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ORIGINAL RESEARCH PAPER

From Carbon Accounting to Operational Change: Managerial Sensemaking and Carbon Management Practices in Iranian Energy-Sector Firms

Mohammad Amin Zarei *

Department of Research, Allameh Tabataba'i University, Tehran, Iran.

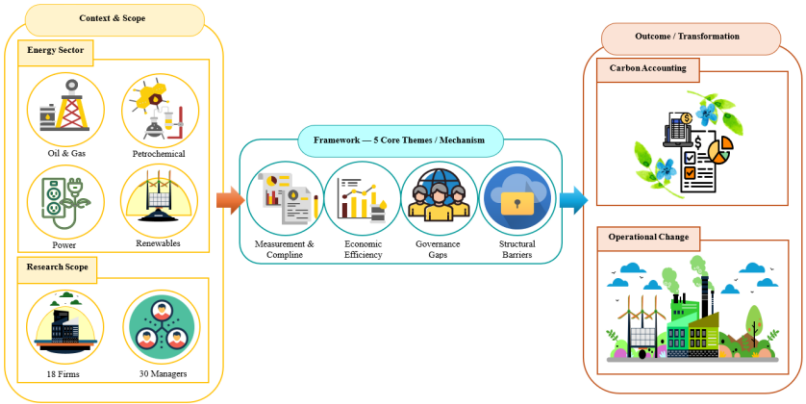
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A B S T R A C T

Corporate carbon management increasingly requires firms to move beyond emissions measurement and reporting toward operational and strategic change. This study examined how managers in Iranian energy-sector firms understood and implemented carbon management and how organizational and institutional conditions shaped the translation of carbon information into practice. An interpretive qualitative multiple-case design was employed with 30 managers and senior professionals from 18 firms operating across oil and natural gas, petrochemical and refining, conventional electricity, renewable energy, and energy-services and technology sectors. Semi-structured interviews were analyzed using reflexive thematic analysis, supported by within-case and cross-case comparisons. Relevant corporate and policy documents were used for contextual interpretation where available. Five interconnected themes were developed: fragmented measurement and compliance; economic efficiency as the dominant pathway to carbon reduction; governance fragmentation and limited managerial ownership; institutional and technological constraints on substantive decarbonization; and a gradual shift from symbolic commitment toward strategic carbon capability. The findings showed that carbon information was more commonly collected than integrated into investment, procurement, production, and executive accountability. Projects gained organizational support primarily when they reduced energy use, costs, maintenance requirements, or operational risk. Sanctions, financial instability, technology restrictions, subsidized energy, and policy uncertainty further constrained long-term decarbonization. Nevertheless, some participating firms demonstrated emerging strategic capability through stronger leadership, cross-functional coordination, domestic technological collaboration, and attention to future market requirements. The study concludes that moving from carbon accounting to substantive operational change depends primarily on integrating information, authority, investment processes, and organizational capabilities.



1. Introduction

Climate change has transformed corporate carbon management from a narrow environmental reporting activity into a central issue of strategy, governance, operations, and investment. The Intergovernmental Panel on Climate Change has concluded that limiting warming requires rapid and sustained reductions across energy systems, industry, transport, buildings, and land use, with particularly consequential changes required in carbon-intensive production and infrastructure [1, 2]. At the same time, the global energy transition remains 'uneven. Investment in renewable power, grids, storage, electrification, and energy efficiency has expanded, but fossil-fuel systems continue to supply a large share of industrial and household demand [3, 4]. Energy-sector firms therefore operate at the center of a difficult managerial problem: they are expected to maintain reliable and affordable production while progressively

* Corresponding Author: Mohammad Amin Zarei
E-mail address: m.zareie@atu.ac.ir
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reducing emissions embedded in assets, technologies, supply chains, and established revenue models.

Corporate carbon management can be understood as the coordinated set of organizational practices used to measure, govern, reduce, disclose, and, where residual emissions remain unavoidable, compensate for greenhouse gas emissions. These practices include organizational emissions inventories, target setting, capital-allocation rules, energy-efficiency programs, fuel switching, renewable-energy procurement, process redesign, employee involvement, supply-chain engagement, and climate-related disclosure. The Greenhouse Gas Protocol distinguishes direct operational emissions, emissions from purchased energy, and value-chain emissions, commonly described as Scopes 1, 2, and 3 [5, 6]. This classification has improved comparability, yet measurement alone does not guarantee organizational change. Carbon information becomes managerially consequential only when it affects budgets, procurement, production planning, executive accountability, and long-term strategy.

The business-management literature increasingly treats carbon management as a system of complementary organizational capabilities. The natural-resource-based view proposes that pollution prevention, product stewardship, clean technologies, and sustainable-development capabilities can strengthen competitive positioning when they are embedded in routines that are valuable, difficult to imitate, and connected to stakeholder needs [7, 8]. Dynamic-capabilities theory adds that firms facing technological and policy disruption must sense emerging risks and opportunities, seize them through investment and business-model choices, and transform carbon-intensive assets and routines [9]. Recent evidence supports this systemic interpretation. Wu et al. [10] organized corporate carbon-management practices into bundles centered on employee engagement, long-term orientation, and measurement and disclosure, showing that isolated initiatives are unlikely to produce the same value as coordinated practices.

Nevertheless, the organizational adoption of carbon policies does not necessarily indicate substantive decarbonization. Companies may announce distant net-zero goals, publish selective indicators, or create environmental committees without changing capital allocation or operational priorities. Dahlmann et al. [11] demonstrated that the environmental effects of corporate targets depend on the strategic intentions and implementation arrangements accompanying them. Coen et al. [12] similarly found that visible corporate climate communication often exhibits a gap between talk and performance. More recent work distinguishes symbolic strategies, which primarily protect legitimacy, from substantive strategies that alter technologies, resources, processes, and emissions outcomes [13, 14]. Science-based targets may strengthen credibility, but their organizational value depends on whether interim milestones, accountability systems, and financial decisions support the stated ambition [15].

The tension between symbolic commitment and operational change is especially important in the energy sector. Oil and gas companies, petrochemical producers, conventional power utilities, renewable-energy firms, and energy-service providers occupy different positions in the transition and face different technological constraints. Firms can reduce emissions through maintenance, leakage control, flare reduction, efficiency improvement, renewable electricity, electrification, portfolio change, carbon capture, and supplier collaboration. Yet many of these options require large investments, stable policies, specialist knowledge, and long planning horizons. Cenci and Tang [16] found that firms in transition-critical sectors achieved stronger emissions reductions when they diversified investments across multiple mitigation and adaptation activities. Liêu et al. [17] likewise showed that stronger climate governance can reduce carbon risk in the global energy sector, partly by supporting corporate environmental initiatives. These findings imply that carbon performance is shaped by managerial coordination and governance, not technology alone.

Economic and institutional conditions also influence which practices become feasible. Energy-efficiency projects can be attractive because they reduce costs and emissions simultaneously, whereas deeper decarbonization may require investments whose returns are uncertain or delayed. Sustainable investment has been associated with better firm-level energy and carbon performance [18], and high emissions can reduce firm value by increasing expected regulatory, financing, and reputational liabilities [19]. However, managers may still postpone low-carbon investments when policy uncertainty, financing constraints, or earnings pressure make short-term continuity more urgent. Stakeholder demands also operate unevenly. Internal stakeholders may support substantive action, while some external pressures encourage visible compliance without equivalent operational transformation [13, 20, 21].

