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SUSTAINABLE PROJECT MANAGEMENT SYSTEM FOR RENEWABLE ENERGY INFRASTRUCTURE: AN INTEGRATED RISK-QUALITY-SUSTAINABILITY GOVERNANCE FRAMEWORK

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Abstract. One of the major structural challenges to the successful implementation of renewable energy infrastructure projects in the European Union is fragmented governance. Although risk management, quality assurance, and sustainability performance are covered separately based on the established standards and models, such as ISO 31000, ISO 9001, and ISO 14001, there is no validated and operationally integrated framework that reflects systemic dependencies of these areas on the project level. This paper introduces the sustainable project management system (SPMS), which is a multi-criteria decision-making (MCDM)-based governance framework that is aimed at simultaneously resolving the risk exposure, quality-assurance maturity, and sustainability governance issues throughout the renewable energy project lifecycle. Based on a risk-quality-sustainability (RQS) interlinkage analysis of offshore wind and utility-scale solar photovoltaic (PV) systems in the EU, the study finds the cascading governance failure pathways and constructs a nine-criterion scoring architecture, which is tested on three cases in Europe: an offshore wind project in Denmark, a utility-scale solar PV facility in Spain, and a geothermal/hybrid project in Italy. Findings show that there are regular improvements of 80–117 % in the integrated value score (IVS) in all cases in the event of SPMS governance application, with the highest improvements obtained in the sustainability area. Its SPMS is placed as an analytical diagnostic focus, as well as a decision-support framework in line with EU Taxonomy, Fit-for-55 targets, and Sustainable Development Goals. The article adds an empirically based, scalable governance structure to the body of literature on project management and renewable energy, and has implications applicable to policy-making, developers, and regulators working on the European energy transition.

Keywords: *European Union, governance integration, multi-criteria decision-making, quality assurance maturity, renewable energy, risk management, sustainability governance, sustainable project management system (SPMS).*

INTRODUCTION

The growing pace of decarbonisation being pursued by the European Union has significantly broadened the scope, magnitude, and ambition of renewable energy infrastructure projects. The fact that the offshore wind capacity is planned to reach

60 GW in 2030 and 300 GW in 2050 (European Commission, 2024), and the solar photovoltaic (PV) deployment has already reached an unprecedented level of over 56 GW of new capacity installed in 2023 alone (SolarPower Europe, 2024) shows the scale of the change that is currently underway. However, with this growth, there has already been an ongoing trend of project cost overruns, schedule slippage, quality deviations, and inconsistent sustainability results – not of technological failure, but of endemic failure in the project governance process.

The organisational frailty is the breakdown of three intertwined areas of governance, which include risk management, quality assurance and sustainability performance. Standards that exist today cover these areas separately. The ISO 31000 offers systematic risk management advice but does not include indicators of sustainability. The ISO 9001 imposes quality discipline in terms of procedures without incorporating social or environmental performance indicators. The ISO 14001 formalises environmental management without operationalising the connection of environmental management to the technical risk and quality processes. The result is the lack of feedback loops within the areas of governance, which leads to regulatory latency, causing quality deviations to be introduced, quality failures to be incurred, and a cascading failure dynamic that fragmented structures cannot capture.

This governance gap is especially acute in the context of the EU, where a renewable energy project must also work around multi-level regulatory approval regimes, global supply chains of diverse maturity levels, marine and terrestrial environmental limitations and high investor-driven environmental, social and governance demands. Although there is an increasing amount of literature on sustainable project management (Silvius & Schipper, 2014; Huemann & Silvius, 2017; Gareis et al., 2013), there is no validated, EU-specific, and integrated operational framework that can manage project-level risk, quality, and sustainability simultaneously.

The gap in this paper is addressed by proposing the sustainable project management system (SPMS): a multi-criteria decision-making model encompassing all the interdependence of risk, quality, and sustainability theory structural facets of a governance framework to be applied in the context of renewable energy infrastructure project development. The SPMS is tested on the case of three EU initiatives involving offshore wind (Denmark), utility-scale solar PV (Spain) and geothermal/hybrid technology (Italy), and the hypothesised and measurable governance performance gains have been observed when the integrated structure is used.

