstances. The use of predictive elements—like stage-gate reviews, compliance

checkpoints, and financial controls—was, however, not quite able to uphold the legitimacy, accountability, and assurance of the regulators and investors by themselves, thus being insufficient in isolation.

Nevertheless, the agile and iterative practices made it possible for the firms to conduct an experiment, to learn, and to respond very quickly to the new information that was coming up, especially in the early times of deployment and stakeholder engagement. The mixture of project management allowed the projects to strike a balance between these demands that were in competition, thus being able to sustain governance stability and also the capacity to adapt. More importantly, it was revealed that the hybrid efficiency was contextually dependent and culture-wise; hybrid methods were successful on the ground of supporting flexibility and were unsuccessful on the ground of control-oriented cultures because they suppressed learning.

This strengthens the contingency-based notion of project management, rejecting universal prescriptions and promoting context-sensitive design instead. Hybrid approaches did not work best just because they were more superior, but because they were in line with the realities of the innovative sustainable energy projects that were characterized by the attributes of uncertainty, interdependence, and change.

4.10 DISCUSSION IN RELATION TO RESEARCH OBJECTIVES

The findings of the study are to be evaluated according to the research objectives defined in Chapter 1 within this section. The discussion by linking explicitly empirical insights to each objective shows the coherence, relevance, and contribution of the research.

Objective 1: Investigate challenges in delivering small- to mid-scale innovative sustainable energy projects (e.g., geothermal, wave energy)

The first goal was completely realized through the discovery of delivery problems that had persisted in all cases. The results indicate that small- to mid-scale innovative energy projects, in general, are exposed to the same kind of structural difficulties due to technical uncertainty, environmental variability, regulatory fragmentation, and stakeholder complexity. Unlike the situation with renewable energy technologies that have reached maturity, the delivery ecosystems

of these projects are not yet stabilized, thereby resulting in a project lifecycle that is more prone to risks.

The cross-case analysis indicates that uncertainty is not limited to the feasibility or planning stages but rather is experienced and continues during early operation, especially with geothermal and tidal/wave projects. This implicitly aligns with the goal of providing knowledge that is supported by empirical data concerning the characteristics, sources, and duration of delivery difficulties that are unique to the new energy systems.

Objective 2: Compare traditional (predictive) versus adaptive project management methods in real-world clean energy implementations

A comparison of three important concepts, Predictive, Agile, and the Hybrid of the project delivery methods, is the heart of this manuscript. The study reveals that even though traditional predictive approaches are still important in the areas of regulatory compliance, funding, and accountability, they are not enough by themselves when the level of uncertainty is really high.

Among the adaptive and agile practices those like iterative planning, small-scale testing, and constant interaction with stakeholders were found to be helpful in the learning and responsiveness process, but at the same time, they were considered not to have enough legitimacy by the institutional actors when used alone. Thus, the study goes on to compare the different approaches and provide empirical support for the claim that neither of them is a cure-all solution, thereby achieving the objective through sophisticated, practically-oriented comparison rather than theoretical abstraction.

Objective 3: Study successful case examples (e.g., Iceland's geothermal PM system, Denmark's biogas integration)

The third objective is achieved by carrying out an in-depth qualitative analysis of the cases from Iceland, Denmark, and some Asian contexts. The main characteristics of the successful cases were: adaptive governance, the presence of iterative learning mechanisms, and robust stakeholder participation that was integrated with the formal control structures.

The outcomes highlight the transferability of certain principles such as the institutionalized feedback loops and the contextual tailoring, rather than viewing success as something that is solely the result of national models. Thus, a new way of looking at success and its explanation

grounded in CAS and IDT perspectives is provided which is informed by Theory rather than by mere benchmarking.

Objective 4: Propose a flexible project management framework suitable for managing innovation in diverse contexts

The results give a strong evidence-based support for the creation of a flexible, contingency-based project management strategy, which directly satisfies the fourth goal. The evidence is consistent across cases and backs the proposed context → delivery approach → outcomes relationship, thereby proving that the effectiveness relies on the synchronization of project context and governance design.