These issues are particularly consequential in Iran. The country's economy and industrial system remain strongly connected to oil, natural gas, refining, petrochemicals, and fossil-fuel-based electricity. Firms operate under subsidized energy prices, aging infrastructure, policy inconsistency, exchange-rate volatility, constrained international finance, and restricted access to equipment and technical services. Sanctions are not the sole cause of environmental and energy problems, but they can limit access to efficient technologies, specialist services, investment, and international knowledge networks [22]. Empirical evidence across 24 Iranian industrial subsectors indicates that greater sanction intensity reduced energy efficiency, with stronger effects in import-dependent activities [23]. Institutional research additionally identifies weak policy credibility, fragmented coordination, and ineffective business models as barriers to renewable-energy development and transition [24, 25].

Despite these pressures, Iran also provides an analytically valuable setting for examining managerial adaptation. Energy shortages, production losses, environmental degradation, and growing international carbon requirements can motivate firms to improve efficiency and build domestic technological capabilities. Managers may develop carbon practices through local engineering, reverse innovation, maintenance, and partnerships with domestic universities or technology companies. Such responses may not resemble the large-scale transformation commonly assumed in studies of firms operating in stable capital markets. They may instead depend on improvisation, resilience, incremental modernization, and the translation of climate concerns into the language of cost, reliability, and energy security.

Existing research on Iran has concentrated mainly on national energy scenarios, renewable-energy potential, sanctions, macroeconomic emissions, and policy barriers. Comparatively little is known about how managers inside heterogeneous Iranian energy firms define carbon management, gather and use emissions information, negotiate investment priorities, coordinate departments, and distinguish achievable operational improvements from symbolic environmental commitments. Quantitative emissions indicators can identify whether performance has changed, but they provide limited access to the meanings, conflicts, informal routines, and institutional judgments through which those outcomes are produced. An interpretive qualitative study is therefore needed to examine carbon management as a situated managerial process rather than merely a reported corporate attribute.

Accordingly, this study investigated carbon-management practices among Iranian managers working in mixed energy-sector firms. It examined how managers understood carbon responsibility, how organizational and institutional conditions shaped implementation, and how carbon information was or was not translated into operational and strategic change. By combining the natural-resource-based view, dynamic capabilities, stakeholder theory, and institutional theory with reflexive thematic analysis, the study aimed to extend corporate decarbonization research into a fossil-fuel-dependent and geopolitically constrained setting.

1.1. Literature Review

1.1.1. Carbon Management as a Strategic Organizational Capability

Early environmental-management research challenged the assumption that environmental protection is necessarily incompatible with competitiveness. Porter and van der Linde [26] argued that well-designed environmental pressures can stimulate innovation and resource productivity. Bansal and Roth [27] subsequently showed that firms adopt ecological responses for different reasons, including competitiveness, legitimacy, and ecological responsibility. These motives matter because they influence whether environmental practices become integrated into core operations or remain peripheral responses intended to satisfy external expectations.

The natural-resource-based view provides a strategic explanation for variation in corporate environmental performance. Hart [7] proposed that pollution prevention, product stewardship, and sustainable development can become sources of advantage when supported by organizational learning and stakeholder integration. Hart and Dowell [8] later emphasized clean technology and capabilities that enable firms to operate within ecological limits. Applied to carbon management, this perspective suggests that emissions reduction depends on routines for measurement, engineering improvement, employee learning, capital appraisal, supplier coordination, and strategic renewal. A firm may purchase efficient equipment, but without complementary governance and operational routines, the technology may not produce sustained carbon improvement.

Dynamic-capabilities theory further clarifies why firms differ in their response to the energy transition. Teece [9] distinguished the capacity to sense changes, seize opportunities, and transform organizational assets. In carbon-intensive industries, sensing involves interpreting regulation, technology costs, energy

security, customer requirements, and physical climate risk. Seizing requires investment, portfolio decisions, and resource commitment. Transforming entails redesigning processes, incentives, competencies, and sometimes the business model itself. The transition literature similarly emphasizes that established systems are stabilized by infrastructure, institutions, user practices, and incumbent interests, making transformation path-dependent and contested [28, 29].

Recent carbon-management studies increasingly reflect this capability-based logic. Wu et al. [10] found that carbon-management practices form coherent bundles rather than independent actions. Employee engagement enables localized problem solving; long-term orientation supports investment beyond immediate payback; and measurement and disclosure create information for accountability. Johnson et al. [30], reviewing corporate responses to climate change, concluded that the literature contains considerably more evidence on conventional efficiency and disclosure than on organizational pathways to deep decarbonization. This imbalance suggests that firms often develop operational improvements without transforming carbon-intensive structures.

1.1.2. Institutional Pressures, Stakeholders, and Carbon Governance

Institutional theory explains how firms respond to coercive, normative, and mimetic pressures [31]. Coercive influences include regulation, state ownership, financing conditions, major customers, and contractual requirements. Normative influences arise from professional standards and accepted practices of responsible management. Mimetic pressures encourage imitation when firms face uncertainty about technologies or appropriate strategies. Delmas and Toffel [32] argued that organizational responses to environmental demands depend on how managers interpret external pressure through internal structures, resources, and interests. Accordingly, two firms exposed to similar regulation may adopt different carbon practices because decision makers assign different meanings to the pressure and possess different capacities to respond.

Stakeholder theory broadens this explanation by focusing on actors whose support or opposition affects organizational survival [33]. Investors, regulators, employees, customers, suppliers, local communities, parent organizations, and industry associations can all influence climate decisions, but their salience differs across contexts. Buysse and Verbeke [34] found that proactive environmental strategies are associated with stronger stakeholder integration. Sharma and Vredenburg [35] likewise linked proactive environmental strategies with organizational capabilities such as learning and stakeholder integration. These studies imply that stakeholder pressure can generate value when it is processed through organizational capabilities rather than treated as a compliance burden.

Empirical carbon research nevertheless reveals inconsistent effects. Cadez et al. [20] showed that stakeholder pressure shapes corporate mitigation strategies, but the response depends on strategic orientation and uncertainty. Yunus et al. [21] found that some stakeholders influenced particular carbon-management practices but not others. Block et al. [13] distinguished internal from external pressure and symbolic from substantive decarbonization, finding that internal stakeholders more consistently supported substantive action, whereas external pressures could encourage both substantive and symbolic practices. These findings are especially relevant where firms can satisfy visible expectations through reporting while leaving operational systems largely unchanged.

Climate governance determines whether stakeholder expectations enter decision-making. Governance includes board oversight, executive responsibility, incentive systems, investment criteria, risk management, and the authority of environmental specialists. Liêu et al. [17] found that climate governance reduced carbon risk among energy companies and that corporate environmental initiatives formed an important pathway. Carbon governance therefore requires more than an environmental department. It requires organizational arrangements that connect emissions information with operational authority and financial control.