The paper is structured as follows: a critical review of project governance, quality management, and sustainability literature establishes the theoretical foundation for the SPMS; the analytical RQS interlinkage quantification across offshore wind and solar PV follows; the SPMS conceptual architecture and MCDM validation methodology are then presented; cross-case validation results, implications, and limitations are discussed; and the paper concludes with proposals for policy, practice, and future research.

1. LITERATURE REVIEW AND THEORETICAL FOUNDATIONS

1.1. Fragmentation in Project Governance Frameworks

Since the classical methods of the PMBOK and PRINCE2 have procedural foundations, the project management literature has developed significantly to be more adaptable and more inclusive of stakeholders (Kerzner, 2017; PMI, 2021). However, the basic premise of environmental and institutional stability, which is enshrined in classical project management theory, still does not fit the reality of renewable energy infrastructure operations. Socio-technical systems, such as offshore wind farms and utility-scale solar PV installations, are ecologically sensitive, are not predictable by the regulatory system, and are multi-level complex stakeholder systems that are impervious to the deterministic paradigm of planning (Turner & Muller, 2003; Shenhar & Dvir, 2007).

Systems theory provides a conceptual insight into interdependency and feedback in the complex project environment (Von Bertalanffy, 1968; Senge, 2006; Meadows, 2008), but is mostly descriptive and non-prescriptive. Lifecycle theory and stage-gate models offer structuring over time and remain inflexible in iteration, and systematically rule out sustainability governance during early project stages (Turner, 2014). The most important discovery is that no single theory that presently exists gives us the combination of the structural discipline, sense of interdependency and integration of operational sustainability to manage renewable energy projects.

1.2. Quality Management Theories and Their Limitations

The global leading standard in quality management is ISO 9001:2015, which offers invaluable procedural rigour in managing the supply chain, commissioning inspection, and managing corrective action in the case of renewable energy projects (ISO 9001, 2015). Nevertheless, its standard assumes stable process environments and does not have specific indicators of sustainability, mechanisms to align ESG, or lifecycle emission tracking. TQM and the plan-do-check-act (PDCA) cycle are extensions of ISO 9001 with similar cultural and iterative learning focuses (Oakland, 2014; Juran & Godfrey, 1999) but are impotent to external regulatory shocks or cross-domain cascades of governance. Digital quality assurance provides (e.g., digital twins, drones, AI-based defects) has gained precision benefits but will demand organisational digital maturity and does not necessarily create sustainability integration (Deming, 1986; Garvin, 1984).

1.3. Sustainability Frameworks and Operational Gaps

The normative orientation and investor-level legitimacy offered by dominant sustainability models such as the triple bottom line (Elkington, 1997), the standards of ESG reporting (Epstein & Roy, 2001; Willard, 2012), and the ISO 14001 (2015) cannot be transferred into project-level operation constructs. Triple bottom line (TBL) has received a lot of criticism as operationally empty but of rhetorical aspiration (Hopwood et al., 2005). ESG frameworks are organisationally oriented as opposed to project-based, retrospective in nature and very methodologically inconsistent across the rating agencies. Environmental management processes are formalised in ISO 14001, but there are no quantitative lifecycle thresholds, and no environmental results coupled with technical risk or quality governance decisions.

These constraints, in combination, are what Silvius et al. (2012) refer to as a structural lack of sustainability integration in mainstream project management – a conclusion by Huemann and Silvius (2017), Gareis et al. (2013). This identified gap is directly addressed by the sustainable project management system that is presented in this paper.