Hybrid project management appears as the most appropriate method in environments with complexity and uncertainty, however, not as a mandatory solution but rather as an evolving configuration that can change with project systems.

4.11 ACHIEVEMENT OF THE RESEARCH AIM

The overall aim of this study was:

To explore how project management practices can be adapted to support the successful delivery of innovative, sustainable energy projects.

The results of the analyses carried out in Chapter 4 indicate that the main objective has been completely attained by means of a thorough qualitative investigation of project delivery practices in different contexts of innovative sustainable energy. The study does not treat project management as a fixed array of tools and methodologies but rather shows how practices are constantly transformed through their adaptation to uncertainty, the complexity of stakeholders, and the changes in regulatory and institutional environments over time.

The investigation points out that change are made at different levels of project delivery. At the governance level, project teams transform the structure of the decision-making process by the combination of predictive controls (for instance, stage-gate reviews and compliance checkpoints) with adaptive mechanisms allowing learning and iteration. At the operational level,

managers among the others adjust the planning horizons and the sequencing of the activities and stakeholder engagement according to the new information of technical, environmental, and social nature coming up. These adaptations not only target but also illustrate the central aim in that they show how project management practices evolve in real life and not merely how they are prescribed by theory.

Above all, the research proves that the successful execution of innovative sustainable energy projects is not through total substitution of the traditional project management practices, but rather through their case-by-case reconfiguration. Predictive techniques are still very much needed for legitimacy, financing, and regulatory assurance, whereas adaptive and learning-oriented practices are the ones allowing to be responsive in uncertain conditions. This equilibrium of adaptations illustrates the reason why hybrid project management methods were consistently found throughout the cases.

Not only does the study take its empirical findings to Innovation Diffusion Theory (IDT) and Complex Adaptive Systems (CAS) but it also reaches its goal at a theoretical level by doing so. The IDT theory puts forward that the changing project management methods entice the support of the stakeholders and the acceptance, whereas the CAS theory describes the project systems' dynamic and non-linear progression. The mix of these perspectives provides the rationale why the innovation in sustainable energy delivery is not a choice but a necessity.

The study has reached its goal by providing the empirical proof and the theoretical foundation for the assertion that the project management practices in the innovative energy projects can be changed for the better in the areas of reliability, sustainability, and stakeholder acceptance. The project management framework and the practical recommendations presented in Chapter 5 are constructed on these insights.

4.12 SUMMARY

This chapter presents a detailed and in-depth qualitative evaluation of the different project management approaches applied in innovative sustainable energy projects. The outcomes show that classic plan-driven techniques are insufficient in difficult and unpredictable situations. Feedback, learning, and stakeholder engagement-based adaptive and hybrid delivery methods,

on the other hand, are the better performers and the more sustainable ones. Thus, these findings provide an excellent empirical foundation for the discussion, framework development, and recommendations made in Chapter 5.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 INTRODUCTION

This thesis concludes by considering the last assertions of research, as performance aspects are observed and given form on the empirical aspect covered in Chapter IV. It verifies that the research aims and objectives have been attained, describes the suggested project management framework which is based on the found, and opens up both the practical and theoretical recommendations. The chapter wraps up with the limitations of the study being recognized and avenues for future research being indicated.

5.2 CONCLUSIONS

The central goal of this study was to investigate the possibility of modifying project management techniques to suit new and innovative sustainable energy projects. The study draws its conclusion on the basis of empirical evidence that the projects of innovative sustainable energy are quite different from those of mature infrastructure in terms of uncertainty, diverse stakeholders, and changing regulations that are all keeping the project in their respective situations.

The researches bag that not only predictive project management methods can manage related issues. Uncertainties and continuously changing legality do still need traditional planning, control, and compliance as a must, but the methods do not cover properly the learning needs, uncertainty absorption, or stakeholder adaptation. Hence, the effectiveness of project delivery is to a great extent reliant on the integration of control and flexibility.