1.1.3. Carbon Accounting, Target Setting, and the Problem of Scope

Carbon accounting provides the informational foundation for management. The Greenhouse Gas Protocol defines Scope 1 as direct emissions from owned or controlled sources, Scope 2 as indirect emissions from purchased energy, and Scope 3 as other value-chain emissions [5, 6]. In energy firms, Scope 1 may include combustion, process emissions, venting, flaring, and methane leakage. Scope 2 reflects purchased electricity or heat. Scope 3 can include purchased equipment, contractor activities, transportation, the use of sold fuels, and end-of-life impacts. Because Scope 3 often accounts for a substantial share of corporate impact, incomplete supplier and customer information can create major blind spots. Measurement quality depends on organizational boundaries, emissions factors, metering, data ownership, production changes, and the treatment of acquisitions or divestments. Carbon metrics can be expressed as absolute emissions or emissions intensity. Intensity indicators can reveal efficiency improvement but may decline while total emissions rise because production expands. Absolute measures capture total climate impact but may obscure operational progress. Effective carbon management therefore requires both, accompanied by clear baselines and explanations of production and boundary changes.

Targets can focus attention and coordinate action, but their effects are conditional. Dahlmann et al. [11] demonstrated that target characteristics and underlying intentions influence environmental performance. The Science Based Targets initiative [36] has increased expectations for targets aligned with climate science, yet corporate participation alone does not demonstrate implementation. Ben-Amar et al. [15] showed that stronger climate commitments can have financial relevance, but substantive commitments require governance and resource allocation. Coen et al. [12] found that corporate climate communication often fails to correspond with equivalent emissions performance. Thus, the managerial question is not simply whether firms announce targets, but whether targets shape near-term budgets, facility objectives, incentives, and technological choices.

1.1.4. Operational, Financial, and Supply-Chain Carbon Practices

Operational carbon management includes equipment maintenance, process optimization, heat recovery, loss reduction, fuel switching, renewable-energy procurement, electrification, and technological redesign. These practices vary in capital intensity and organizational disruption. Efficiency measures may be attractive because they lower operating costs and emissions, whereas deeper changes may have long payback periods and depend on policy support or infrastructure. Atif et al. [18] found that sustainable investment improved energy and carbon performance without necessarily compromising financial returns. Perdichizzi et al. [19] reported a negative relationship between corporate emissions and firm value in Europe, suggesting that markets increasingly recognize carbon-related liabilities.

Firms also face transition risk through future carbon prices, customer standards, asset obsolescence, and financing constraints. Cenci and Tang [16] found that firms investing across a diversified portfolio of environmental initiatives reduced emissions more effectively and lowered exposure to transition risk. This result supports a portfolio approach rather than reliance on a single technology. However, diversification requires managerial coordination and resources, which may be difficult for firms operating under financial and technological constraints.

Carbon management extends beyond organizational boundaries. Lintukangas et al. [37] showed that firms integrating climate issues into strategy were more likely to engage suppliers and customers. Supply-chain engagement can include data requests, procurement criteria, joint efficiency projects, logistics redesign, and shared technology development. Yet it is difficult when suppliers lack measurement systems, finance, or technical knowledge. Scope 3 management therefore depends on relational capabilities and bargaining power as much as accounting methodology.

In energy-intensive industries, operational continuity can compete with carbon objectives. Equipment replacement may require shutdowns; alternative technologies may reduce reliability; and imported components may be difficult to maintain. Carbon projects are consequently evaluated through multiple criteria, including safety, output, cost, energy security, and environmental value. Qualitative research is particularly useful for identifying how managers negotiate these competing criteria in practice.

1.1.5. Symbolic and Substantive Decarbonization

The distinction between symbolic and substantive environmental action is central to corporate carbon research. Symbolic action communicates conformity and protects legitimacy without proportionate change in operations. Substantive action modifies resources, technologies, routines, and outcomes. These categories are analytically useful but not always mutually exclusive. A public target may begin as a symbolic commitment and subsequently create internal pressure for implementation; conversely, a technically meaningful project can be overstated in corporate communication.

Coen et al. [12] documented a climate talk-walk gap in corporate reporting. Block et al. [13] showed that stakeholder and ownership conditions influence whether firms adopt symbolic or substantive strategies. Block et al. [14] identified distinct decarbonization profiles among medium-sized manufacturing firms, indicating that organizations combine practices in different ways rather than moving through a single linear sequence. The distinction is therefore best treated as a continuum of integration: at one end, reporting and commitments are disconnected from resources; at the other,

carbon considerations are embedded in governance, investment, procurement, operations, and accountability. This continuum is relevant to the present study because Iranian firms may face incentives to display environmental responsibility while lacking stable access to technology, finance, or carbon regulation. A purely moral interpretation could misclassify constrained firms as unwilling, while a purely structural interpretation could overlook organizational choices and symbolic behavior. An interpretive analysis can examine how managers themselves explain this boundary and how they construct feasible carbon action under constrained conditions.

1.2. Iranian Energy-Sector Context and Research Gap

Iran's energy system is characterized by extensive fossil-resource endowments, energy-intensive production, and close relationships among state policy, large industrial firms, and national energy security. Low domestic energy prices can support industrial production but weaken financial incentives for efficiency and renewable investment. Aging capital stock and rapid demand growth can further increase energy losses and emissions. These conditions create a managerial environment in which reducing carbon may be valued when it improves reliability or lowers fuel use, but receives less support when it requires long-term expenditure without an immediate production benefit.

Sanctions intensify these constraints by affecting imports, finance, exchange rates, and technical support. Madani [22] argued that sanctions have restricted environmental technology, services, and knowledge and increased the resource intensity of parts of the Iranian economy. Jabari et al. [23] provided firm-relevant sectoral evidence that sanctions reduced energy efficiency, particularly in import-dependent industries. These effects suggest that carbon management in Iran is partly a problem of technological access and organizational resilience.

Institutional research also points to weak policy credibility and fragmented coordination. Aghlimoghadam [24], using qualitative evidence on Iran's energy transition, identified problems in the interaction among institutions, actors, technologies, and business models. Sadabadi et al. [25] similarly emphasized governance and change-management barriers in the transition from fossil fuels to renewable energy. These studies advance understanding of policy systems but do not focus primarily on the internal managerial processes through which mixed energy-sector firms measure emissions, evaluate projects, coordinate departments, and enact carbon practices.

The present study addresses this gap in four ways. First, it examines carbon management at the organizational level rather than treating the firm as a unitary actor. Second, it includes managers from multiple energy subsectors, allowing comparison across fossil-based, electricity, renewable, and service activities. Third, it analyzes carbon practices through participants' accounts of actual decision processes rather than public commitments alone. Fourth, it extends theories of capabilities and institutional pressure by examining how managers translate carbon concerns into the locally salient language of cost, production continuity, technology access, and energy security.

1.3. Objectives and Research Questions

The overall objective was to develop an interpretive account of how carbon-management practices were understood, organized, and implemented in Iranian energy-sector firms. More specifically, the study sought to: (a) identify the carbon-measurement, operational, governance, and strategic practices described by managers; (b) examine the organizational, institutional, technological, and market conditions that enabled or constrained those practices; (c) explore how managers reconciled carbon reduction with cost, reliability, production, and investment priorities; and (d) explain how firms moved, or failed to move, from reporting-oriented activity toward substantive operational change. The study addressed the following research questions:

RQ1. How do managers in Iranian energy-sector firms understand and enact carbon-management practices?