2. ANALYTICAL FOUNDATIONS: RQS INTERLINKAGE QUANTIFICATION

2.1. Offshore Wind: Risk-Quality-Sustainability Interlinkages

Offshore wind is the most capital-intensive renewable technology used in the EU, which has experienced an average increase in CAPEX per kilowatt in the years 2020–2024 of EUR 2200–2400/kW to today EUR 3200–3500/kW, a 45–59 % change due to inflationary pressures, supply chain strangles effects, increased interest rates and zero subsidy auction failures (IEA, 2024; WindEurope, 2023). Such financial instability cannot be discussed outside the context of governance structure: allowing a process in most of the Member States longer than four to six years (WindEurope, 2023) and increasing vulnerability to macroeconomic fluctuations through the process of development.

Offshore wind technical risk is inflexible, episodic, and has a high impact. In offshore wind, the percentage of offshore wind insurance claims due to faults in subsea cables is estimated to be 70–80 %, and turbine scaling up to 14–15 MW has exceeded the maturity of quality-assurance processes, creating high rates of blade defects, nacelle anomalies and variation in weld-quality (Carroll et al., 2021). Governance failures are systematically combined with these technical vulnerabilities: schedule compression caused by regulatory delays raises the rate of deviation during installation, which further raises maintenance demands and lifecycle emissions – a measurable RQS cascade.

In operationalising these interdependencies, a five-point scoring model of RQS on key governance mechanisms was generated in the form of a composite RQS index, which is expressed as RQS = $(P \times I) + S$, where P is probability (1–5), I is impact (1–5), and S is sustainability significance (1–5). The quantification of the RQS mechanisms of offshore wind is reflected in Table 1.

Table 1. Quantified Risk-Quality-Sustainability Mechanisms in EU Offshore Wind (developed by authors based on WindEurope (2023), DNV (2023), and IEA (2024))

Mechanism	*P* (1–5)	*I* (1–5)	*S* (1–5)	RQS index	Interpretation
Permitting delays → schedule compression → QA deviations	4	5	3	23	Dominant governance-driven cascade; highest RQS in offshore wind
Turbine scaling (14–15 MW) → manufacturing defects → ecological cost	4	4	3	19	Rapid scaling creates QA stress and environmental externalities
Cable supply shortages → rushed installation → early faults	3	5	2	17	Technical risk amplified by supply-chain fragility
Corrosion protection failure → increased maintenance → lifecycle emissions	3	4	4	16	Operational risk with substantial sustainability implications
Vessel unavailability → installation delay → weather exposure	3	4	3	15	Operational bottlenecks amplify quality and environmental risk

2.2. Solar PV: Risk-Quality-Sustainability Interlinkages

The structurally different RQS profile of solar PV is distributed and cumulative as opposed to episodic and impactful. Technical defects such as microcracks of modules, possible degradation (PID), inverter failures, and connector wear and tear are gained in small steps throughout the lifespan of the system (Fraunhofer ISE, 2023; DNV Solar Report, 2022). The localisation of the manufacturing of modules in carbon-intensive supply chains creates the embodied emissions, which is mostly unknown to traditional quality governance mechanisms. The grid congestion, which is caused by deployment exceeding grid-reinforcement investment, where high penetration rates can be achieved in such markets as Germany and the Netherlands, produces the highest RQS score of all the mechanisms under analysis (RQS = 25), and indicates a systemic governance failure of strategic planning of infrastructure, as summarised in Table 2.

Table 2. Quantified Risk-Quality-Sustainability Mechanisms in EU Solar PV (developed by authors based on SolarPower Europe (2024) and Fraunhofer ISE (2023))

Mechanism	*P* (1–5)	*I* (1–5)	*S* (1–5)	RQS index	Interpretation
Grid congestion → energy curtailment → reduced climate benefit	4	4	5	25	Highest RQS score across all technologies; systemic governance failure
Low-cost module imports → manufacturing variability → early degradation	4	3	4	19	Sustainability impact from embodied carbon and reduced yield
EPC inconsistency → cable/connectivity faults → performance losses	3	3	2	11	Moderate technical risk: governance quality determines severity
Inverter failure → downtime → higher relative lifecycle emissions	3	3	3	12	Widespread moderate risk affecting operational sustainability
Land-use conflict → permitting delays → project redesign costs	2	3	4	10	Sustainability and governance risks deeply intertwined