Also, for the case of the innovative sustainable energy projects research states that hybrid project management approaches fit best as the very project delivery configuration. They allow projects to keep their deliverables billable and non-technical while at the same time acquiring iterative learning, adaptive decision-making, and constantly involving stakeholders. Thus, the way

of success is not through methodological purity, but rather by context-sensitive adaptation of project management practices.

5.3 ACHIEVEMENT OF RESEARCH AIM AND OBJECTIVES

The complete empirical investigation of the adaptation of project management practices in the real-world innovative sustainable energy projects has met the research goal fully. Along with stakeholders' complexity and fragmented regulations, the main delivery problems, which are typical of such projects, have been successfully identified by the study and these include technical uncertainty. It has furthermore provided a comparative analysis of the three project management practices—predictive, adaptive, and hybrid—in which the pros and cons of each are emphasized based on the situation. Besides, the research has investigated the success cases that are not confined to the same geographical and institutional contexts, thus permitting the rise of transferable principles instead of relying on fixed or prescriptive models. Lastly, the study has come up with a flexible, contingency-based project management framework that is appropriate for the management of innovation in various contexts. Taken together, all these outcomes indicate that the research has indeed accomplished its goal and has contributed to the area of sustainable project management with new and important insights.

5.4 PROPOSED FLEXIBLE PROJECT MANAGEMENT FRAMEWORK

The proposed project management framework that is flexible according to the study's empirical results will guarantee the effective delivery of. A systematic link is established among the elements of the project, its delivery mode, and the project's results. The framework also states that the success of project management is determined by how well the governance and the delivery systems match the situational factors. The framework does not restrict with one single methodology, instead it embraces the dynamic and uncertain nature of the environments where innovative energy projects exist, thus paving the way for making adaptive decisions.

The first framework element consists of project context, which indicates the various conditions that are set for a project to start and be delivered. The indicated conditions envelope the technological maturity angle, the environmental and technical uncertainty, the stability or

disruption of the regulatory regime, the degree of complexity of the stakeholder networks, and the organizational capability (technology and human resources) of the project sponsors and the delivery teams. The results prove that the aforementioned context factors define the risk character and level for the project and that they, in turn, affect the project management practices. If decision-makers acknowledge and carry out systematic project context assessment at the beginning, they will be able to forecast governance and delivery issues more accurately.

The second element, the delivery method, denotes the arrangement of project management practices that have been chosen in response to the requirements of the specific context. Delivery methods are distributed over a spectrum that has the traditional predictive models at one extreme and hybrid configurations at the other. Although the predictive methods are still considered as being useful for purposes such as compliance, financial control, and accountability, the framework has pointed out that hybrid methods are the most suitable ones to be used in the environments marked by high uncertainty and complexity. The hybrid delivery combines the formal control mechanisms, which include stage-gate reviews and regulatory checkpoints, with adaptive and iterative practices that allow learning, experimentation, and stakeholder engagement to take place during the whole project lifecycle. The framework thus promotes on-purpose tuning of delivery methods instead of depending on inflexible or uniform practices.

The third element of the framework highlights the outcomes of the projects as such, which are evaluated through a multifaceted and multidimensional criterion. This includes but is not limited to sustainability, system reliability, acceptance by and involvement of the various stakeholders, resistance to changes, and adaptiveness over the long run, as making such assessments aint the traditional way of looking through the lens of time and cost and making the stakeholders that matter the least in the project openly or secretly pay more to the project than it is worth.

In the context of the model suggested, a new, wider, more nuanced, multidimensional and longer-lasting value generation rather than mere short-term efficiency, has become the mainstream in the performance assessment of the project as it is among the strategic and societal goals of the energy projects associated with the new technologies whose sustainability is not only the concern but the main purpose as well.