RQ2. What organizational, institutional, technological, and market conditions enable or constrain the implementation of carbon-management practices?

RQ3. How do Iranian energy-sector firms translate carbon measurement and environmental commitments into operational and strategic change?

2. Method

2.1. Methodology

2.1.1. Research Design

The study adopted an interpretive qualitative multiple-case design. This design was appropriate because the research questions concerned managerial meanings, organizational processes, and context-dependent judgments rather than the estimation of predetermined causal relationships. Each of the 18 participating firms was treated as an organizational case embedded in Iran's broader energy, policy, and economic environment. Analysis proceeded in two linked stages. First, interview material associated with each firm was reviewed within case to summarize its carbon-measurement arrangements, governance structure, operational practices, constraints, and strategic orientation. Where a firm contributed more than one participant, the accounts were examined together for convergence, complementarity, and tension before an organizational case summary was carried forward. Second, these case summaries and the underlying coded extracts were compared across firms and subsectors to identify recurrent patterns as well as meaningful differences. This within-case/cross-case procedure allowed themes to be developed across the dataset without treating a firm with several interviewees as proportionally more important than a firm represented by one interviewee.

The study was theoretically sensitized by the natural-resource-based view, dynamic-capabilities theory, institutional theory, and stakeholder theory. These perspectives directed attention to resources, routines, external pressures, governance, and strategic adaptation. They were not imposed as a fixed coding framework. In keeping with an abductive approach, early coding remained close to participants' accounts, while later interpretation moved recursively between the empirical material and relevant theory.

2.1.2. Participants and Sampling

Participants were Iranian managers and senior professionals with direct knowledge of environmental strategy, emissions, energy use, operations, investment, engineering, or sustainability decision-making. Purposive maximum-variation sampling was used to obtain diversity in sector, ownership context, organizational size, managerial function, and carbon-management maturity. Eligibility required at least three years of relevant professional experience and direct involvement in decisions or practices related to energy, production, environmental performance, capital projects, or corporate strategy. Thus, the sample represented experienced managerial and specialist perspectives rather than entry-level employees, and it included environmental/sustainability, operational/engineering, strategic-planning, financial/investment, energy-efficiency, and regulatory/compliance functions.

The final empirical sample comprised 30 participants from 18 firms. Every firm contributed at least one participant; because 30 individuals were interviewed across 18 organizations, some cases were represented by additional informants from different managerial or specialist functions. The exact organization-by-participant matrix is not reported because combining a precise role with a narrowly defined energy subsector could make individuals or firms identifiable in relatively small professional networks. During analysis, multiple informants from the same firm were treated as complementary accounts of one organizational case rather than as independent replications. Initial participants were approached through professional networks, after which purposive referrals were used to identify additional participants. Referrals were screened to avoid overrepresentation of a single organization or professional network.

Sampling and analysis proceeded concurrently. Recruitment ended when the dataset offered sufficient information power to explain the research problem across the major sectoral and managerial variations and later interviews no longer materially changed the thematic structure. This decision was guided by the complexity of the phenomenon, sample specificity, interview quality, and cross-case diversity rather than a universal numerical threshold [38].

Table1. Sectoral Distribution of Firms and Participants

Sector	Firms	Participants
Oil and natural gas	5	9
Petrochemical and refining	4	7
Conventional electricity generation and distribution	4	6
Renewable-energy development	3	5
Energy services and technology	2	3
Total	18	30

Source: Research Findings
Note: Figures report the final empirical sample of 30 participants from 18 participating firms.

2.1.3. Data Collection

Data were collected between January and May 2026 through individual semi-structured interviews conducted in Persian. Interviews were selected because they enabled participants to explain sensitive decisions, informal routines, implementation barriers, and tensions that were unlikely to appear in formal corporate reports. Depending on location and participant preference, interviews were conducted face-to-face or through an encrypted online platform. Interviews lasted approximately 50 to 85 minutes.

The interview guide addressed participants' definitions of carbon management; emissions measurement and reporting; energy-efficiency and reduction projects; governance and responsibility; target setting; investment decisions; employee involvement; procurement and supply-chain practices; regulation; sanctions; technology access; and tensions among environmental, financial, and production priorities. Open-ended questions were followed by probes requesting specific examples, decision episodes, unsuccessful projects, and explanations of differences between formal policy and plant-level practice.

The guide was reviewed by two qualitative-management researchers and two Iranian energy specialists. Two pilot interviews were used to evaluate clarity, sequencing, and the distinction among energy management, local pollution control, and greenhouse gas management. Minor wording and sequencing changes were made. With permission, interviews were digitally recorded and transcribed verbatim. Transcripts were checked against recordings, and field notes were prepared to document context, emphasis, and emerging analytic ideas. To maintain clear conceptual boundaries, the study distinguished three related but non-equivalent domains. Greenhouse-gas management referred to practices that measured, governed, or sought to reduce climate-relevant emissions, including Scope 1, Scope 2, and where feasible Scope 3 emissions. Energy management referred more broadly to monitoring and reducing fuel or electricity consumption for efficiency, cost, reliability, or operational purposes; such activities were discussed as carbon relevant when participants explicitly connected lower energy use with reduced greenhouse-gas emissions. Conventional environmental compliance referred primarily to local pollution and regulatory controls, such as air pollutants, wastewater, waste, and occupational or site requirements. The findings, therefore, do not treat every energy-efficiency or local-pollution-control activity as evidence of an integrated carbon-management system.

A supplementary set of approximately 40 documents was reviewed where access did not breach legal, security, or commercial restrictions. The principal sources were public environmental or sustainability reports, corporate webpages, energy-efficiency or modernization plans, and relevant policy or regulatory documents. These materials were used for contextualization and case comparison rather than being coded as a second, co-equal dataset in the reflexive thematic analysis. In particular, they helped identify formal commitments, terminology, reported projects, and policy expectations that could be compared with interview accounts. Documents were not treated as independent proof that a reported practice had been implemented or that it had produced a verified emissions effect.

2.2. Data Analysis

The interviews were analyzed through Braun and Clarke's reflexive thematic analysis [39,40]. Reflexive thematic analysis was appropriate because it enables the development of interpretive patterns of shared meaning while acknowledging that themes are actively produced through the researcher's engagement with the data. The process was recursive rather than strictly linear.

First, the researcher became familiar with the dataset through repeated reading, transcript checking, and analytic memo writing. Second, the Persian transcripts were coded in MAXQDA. Initial codes remained close to participants' language and captured practices, constraints, rationales, contradictions, and consequences. Examples included carbon data collected mainly for compliance, cost savings used to justify carbon projects, production continuity overriding emissions concerns, environmental units lacking budget authority, sanctions delaying equipment replacement, and carbon requirements emerging in export markets.

Third, codes were compared and combined into candidate themes. Fourth, candidate themes were reviewed against the coded extracts and complete transcripts to determine whether they represented coherent central organizing concepts. Fifth, themes were refined, defined, and named. Sixth, the themes were integrated into an explanatory account connecting institutional conditions, organizational governance, managerial logics, practices, and outcomes. Semantic analysis captured explicit accounts of practices and barriers, while latent analysis examined assumptions about what counted as a legitimate business case for carbon action.