The convergent findings in the synthesis of cross-technology RQS disclose three main findings. To begin with, the main amplifiers of RQS risk in both technologies are the governance failures, as opposed to technological ones. Second, the international supply-chain concentration increases the quality performance uncertainty in offshore wind (cable supply) as well as solar PV (module manufacturing). Third, sustainability results are preset at an upstream level based on planning, procurement and quality governance decisions, as opposed to the operational level.

3. THE SPMS FRAMEWORK: ARCHITECTURE AND VALIDATION METHODOLOGY

3.1. Conceptual Architecture

Risk management, quality assurance, and sustainability governance are the three governance domains that the SPMS combines into a single, nine-criterion analytical framework for renewable energy projects of all sizes. Three quantifiable sub-criteria (Table 3) operationalise each domain and convert qualitative governance characteristics into equivalent numerical indices.

Table 3. SPMS Governance Domains, Sub-Criteria, and Measurement Logic (developed by authors)

Domain	Sub-criterion	Code	Score range	Measurement focus
Risk management	Risk probability	RP	1–5	Likelihood of risk events given the regulatory, technical, financial, and operational context
Risk management	Risk impact severity	RI	1–5	Magnitude of consequences (cost overrun, schedule, technical failure, safety)
Risk management	Risk governance maturity	RM	1–5	Formal risk identification, assessment, monitoring, and mitigation capability
Quality assurance	Process maturity	QPM	1–5	Standardisation, documentation, and repeatability of quality processes
Quality assurance	Defect rate likelihood	QDR	1–5	Expected frequency of non-conformities during construction/installation
Quality assurance	Compliance level	QCI	1–5	Alignment with technical standards, regulatory requirements, and QA protocols
Sustainability governance	Environmental performance	SEI	1–5	Lifecycle emissions, ecological disturbance, and resource use impacts
Sustainability governance	Social acceptance and performance	SSI	1–5	Community alignment, stakeholder engagement, and social licence to operate
Sustainability governance	Governance integrity	SGI	1–5	Transparency, accountability, and ESG alignment in project decision-making

The framework draws on the operational constructs of ISO 31000 (risk), ISO 9001 (quality), and ISO 14001/ESG standards (sustainability), while addressing the cross-domain integration deficiencies identified in each.

3.2. MCDM Scoring and Weight Allocation

All criteria are scored on a five-point ordinal scale: 1 – very poor, 2 – poor, 3 – moderate, 4 – good, and 5 – excellent. The scores are obtained from structured expert evaluation, documented failure cases, empirical project data, and international standard benchmarks. The empirical data from RQS analysis is reflected in domain weights: given its role as the main cascade initiator in offshore wind and solar PV governance failures, risk management is given the highest weight (0.40); quality assurance (0.30) is the mediating governance domain that translates risk exposure into performance deviation; and sustainability governance (0.30) reflects the EU regulatory imperative and the discovery that upstream risk and quality decisions systematically affect sustainability outcomes (Table 4).

Table 4. MCDM Domain Weights and Rationale (developed by authors)

Domain	Weight	Rationale
Risk management	0.40	High RQS evidence that governance and supply-chain risks are the primary cascade initiators in offshore wind and solar PV project failures
Quality assurance	0.30	Quality deviations propagate directly into long-term sustainability and cost impacts; mediating role between risk exposure and sustainability outcomes
Sustainability governance	0.30	EU Taxonomy and Fit-for-55 compliance requirements; sustainability outcomes determine long-term project acceptance and viability

The integrated value score (IVS) aggregates domain scores through weighted summation:

$$\text{IVS} = \Sigma\ (W_i \times C_i),\ i = 1, 2, \ldots n, \quad (1)$$

where W_i is the domain weight, and C_i is the domain score on a 1–5 scale. The IVS ranges from 1.0 (severe governance deficiency) to 5.0 (excellent governance integration). The SPMS is considered analytically validated when (i) IVS(SPMS) > IVS (actual) in all case studies, (ii) measurable improvement is observed in at least two of three domains, and (iii) improvements are consistent across all three EU technology cases.