This is the main aim of the framework that it leads the practitioners to choose and design project management methods based on the actual situation rather than using common or prescriptive models that repeat the same process over and over. The framework provides informed decision-making support in complex and uncertain environments by emphasizing adaptation, continuous learning, and governance alignment. In this way, it becomes a tool of great value not only to project managers but also to organizations and policymakers as they try to increase project delivery efficiency while still being responsible and considerate of sustainability in the context of new energy projects.

5.5 PRACTICAL RECOMMENDATIONS

5.5.1 Recommendations for Project Managers

Project managers should:

- Utilize delivery methods that combine formal control and adaptive learning in a balanced way.
- Make feedback an integral part of the system through continuous reviews and plan adjustments.
- Consider the management of stakeholder relationships as a constant governance responsibility that requires their active involvement.
- Build up the organizational skills of interpreters and facilitators for better communication across boundaries.

5.5.2 Recommendations for Organisations and Sponsors

The organizations should carry out the following tasks:

- Construct governance frameworks that allow for flexibility along with accountability.
- Unite performance indicators with sustainability, resilience, and learning results.\
- Put money into the organizational skills that facilitate adaptive decision-making.

5.5.3 Recommendations for Policymakers and Regulators

Regulatory bodies should:

- Allow adaptive permitting and phased approval mechanisms for the innovative technologies that are still under learning process.
- Engage openly and continually with project groups.
- Consider project designs focused on learning as the main input for the up-scaling of innovations.

5.6 THEORETICAL CONTRIBUTIONS

The study adds to the theoretical development by:

- Prolonging Innovation Diffusion Theory to prove that project management practices influence adoption outcomes.
- Applying Complex Adaptive Systems theory in project governance and delivery contexts.
- Offering empirical validation to the contingency-based hybrid project management models.

These contributions propose project management as a not rigid methodical system, but an adaptive sociotechnical capability.

5.7 LIMITATIONS OF THE STUDY

The study has few limitations. Its qualitative nature, while disallowing generalizability, permitted analytical transferability through cross-case analysis. The commercial and regulatory sensitivities limited the number of cases and participants to whom the researchers could get access. Furthermore, the project experiences were captured at specific points in time rather than through their entire lifespan.

5.8 RECOMMENDATIONS FOR FUTURE RESEARCH

Future research might:

- Longitudinal studies could be done to see how hybrid project management changes during the time period.
- Different research methodologies including both qualitative and quantitative approaches could be used for the scientific measurement of the framework.
- The impact of modern digital technologies such as AI and digital twins on the facilitation of adaptive governance could be examined.
- Regulatory innovation may be investigated to function as a moderator of the effectiveness of project delivery.

5.9 FINAL CONCLUSION

The contextualization of various project management methods to the particular situation is regarded as the major factor for the delivery of innovative, sustainable energy projects to be successful. The combined project management methods have demonstrated their superiority and have remained the sole way to deal with uncertainty, complexity, and change. Aligning governance structures with learning-oriented practices, project managers and organisations can enhance the resilience, sustainability, and long-term success of energy innovation projects.

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INTERVIEW QUESTIONS

Project Management in Sustainable Energy Innovation

1. What major management or delivery challenges arise when working on innovative sustainable energy projects such as geothermal, tidal, wave, bioenergy, or micro-hydro?
2. How does uncertainty, regulatory shifts, or technical complexities influence your project planning and decision-making?
3. How do you identify and respond to emerging risks or unexpected changes during the project lifecycle?
4. Which project management approach (predictive, agile, hybrid) do you use in this project, and why was it chosen?
5. In your experience, how effective is the chosen delivery approach in addressing uncertainty, stakeholder needs, and technical challenges?
6. How do stakeholders (regulators, communities, investors, technical teams) influence adoption, acceptance, or modification of innovative technologies in your project?
7. What feedback mechanisms or learning processes (e.g., trials, prototypes, environmental monitoring, digital dashboards) help guide project decisions?
8. Overall, how would you evaluate the project's performance in terms of schedule, cost, reliability, and sustainability outcomes? What factors contributed most to these outcomes?