Case comparison was used as an analytic discipline rather than as a separate case-reporting format. A concise matrix was maintained for the 18 firms, organized by subsector and by the five developing thematic domains. Candidate themes were checked against this matrix to determine whether an apparent pattern reflected variation across several organizational cases or was driven mainly by repeated interviews within one firm. Sectoral contrasts and negative cases were retained in analytic memos even when the final presentation emphasized shared themes. The resulting themes therefore represent cross-case patterns of meaning while preserving organizational-case and subsector variation in interpretation.

The analysis was initially inductive and became progressively abductive. Theoretical concepts were used to deepen interpretation after the themes had begun to take shape. Statistical intercoder reliability was not calculated because it is inconsistent with the reflexive orientation adopted here [39]. Instead, selected transcripts and thematic maps were discussed with two qualitative researchers to challenge premature conclusions, identify alternative interpretations, and improve conceptual clarity.

2.3. Translation, Reflexivity, and Trustworthiness

Analysis was conducted primarily in Persian to preserve the meanings of culturally and professionally specific expressions. Illustrative extracts were subsequently translated into English using a meaning-based approach. A bilingual researcher reviewed the English extracts against the Persian text, and technical expressions were discussed until conceptual equivalence was achieved.

The researcher maintained a reflexive journal documenting prior assumptions, professional relationships, theoretical preferences, and decisions made during recruitment, interviewing, coding, and writing. Reflexivity was particularly important because participants could emphasize external constraints, present their organizations defensively, or understate internal responsibility. Neutral probes, requests for concrete examples, and attention to contradictory cases were used to reduce reliance on generalized organizational narratives.

Trustworthiness was supported through iterative interviewing, cross-sector comparison, negative-case analysis, peer debriefing, and an audit trail. A concise thematic summary was shared with eight participants from different sectors. Their responses were used to refine clarity and contextual accuracy rather than as a final verification of a single objective truth. In particular, participant feedback reinforced the need to distinguish greenhouse-gas management from energy-efficiency and conventional environmental-compliance practices and to avoid interpreting every reporting-oriented or incremental practice as deliberate symbolism when resource and institutional constraints could also produce decoupling. This feedback sharpened the boundaries and contextual explanation of the themes without requiring participants to endorse a single definitive interpretation. Detailed description of the organizational and institutional setting supported transferability. Reporting was informed by the Consolidated Criteria for Reporting Qualitative Research [41] and broader qualitative-quality principles concerning rigor, sincerity, credibility, resonance, and coherence [42, 43].

2.4. Ethical Considerations

Participants received information about the purpose of the study, voluntary participation, recording, confidentiality, the use of anonymized quotations, and their right to withdraw before data anonymization. Written or electronically documented informed consent was obtained.

Participants were assigned identifiers such as Interviewee 1–Interviewee 30. Company names, exact locations, and potentially identifying combinations of position and sector were removed or generalized. Recordings, transcripts, consent records, and analytic files were stored separately in encrypted, password-protected locations. Participants were not asked to reveal classified, legally restricted, or commercially sensitive information. Because the combination of a specific managerial title, narrow subsector, and quotation content could identify individuals in the Iranian energy-sector professional community, quotation labels retain numerical identifiers rather than full role-sector combinations. Contextual variation is instead reported in aggregate through the participant-function description, sectoral sample table, and cross-sector comparison below. This approach preserves interpretability while maintaining the confidentiality commitments made during consent.

3. Results and Discussion

Reflexive thematic analysis generated five interconnected themes: (1) carbon management as fragmented measurement and compliance; (2) economic efficiency as the dominant pathway to carbon reduction; (3) governance fragmentation and limited managerial ownership; (4) institutional and technological constraints on substantive decarbonization; and (5) a gradual shift from symbolic commitment toward strategic carbon capability. The themes represent patterns of shared meaning rather than counts of frequently used words. Across the participating firms, carbon management was present but varied considerably in integration, authority, and strategic influence. In interpreting the themes, routine energy management and conventional environmental compliance were treated as adjacent practices rather than automatically as carbon management; they became analytically relevant to carbon management when participants connected them to greenhouse-gas measurement, reduction, governance, or strategic decision-making.

Table 1. Themes and Subthemes Developed Through Reflexive Thematic Analysis

Theme	Subthemes	Central interpretive meaning
Fragmented measurement and compliance	Partial inventories; reporting-driven measurement; weak Scope 3 accounting	Carbon information was collected more consistently than it was used in operational or strategic decisions.
Economic efficiency as the dominant pathway	Cost-saving projects; short payback expectations; reliability and maintenance	Carbon initiatives gained legitimacy when they reduced energy use, costs, downtime, or production risk.
Governance fragmentation and limited ownership	Peripheral environmental units; weak coordination; unclear accountability	Environmental specialists carried responsibility without equivalent authority over investment and production.
Institutional and technological constraints	Sanctions; finance and technology restrictions; subsidies; policy inconsistency	External conditions narrowed feasible choices and reinforced incremental, short-term action.
From symbolic commitment to strategic capability	Market awareness; leadership; local innovation; emerging integration	Some firms were beginning to embed carbon considerations in planning, but progress remained uneven and conditional.

Source: Refs [10-12]

Theme 1: Carbon Management as Fragmented Measurement and Compliance

Participants commonly described carbon management as beginning with the collection of environmental and energy information. Firms monitored fuel consumption, electricity use, flaring, production efficiency, and regulated pollutants. However, the resulting information was distributed across engineering, accounting, environmental, and production systems and was not always consolidated into a comprehensive greenhouse gas inventory.

Managers distinguished routine energy monitoring from systematic carbon accounting. Scope 1 emissions were considered more manageable because data on combustion, fuel use, and some production processes were available. Scope 2 was sometimes estimated from purchased electricity, although managers reported uncertainty about grid emissions factors. Scope 3 remained largely incomplete because suppliers, contractors, logistics providers, and customers did not provide consistent information.

Interviewee 1 stated: “For the fuel we burn inside the plant, we have numbers. We know more or less what is happening. But when you ask about contractors, transportation, suppliers, or even what happens after the product leaves us, honestly, the data are not there. Everyone has a separate record, and sometimes there is no record at all.”

Similarly, Interviewee 6 explained that Scope 3 was still an unclear area because many suppliers neither measured carbon nor understood why the focal company requested the information. The difficulty was therefore not merely technical; it reflected the absence of shared accounting routines and carbon expectations across the value chain.

A second pattern concerned the purpose for which carbon information was prepared. Environmental departments frequently compiled data for regulators, parent organizations, annual reports, internal audits, and certification. Participants were less able to identify situations in which worsening carbon indicators directly changed production schedules, procurement choices, capital budgets, or executive evaluation.

Interviewee 3 stated: “We prepare the report, we show that emissions have increased, and we send it to senior management. But after that, production continues in the same way. They say, “Yes, this is important,” but when the budget is discussed, production and income come first.”