4. CASE-BASED VALIDATION

Case 1. Denmark's Offshore Wind Project – Environmental Permitting and Marine Ecology

Prolonged environmental impact assessment (EIA) processes that are prompted by the identification of harbour porpoise habitat zones, migratory bird flight corridors, and underwater noise thresholds are characteristics of the Danish North Sea offshore wind case. According to the Energinet project documentation and the Danish Environmental Protection Agency, the prolonged EIA process pushed the installation schedule into less-than-ideal weather windows, resulting in quality deviations like irregular offshore coatings, monopile misalignment, and inconsistent cable burial. The project's net climate benefit was reduced by higher lifecycle emissions than anticipated due to extended vessel operating times and the need for corrective maintenance.

Table 5. Denmark's Offshore Wind Project – MCDM Scoring Without SPMS (developed by authors based on Danish EPA, Energinet, and DNV, 2023)

Criterion	Code	Score	Governance justification
Risk probability	RP	2	High likelihood of environmental-permitting delays and weather-window constraints
Risk impact severity	RI	2	Delays caused major cost overruns and schedule compression, affecting project viability
Risk governance maturity	RM	1	Weak integration of ecological risk into early planning; reactive rather than anticipatory governance
Process maturity	QPM	2	QA protocols strained under compressed installation schedules; insufficient pre-commissioning checks
Defect rate likelihood	QDR	2	Notable cable burial deviations and foundation alignment anomalies reported in inspection records
Compliance level	QCI	2	Limited adherence to offshore QA guidelines under time pressure; procedural shortcuts documented
Environmental performance	SEI	2	Increased vessel fuel consumption and seabed disturbance, exceeding projected ecological thresholds
Social acceptance and performance	SSI	2	Public concern over marine ecology disturbance; regulatory challenges to social licence
Governance integrity	SGI	2	Insufficient coordination between the permitting authority, grid operator, and project developer

The project's IVS of 1.89 in the absence of SPMS indicates a high level of governance vulnerability in each of the three domains (see Table 5). Domain scores significantly improve in all three areas when SPMS is used, which includes early ecological risk modelling, integrated scheduling scenario analysis, digital QA controls, and formal marine-ecology sustainability indicators. This results in an IVS of 4.11 and a governance performance improvement of 117 % (Tables 6 and 7).

IVS (Without SPMS) = 1.89, indicating high governance vulnerability and fragmented risk-quality-sustainability decision-making.

Reactive risk management, streamlined quality assurance procedures, and inadequate sustainability integration are characteristics of the governance condition reflected in the baseline IVS of 1.89.

Given that ecological risks were not methodically included in early project planning, which is the primary cause of the observed cascading schedule and quality failures, the low-risk governance maturity score (RM = 1) is especially noteworthy. The anticipated performance under SPMS governance is shown in Table 6.

Table 6. Denmark's Offshore Wind – MCDM Scoring with SPMS Applied (developed by authors)

Criterion	Code	Score	SPMS governance intervention
Risk probability	RP	4	Early ecological risk integration and scenario-based EIA scheduling reduce regulatory uncertainty
Risk impact severity	RI	4	Optimised weather-window scheduling minimises cascading schedule and cost impacts
Risk governance maturity	RM	4	Formalised risk governance processes include regulatory monitoring and contingency protocols
Process maturity	QPM	4	Structured QA planning and mandatory pre-installation inspection protocols enhance procedural rigour
Defect rate likelihood	QDR	4	Integrated QA controls and digital monitoring reduce installation non-conformity rates
Compliance level	QCI	5	Full alignment with ISO 9001 and DNV offshore QA standards through structured audit trails
Environmental performance	SEI	4	Reduced vessel operating hours, seabed disturbance mitigation measures, and improved LCA outcomes
Social acceptance and performance	SSI	4	Proactive stakeholder engagement and transparent ecological monitoring improve community trust
Governance integrity	SGI	4	Streamlined permitting coordination with Danish EPA and Energinet through integrated governance protocols

IVS (With SPMS) = 4.11 — representing a 117 % improvement in governance performance.