Likewise, Interviewee 11 stated that a report could reach senior managers without producing investment: the organization might acknowledge that emissions were high but argue that the plant could not stop and that equipment replacement was not financially possible in the current year. Carbon accounting thus functioned more consistently as documentation than as a decision system.

The theme did not indicate that measurement lacked value. Several participants described attempts to install digital meters, establish energy baselines, and compare facilities. These efforts were more developed in larger, export-oriented, renewable-energy, and technology-service firms. Nevertheless, only a minority of participants described fully integrated systems connecting inventories with accountability and investment appraisal.

Theme 2: Economic Efficiency as the Dominant Pathway to Carbon Reduction

The second theme captured the dominant business logic through which carbon projects gained approval. Participants repeatedly explained that proposals became legitimate when they promised lower fuel consumption, lower maintenance costs, less downtime, improved process stability, or higher production efficiency. Carbon reduction strengthened the proposal but seldom served as the decisive argument.

Managers identified heat recovery, leakage reduction, combustion optimization, preventive maintenance, insulation, process integration, control-system upgrades, and flare reduction as common practices. These interventions could generate meaningful emissions reductions, but internally they were often categorized as efficiency or reliability projects rather than as climate initiatives.

Interviewee 8 stated: “When we say a project will reduce carbon emissions, the response is usually, “Okay, but how much money will it save?” If we show that fuel consumption will decrease or maintenance costs will go down, then they listen more carefully.”

Similarly, Interviewee 14 explained that an energy-saving project was approved because it reduced gas consumption and improved production efficiency; the emissions benefit was welcomed but was not the principal reason for allocating the budget.

The same economic logic shaped project time horizons. Managers reported a strong preference for low-cost measures with rapid and predictable returns. Exchange-rate volatility, inflation, financing constraints, and policy instability made long-term calculations uncertain. Imported technology and multi-year projects were particularly difficult because equipment prices, access routes, and expected savings could change before implementation.

Interviewee 5 stated: “These days, nobody wants to approve a project that may give a return after seven or eight years. The exchange rate may change next month. The equipment price may double. Managers want something cheap that gives a result quickly.”

Likewise, Interviewee 16 described a proposal for efficient imported equipment that was rejected because the initial investment was high and the payback period extended over several years. The firm repaired the existing system and postponed replacement.

This preference favored incremental improvement. Firms repaired equipment, improved operating parameters, reduced leakage, and optimized energy use. Such actions were practically important and sometimes substantial, but they rarely transformed the carbon intensity of the underlying production system. More disruptive options large renewable installations, electrification, major process redesign, and carbon capture remained difficult to justify under prevailing financial conditions.

Participants also interpreted production reliability as a carbon-management pathway. Unplanned shutdowns, repeated start-up cycles, unstable processes, and poorly maintained equipment increased fuel use and emissions. In this sense, reliable operations were not opposed to environmental performance. The limitation was that only projects with an immediate operational business case were likely to proceed.

Theme 3: Governance Fragmentation and Limited Managerial Ownership

The third theme concerned the distribution of responsibility and authority. Most firms assigned environmental reporting and monitoring to environmental, health and safety, sustainability, or energy units. These departments possessed technical knowledge and were accountable for reporting, but major decisions concerning equipment, production, fuel, expansion, and capital investment were made elsewhere.

Participants described environmental units as advisory. Their proposals were more likely to be accepted when they aligned with safety, efficiency, maintenance, or production. Recommendations requiring significant expenditure or interruption were commonly deferred.

Interviewee 4 stated: “We can identify the problem and recommend a solution, but we do not control the budget. We cannot decide to replace equipment, reduce production, or change the fuel. Those decisions are made at a much higher level.”

Similarly, Interviewee 18 characterized the situation as responsibility without control: environmental personnel were expected to explain poor outcomes, while finance and operations controlled the resources required to improve them.

Cross-functional coordination was also weak. Environmental teams focused on compliance and emissions; operations prioritized output and reliability; finance evaluated cost and liquidity; and procurement emphasized availability, price, and delivery. Because departments used different criteria, a technically

efficient option could be rejected by finance or replaced by a cheaper procurement alternative with poorer energy performance.

Interviewee 9 stated: “The environmental team says emissions must go down. Production says output cannot decrease. Finance says there is no budget. Procurement says this is the cheapest equipment available. Everyone is correct from their own point of view, but there is no common carbon objective.”

Similarly, Interviewee 24 explained that departments could discuss a single project for months and that agreement was unlikely without sponsorship from a senior executive.

Carbon accountability was correspondingly diffuse. Participants rarely reported that emissions were included in executive appraisal, bonuses, or departmental performance agreements. When emissions rose, the cause could be attributed to production growth, fuel quality, equipment age, shortages, or external policy. Firms with clearer ownership assigned energy or emissions indicators to operational managers and reviewed them regularly, but this arrangement was not common.

Theme 4: Institutional and Technological Constraints on Substantive Decarbonization

The fourth theme located organizational practice within Iran’s wider institutional environment. Sanctions and import restrictions were described as obstacles to advanced machinery, digital monitoring, software, sensors, spare parts, finance, and specialist services. The problem did not end with purchasing equipment: managers also considered warranties, maintenance, updates, and future access to components.

Interviewee 2 stated: “We identified equipment that could reduce energy use significantly, but we could not purchase it directly. Through an intermediary, the price was almost twice as high, and there was no proper guarantee or technical support.”

Similarly, Interviewee 12 described an emissions-reduction project that was delayed for more than a year because one critical imported component was unavailable; the company eventually postponed the entire project.

Some firms adapted through domestic sourcing, reverse engineering, and collaboration with Iranian technology companies and universities. These responses demonstrated learning and resilience. However, participants acknowledged that locally available substitutes did not always provide equivalent efficiency, scale, or reliability. Financing uncertainty reinforced technological constraints. Carbon projects competed with maintenance, safety, production continuity, and replacement of essential equipment. High inflation and exchange-rate volatility changed project costs between planning and approval and weakened the credibility of long payback estimates.

Interviewee 7 stated: “With this level of inflation, it is very difficult to calculate a real payback period. Today we estimate one cost, but six months later the price may be completely different.”

Likewise, Interviewee 26 argued that long-term carbon projects required stable assumptions, while equipment prices, financing costs, and energy policies were unstable. Participants also described subsidized energy as a contradictory policy condition. Low energy prices supported production but reduced the financial return from efficiency and renewable-energy projects. Carbon-specific regulatory requirements were perceived as less developed and less consistently enforced than rules concerning local air pollution, wastewater, and occupational safety. Managers therefore hesitated to make major investments when future standards and incentives were uncertain. The theme showed that limited carbon action could not be attributed solely to managerial indifference. Institutional conditions narrowed the feasible set of strategies and reinforced production continuity and short-term survival. Nevertheless, managers and firms retained agency in how they interpreted and responded to these conditions.

Theme 5: From Symbolic Commitment to Strategic Carbon Capability

The final theme captured variation in organizational maturity and evidence of gradual change. Participants increasingly recognized that carbon performance could affect future export markets, financing, reputation, certification, and relationships with international customers. This concern was most visible in export-oriented petrochemical firms, renewable-energy companies, and technology-service providers. Interviewee 10 stated: “Maybe carbon performance is not a major condition in our domestic market today, but international customers are already asking questions. In the future, if we cannot provide credible data, we may lose some markets.”Similarly, Interviewee 20 argued that product carbon information was becoming a competitiveness and financing issue rather than only an environmental matter.