Table 7. Denmark's Offshore Wind Project – Comparative SPMS Performance Gains (developed by authors)

Governance domain	IVS without SPMS	IVS with SPMS	Relative improvement (%)
Risk management	1.67	4.00	+139 %
Quality assurance	2.00	4.33	+116 %
Sustainability governance	2.00	4.00	+100 %
Integrated value score (IVS)	1.89	4.11	+117 %

The findings demonstrate the importance of anticipatory ecological risk integration in offshore wind delivery, with the risk management domain recording the largest governance gain (+139 %). The SPMS's efficacy as an integrated governance tool for marine renewable energy infrastructure is confirmed by the steady progress made in all three areas.

Case 2. Spain's Utility-Scale Solar PV Project – Land-Use Governance and Social Acceptance

After steppe bird species habitat risks and soil degradation issues were identified during the EIA process, agricultural communities and environmental NGOs in Spain's Extremadura region steadfastly opposed a utility-scale solar PV project with a capacity of over 100 MW. The construction window was shortened by numerous legal challenges and administrative appeals that prolonged the permitting process. These delays also led to EPC quality deviations, such as irregular cable routing and inadequate mounting-torque verification, which were recorded in regional construction auditing records (SolarPower Europe, 2024). The impact on biodiversity was noted to be substantial, and during the litigation period, social acceptance significantly declined.

The case highlights a crucial conclusion: when sustainability and social governance aspects are not sufficiently incorporated into early planning, even technically straightforward renewable technologies are vulnerable to systemic governance failure. With the sustainability domain showing the biggest improvement (+140 %), the SPMS validation shows an IVS improvement from 2.04 (without SPMS) to 4.00 (with SPMS), indicating a 96 % governance performance gain. This indicates how well proactive stakeholder engagement, biodiversity planning integration, and land-use conflict mapping address the project's main governance failure mode (Table 8).

Table 8. Spain's Solar PV Project – Comparative SPMS Performance Gains (developed by authors)

Governance domain	IVS without SPMS	IVS with SPMS	Relative improvement (%)
Risk management	2.33	4.00	+72 %
Quality assurance	2.00	4.00	+100 %
Sustainability governance	1.67	4.00	+140 %
Integrated value score (IVS)	2.04	4.00	+96 %

The case of Spain's Solar PV shows that sustainability governance is not a marginal issue of land-based renewable energy projects but a major factor of the overall project feasibility. The domain improvement of risk management appears +72 %, but is still the lowest in the three domains; however, it indicates significant accruing gains due to the proactive land-use conflict mapping and anticipatory stakeholder risk assessment. The quality assurance domain gain (+100 %) can be directly connected to the decrease in schedule compression – also the result of the better governance upstream. More importantly, the sustainability domain improvement (+140 %) is the greatest improvement registered in this instance, and this is an indication that the failure of the original project was not necessarily a technical problem but a governance failure. These results are in line with the SPMS argument that the integration of sustainability should not be implemented as a compliance requirement during the permitting stage, but rather be a strategic input in governance, which influences the selection of site, procurement, and community involvement since the very beginning of the project.

Case 3. Italy's Geothermal/Hybrid Project – Drilling Risk and Community Governance

The induced seismic events during the exploratory drilling in one of the hybrid geothermal development projects in Tuscany, Italy, led to community protests, the interim suspension of the project and piecemeal regulation between the Italian National Institute of Geophysics and Volcanology (INGV), the local municipalities and energy authorities. The geotechnical risk modelling was not adequately embedded in the project governance; the deviations in the quality of drilling operations, such as casing deviations and variation in the well paths, could be explained by the failure of the contractors to meet the performance requirements, and the lack of proactive community engagement procedures resulted in a significant loss of social licence to operate.