Strategic awareness, however, did not guarantee implementation. Participants contrasted broad environmental language with plant-level investment and accountability. Net-zero aspirations and renewable-energy commitments could be announced without near-term budgets, equipment plans, or responsible managers.

Interviewee 23 stated: “The company website talks a lot about green development and renewable energy, but inside the plant, the old equipment is still operating. The budget has not changed, and the production targets have not changed.”

Likewise, Interviewee 28 observed that announcing a 2050 goal was easier than specifying what equipment would be replaced in the following year and who would be accountable. Participants nevertheless identified pathways toward more substantive capability. Senior leadership support increased the influence of environmental managers, improved cross-functional coordination, and enabled longer-term projects to enter planning discussions. Domestic partnerships supported monitoring, process optimization, and equipment adaptation. In these firms, carbon management was increasingly connected to modernization, resilience, energy security, and competitiveness. Overall, the firms occupied different positions along a continuum. At one end, carbon practices remained fragmented, reporting-oriented, and largely symbolic. At the other, firms were beginning to integrate measurement, leadership, investment, employee knowledge, and local innovation. The movement was gradual and conditional rather than a rapid transformation of business models.

3.1. Cross-Sector Comparison

Cross-case comparison showed that the five themes were shared across subsectors but not with equal intensity. Within the participating oil-and-gas, petrochemical, refining, and conventional-electricity cases, managers more often emphasized aging assets, production continuity, fuel use, maintenance, and the financial difficulty of replacing capital-intensive equipment. Carbon reduction was therefore commonly translated into efficiency, loss reduction, reliability, and incremental modernization. Export-oriented petrochemical participants were also comparatively attentive to product-carbon information and future customer requirements. Renewable-energy firms entered the study with a business model already aligned more directly with low-carbon investment, yet they still reported financing, policy, grid, and technology-access constraints. Energy-service and technology firms more often described carbon issues through measurement, digital monitoring, engineering solutions, and emerging customer demand. These contrasts should be interpreted as patterns within the purposively selected cases rather than as prevalence estimates for the corresponding Iranian industries. The shared cross-sector finding was that carbon capability depended less on sector label alone than on the combination of credible information, decision authority, leadership support, and access to financial and technological resources.

3.2. Integrative Thematic Model

The five themes formed an empirically derived conceptual framework emerging from the reflexive thematic analysis and the within-case/cross-case comparison. As shown in Figure 1, institutional and technological constraints shaped organizational governance and available investment choices. Governance fragmentation influenced whether carbon information entered core decisions, while managerial priorities translated carbon concerns through the locally salient criteria of cost, reliability, and production continuity. These conditions influenced whether carbon-management practices remained incremental and reporting-oriented or developed into more substantive capability. Substantive capability was most evident when four enabling conditions converged: credible information, a persuasive business or strategic case, senior leadership support, and access to financial and technological resources. The model is interpretive rather than causal; it summarizes relationships evident across the participating cases and does not imply a fixed sequence through which all firms must progress.

3.3. Discussion

This study examined how managers in the participating Iranian energy-sector firms understood and enacted carbon-management practices and how they translated environmental information into operational and strategic action. The findings indicate that the participating firms were not simply divided into organizations that managed carbon and organizations that did not. Instead, carbon management operated as an unevenly developed organizational system. Measurement was more common than strategic use; efficiency projects were more acceptable than transformational investments; environmental responsibility was more clearly assigned than decision authority; and growing strategic awareness coexisted with institutional and technological constraints.

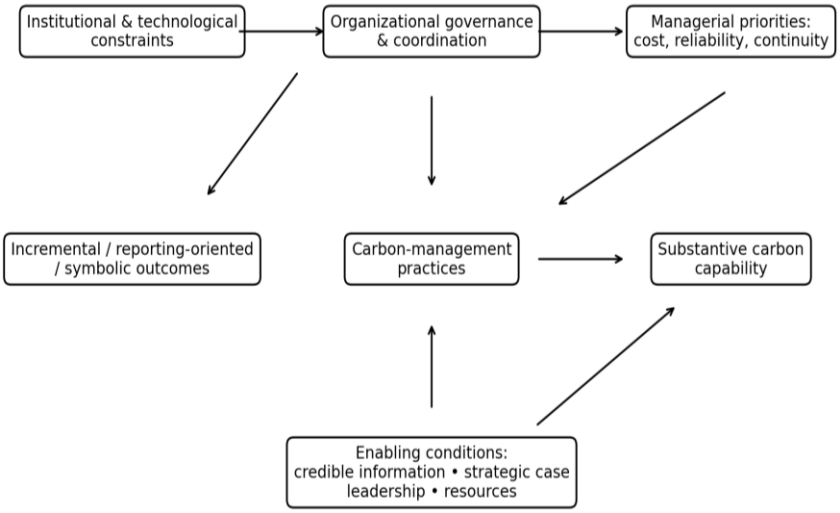


Figure 1. Empirically derived integrative thematic model linking institutional constraints, organizational governance, managerial priorities, carbon-management practices, and substantive carbon capability

Source: Refs [10-12]

The first contribution concerns the distinction between possessing carbon-related data and possessing a carbon-management capability. Participants described substantial operational and energy information, yet inventories remained incomplete and were often prepared for reporting. This finding supports the Greenhouse Gas Protocol's emphasis on organizational boundaries and value-chain information [5, 6], but it also shows that accounting quality is an organizational rather than merely methodological problem. Scope 3 gaps resulted from weak supplier systems, fragmented records, and limited interorganizational expectations. The finding is consistent with Lintukangas et al. [37], who showed that supply-chain carbon engagement depends on strategic integration and relational motives. Within the participating Iranian firms, the findings suggest that carbon accounting cannot be improved only by issuing a technical template; supplier capability, data ownership, and governance mechanisms are also needed to make the information consequential.

The reporting orientation also supports research on the talk-walk gap. Coen et al. [12] showed that corporate climate communication does not consistently correspond with emissions performance, while Dahlmann et al. [11] demonstrated that targets have different effects depending on substantive intent. The present findings identify a mechanism through which decoupling occurs: environmental departments produce reports, but budgets and production decisions are controlled by other functions. Decoupling was therefore not simply deliberate greenwashing. It sometimes emerged from structural separation between information and authority. This nuance extends symbolic-substantive research by showing that weak integration can produce symbolic outcomes even when environmental managers are personally committed to change.

The second theme showed that cost and operational efficiency were the dominant legitimating language for carbon action. This result is compatible with the natural-resource-based view, which predicts that pollution prevention and resource efficiency can create competitive benefits [7, 8]. It also aligns with Atif et al. [18], who found that sustainable investment can improve energy and carbon performance. However, the Iranian evidence qualifies an optimistic win-win interpretation. Efficiency provided a practical entry point, but it also narrowed the portfolio of acceptable projects. Interventions without a short and visible payback were marginalized, even when their long-term emissions value was greater. The managerial logic therefore enabled incremental improvement while constraining deep decarbonization.