Table 9. Italy's Geothermal Project – Comparative SPMS Performance Gains (developed by authors)

Governance domain	IVS without SPMS	IVS with SPMS	Relative improvement (%)
Risk management	2.33	4.00	+72 %
Quality assurance	2.00	4.00	+100 %
Sustainability governance	1.67	4.00	+140 %
Integrated value score (IVS)	2.22	4.00	+80 %

The SPMS application to this case demonstrates the particular value of integrated geological risk modelling, geothermal-specific quality assurance standards (casing cementation quality, well trajectory verification), and community-oriented sustainability governance – including seismic monitoring transparency and structured community engagement forums. The IVS improves from 2.22 to 4.00, an 80 % gain, with quality (+100 %) and sustainability (+140 %) domains showing the most pronounced improvements (Table 9).

Cross-Case Synthesis

The cross-case validation demonstrates the three convergent findings of theoretical and practical value. To start with, compounding performance advantages are created through integrated governance: risk maturity gains are converted into quality gains, which again lead to sustainable performance, a synergy that domain-siloed governance systems cannot achieve. Secondly, the SPMS architecture is technology-neutral and context-adaptive: the same nine-criterion conceptualisation is useful in describing the marine engineering governance issues of offshore wind, the socio-environmental complexity of terrestrial solar PV, and the geologic and community risk process of geothermal development. Third, the sustainability domain has repeatedly shown the greatest relative change across all instances of the greatest improvement (+100–140 %), which serves as strong evidence that sustainability governance is the most systematically underserved aspect of the present practices of EU renewable energy project management.

Table 10. Cross-Case Summary of SPMS Validation Results (developed by authors)

Case	IVS without SPMS	IVS with SPMS	Improvement (%)	Dominant governance failure	Primary SPMS contribution
Denmark, Offshore Wind project	1.89	4.11	+117 %	Environmental permitting delays; installation schedule compression	Integrated ecological risk governance; QA scheduling optimisation
Spain, Solar PV project	2.04	4.00	+96 %	Land-use conflict; EPC quality variability; social opposition	Stakeholder governance frameworks; biodiversity planning integration
Italy, Geothermal/hybrid project	2.22	4.00	+80 %	Geotechnical drilling risk; induced seismicity; loss of social licence	Advanced geological risk modelling; community-oriented sustainability governance

The cross-case evidence provided in Table 10 helps to prove that the SPMS is able to provide the same and significant improvement in governance, no matter the type of technology, geographical setting, or leading failure mode. The progressive worsening of the IVS improvement, among Denmark with the +117 %, Spain with the +96 % and Italy with the +80 %, is not the evidence of the weakening of the effectiveness of the given framework; it is only the evidence of the relatively higher maturity of the given governance maturity in the Italian case, where geological risk awareness, although not sufficiently integrated, still existed in the project planning. In all three cases the trend is clear: a broken governance has been the structural antecedent of project underperformance, and integrated risk-quality-sustainability governance has been delivering average improvements across the board. These conclusions offer solid empirical evidence to the theoretical arguments of the SPMS and provide a valid methodology of validation that can be used in future research in the area of renewable energy governance in the European Union.

5. DISCUSSION

5.1. Theoretical Contributions

The SPMS contributes to the project management and renewable energy governance literature in three major ways. First, it empirically proves the fact that risk, quality, and sustainability are not independent governance areas, but are systematic, mutually dependent constructs within which failures spread through boundaries. This result propels the systems theory argument (Von Bertalanffy, 1968; Meadows, 2008) by quantifying it using quantifiable metrics of interlinkages in RQS. Second, the SPMS implements an integrated governance architecture that overcomes the structural constraints identified in all of the main standards domains: it brings sustainability metrics into risk assessment (addresses the insularity of ISO 31000), links quality delivery to ecological and social performance (addresses the siloing of ISO 9001), and relates sustainability principles to project-level working constructs (addresses the conceptual abstraction of TBL, ESG and ISO 14001). Third, it has been shown in the paper that an MCDM-based scoring architecture can generate consistent, replicable, and analytically defendable governance evaluations of the different renewable energy technologies and regulatory environments.