This pattern corresponds with Johnson et al.'s [30] conclusion that corporate climate research documents many conventional responses but fewer pathways to near-zero emissions. It also helps explain why diversified investment is difficult under constrained conditions. Cenci and Tang [16] found that diversified environmental initiatives improved emissions reduction and transition-risk management. The participants in this study recognized the value of multiple interventions but lacked stable finance and technology access. The ability to diversify is thus a capability and a resource privilege, not only a strategic choice.

The third theme emphasizes governance. Environmental managers held technical responsibility without equivalent control over capital and production. This finding extends stakeholder and institutional explanations by identifying internal organizational architecture as a mediating mechanism. External pressure cannot produce substantive decarbonization when the responsible unit lacks authority and cross-functional carbon objectives are absent. Block et al. [13] found that internal stakeholders are particularly important for substantive strategies. The present findings suggest why: internal stakeholders can influence daily routines, budgets, and operational trade-offs when governance gives them access. When carbon remains confined to a specialist unit, the organization can comply symbolically while core functions continue to optimize other objectives.

The absence of clear accountability also complicates target implementation. Science-based or corporate targets can focus attention, but their effects depend on interim responsibilities and incentives [15, 36]. Participants rarely described carbon indicators in executive evaluation or departmental performance agreements. Consequently, rising emissions could be explained through multiple external or operational factors without a responsible decision owner. This finding suggests that carbon governance should be evaluated through the distribution of decision rights, not merely the presence of a committee or policy.

The fourth theme demonstrates the importance of context. Sanctions, technology restrictions, inflation, exchange-rate instability, subsidized energy, and policy inconsistency narrowed the range of feasible practices. These findings are consistent with Madani's [22] analysis of the environmental effects of sanctions and Jabari et al.'s [23] evidence that sanctions reduce industrial energy efficiency. They also reinforce Aghlimoghadam's [24] argument that weak policy credibility and ineffective business models constrain Iran's energy transition. Corporate carbon-management models developed in stable regulatory and capital-market settings may therefore overestimate managerial discretion.

At the same time, the findings should not be interpreted as environmental outcomes being entirely determined by sanctions or policy. Firms differed in leadership, coordination, local innovation, and strategic orientation despite operating under broadly similar conditions. This variation supports dynamic-capabilities theory [9]. Some firms sensed future market requirements, seized opportunities through domestic partnerships, and began transforming routines. Others remained focused on reporting and short-term repair. Institutional constraints set boundaries, but organizational capabilities influenced how firms acted within those boundaries. The fifth theme contributes to the symbolic-substantive debate by conceptualizing carbon management as a continuum of integration. Block et al. [14] found distinct decarbonization profiles rather than a single uniform approach. The Iranian firms similarly combined practices in different ways. A firm could have sophisticated environmental language and weak operational integration, or limited public communication but meaningful efficiency practices. Substantive capability was most visible when measurement, leadership, investment, operations, and local innovation reinforced one another.

Growing concern about export markets and international carbon standards also reflects stakeholder change. Domestic carbon regulation was not the only or necessarily strongest driver. Customers, certification systems, lenders, and supply-chain requirements could become influential even in the absence of domestic carbon pricing. This is consistent with Cadez et al. [20] and Yunus et

al. [21], who found that stakeholder influence varies across strategies and contexts. For several managers interviewed in this study, anticipated future exclusion from markets or financing appeared more motivating than immediate domestic climate regulation.

The findings support three broader theoretical conclusions. First, carbon management is a cross-functional capability rather than an environmental-department activity. Second, the substantive-symbolic distinction should incorporate organizational integration and resource constraints, not only managerial intention. Third, dynamic capabilities in constrained economies may take the form of local adaptation, maintenance innovation, domestic collaboration, and resilience rather than large-scale acquisition of frontier technologies. These conclusions extend business-management research by locating carbon practice within the institutional and operational realities of a fossil-fuel-dependent emerging economy.

4. Conclusions

This qualitative study showed that carbon management across the participating Iranian energy-sector firms was developing but remained unevenly institutionalized. Firms commonly possessed energy and environmental data, yet the information was often fragmented and reporting-oriented. Carbon projects gained approval primarily when they reduced costs, increased reliability, or protected production. Environmental units carried technical responsibility but often lacked authority over budgets and operations. Sanctions, financing instability, technology restrictions, subsidized energy, and inconsistent regulation further constrained long-term investment. At the same time, the findings did not depict firms as passive. Managers described local innovation, domestic partnerships, improved monitoring, and growing awareness of export and financing requirements. Some organizations were beginning to connect carbon management with modernization, energy security, competitiveness, and resilience. Substantive carbon capability emerged when information, authority, leadership, and resources converged. Without this alignment, carbon practices tended to remain incremental or symbolic. The study therefore concludes that the transition from carbon accounting to operational change is primarily an organizational integration challenge. Better measurement is necessary but insufficient. Carbon reduction must enter capital appraisal, procurement, operational accountability, executive oversight, and interorganizational collaboration. In constrained contexts, the most realistic pathway may combine immediate efficiency and reliability gains with staged investments that progressively build the governance and technological foundations for deeper decarbonization.

Policymakers should improve the credibility and continuity of energy and carbon policy. Stable efficiency standards, renewable-energy procurement rules, emissions-reporting guidance, and investment incentives would reduce uncertainty. Carbon requirements should be introduced with technical assistance and phased expectations so that firms can develop data and governance capacity. Energy-pricing reform should be coordinated with industrial support. Abrupt removal of subsidies could create severe production and social costs, while permanently weak price signals discourage efficiency. Targeted finance, tax incentives, guarantees, and performance-based support can make efficiency and renewable projects economically viable while protecting strategically important production. Policy should also strengthen domestic technology ecosystems. Public procurement, applied research funding, testing facilities, and partnerships among firms and universities can reduce dependence on imported systems. International climate and environmental policy discussions should recognize that sanctions can impede access to technologies needed for emissions reduction. The study relied primarily on managerial and senior-professional accounts and did not independently verify the implementation, persistence, or emissions effects of all carbon-management initiatives described by participants. Although contextual documents were used to compare formal commitments with interview accounts, those documents were not treated as implementation evidence. Participants may have emphasized external barriers or presented their organizations favorably, and the perspectives of frontline employees, contractors, regulators, community actors, and other stakeholders were not directly sampled. The purposive sample captured diverse energy activities but was not statistically representative of all Iranian firms, and the cross-sectional design limited the ability to observe how practices changed over time. Participant-level role and subsector descriptors were also deliberately limited in quotations to reduce re-identification risk in small professional networks.

Future research should combine interviews with facility-level emissions data, investment records, and longitudinal observation. Comparative studies could examine whether similar patterns occur in other sanctioned, fossil-dependent, or emerging economies. Research should also investigate differences among state-owned, private, and quasi-public firms; the role of executive incentives; supplier carbon capability; and the effectiveness of locally developed technologies. Longitudinal case studies could clarify whether symbolic commitments become substantive over time or remain disconnected from operations.

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Author Contributions

M.A. Zarei is solely responsible for the conception, preparation and writing of this manuscript.

Conflict of Interest

M.A. Zarei, while observing publication ethics in the referencing, declared the absence of interest of conflict.

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