5.2. Policy and Practice Implications

The findings highlight that policymakers and other regulatory bodies should consider efficiency permission to be the key factor that determines quality and sustainability performance in renewable energy projects. To minimise the identified governance cascades in this analysis, Member States' competent authorities must develop integrated time-bound permitting procedures that combine environmental, grid-connection, and social assessment streams, especially of offshore wind and grid-intensive solar PV developments.

To project developers and EPC contractors, the SPMS offers a diagnostic tool to be used in the assessment of vulnerability in governance at the initial stage. Using the nine-criterion framework in the project development and pre-tender stages allows for dealing with the concentrations of risk exposures, quality assurance gaps and the shortcomings of sustainability governance before triggering the downstream performance losses. The cross-case evidence is quite influential to indicate that proactive community involvement and biodiversity planning are investment items that tend to be the most under-prioritised in the face of cost pressures, but are the highest-paying governance interventions in the land-based renewable projects.

To EU institutions, the SPMS will provide a template framework that can be applied to the governance integrity standards the EU Taxonomy, Fit-for-55 policy agenda, and Sustainable Development Goals will need to fulfil in their governance performance, which will involve a systematic method of ensuring renewable energy project delivers the integrated environmental, social, and governance performance that the EU climate policy demands.

5.3. Limitations

There are several limitations that must be acknowledged. The SPMS validation relies on the secondary data source and expert-based scoring as opposed to the primary project data, interview evidence and statistical hypothesis testing, which is a limitation of the studies on conceptual framework development in general. The case studies are analytically deep and diverse, and not statistically representative (Yin, 2018), and findings cannot be viewed as generalisable by inferential logic. The scoring methodology entails expert rating that creates a subjective element that is overridden in this case by clear scoring criteria, multi-source triangulation and repeatability of methodology description. The given SPMS represents an abstract prototype and not a digitally operating management system, and in order to be fully operational, it needs to be tested in real projects (a direction of future research is identified in the following section).

CONCLUSIONS

The paper introduces and justifies the sustainable project management system (SPMS) as an integrated governance system of renewable energy infrastructural projects within the European Union. Basing its conclusions on a systematic RQS interlinkage analysis of offshore wind and solar PV technologies and confirmed by MCDM-based evaluation of three case studies in the EU, the study reveals that one of the key structural drivers of project performance failures in the delivery of renewable energy in the EU is fragmented governance, i.e., the compartmentalisation of risk management, quality assurance, and sustainability governance.

Integrated value scores in the SPMS framework are doubled in all three case studies, and the governance performance is improved by 80–117 %. The sustainability governance domain gets the highest relative gains in all situations, which confirms the fact that sustainability integration is the most systematically overlooked aspect of contemporary practice. The technology-neutral flexibility of the framework, shown through offshore wind, utility-scale solar PV, and geothermal/hybrid projects, makes the framework a potentially generalised instrument for the European energy transition.

The main value of this study lies not only in the new device of governance construction but also in the fact that through integrated governance architecture, qualitatively new and empirically better results can be obtained than the aggregate results of domain structures applied separately. The evidence of the RQS cascade shows that governance failures do not have any meaningful treatment: a regulatory hold-up is a risk occurrence, a quality requirement, and a sustainability determinant.

It can only be governed by means of structures that are geared towards capturing this interdependency.

Future studies should involve primary data confirmation of the SPMS by actual project implementation, the creation of a digital implementation system, expansion into hydropower and hydrogen storage systems, and longitudinal research of the outcomes of the SPMS in managing the project lifecycle. The evidence base that is provided herein should offer a rigorous basis for that research programme.

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