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A Strategic Framework for ESG-Aligned Product Positioning of Methane Capture Technologies

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Abstract
Methane is a potent greenhouse gas with a global warming potential approximately 84 times greater than carbon dioxide over a 20-year period. Despite accounting for a smaller proportion of total anthropogenic emissions, methane is responsible for nearly 30% of current global warming. Key sources include oil and gas operations, agriculture, landfills, and wastewater systems. Technological advances in methane capture—such as anaerobic digestion, vapor recovery units (VRUs), leak detection and repair (LDAR) systems, and flare mitigation solutions—present significant opportunities for reducing emissions rapidly and cost-effectively. However, broad adoption of these technologies remains constrained by economic, regulatory, and awareness barriers. Simultaneously, Environmental, Social, and Governance (ESG) criteria have emerged as dominant forces shaping corporate strategy and investment decisions. Investors, regulators, and consumers are increasingly demanding transparency, emissions accountability, and sustainability in business practices. Methane mitigation aligns closely with ESG goals, particularly those focused on climate risk reduction, resource efficiency, and social license to operate. Companies that proactively integrate methane capture solutions into their ESG roadmaps stand to gain reputational benefits, improved investor confidence, and access to green financing instruments, such as sustainability-linked bonds or carbon offset credits. This proposes a strategic framework for ESG-aligned product positioning of methane capture technologies. The objective is to guide technology developers, service providers, and adopters in aligning their value propositions with evolving ESG metrics, stakeholder expectations, and policy landscapes. The framework emphasizes market segmentation, ESG performance mapping, co-benefit communication, and integration with climate disclosure protocols (e.g., TCFD, GRI, OGMP 2.0). By framing methane capture not just as an environmental compliance measure, but as a strategic ESG value proposition, this approach enhances commercialization pathways, accelerates market adoption, and supports the global transition toward a low-carbon economy.

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1. Introduction

Methane, the second most prevalent anthropogenic greenhouse gas after carbon dioxide, is a critical driver of short-term climate change (Otokiti, 2019; SHARMA *et al*., 2019). Although it has a shorter atmospheric lifespan—around 12 years—its global warming potential (GWP) is over 80 times more potent than carbon dioxide over a 20-year period. Methane emissions account for approximately 30% of the observed rise in global temperatures since the pre-industrial era. Key emission sources include the oil and gas industry (through leaks and flaring), agriculture (notably livestock and manure management), landfills, and wastewater treatment facilities (Lawal *et al*., 2014; Amos *et al*., 2014). Addressing methane emissions is widely recognized as one of the most immediate and cost-effective strategies to slow global warming and improve air quality (Akinbola and Otokiti, 2012; Otokiti, 2017).

In response to this challenge, a growing suite of methane capture technologies has emerged across multiple sectors. These include anaerobic digesters, which convert organic waste into biogas for energy production; vapor recovery units (VRUs), which capture fugitive emissions from oil and gas storage tanks; and flaring alternatives that recover rather than burn excess gas (Ajonbadi *et al*., 2015; Otokiti, 2017). Additionally, leak detection and repair (LDAR) systems and satellite-based monitoring tools are improving the accuracy and timeliness of emission identification. While these technologies vary in technical readiness and economic feasibility, they offer substantial potential to reduce emissions at source, recover valuable resources, and align with net-zero climate targets (Otokiti, 2017; Otokiti and Akorede, 2018).

Concurrently, Environmental, Social, and Governance (ESG) frameworks have gained prominence as both strategic and regulatory imperatives for corporations and investors. ESG reporting standards—such as the Task Force on Climate-Related Financial Disclosures (TCFD), Global Reporting Initiative (GRI), and the Sustainability Accounting Standards Board (SASB)—are shaping how companies assess and disclose their environmental impact, particularly regarding greenhouse gas emissions (Otokiti and Akinbola, 2013; Ajonbadi *et al*., 2016). Methane, due to its high GWP and direct link to operational inefficiencies, is becoming a focal point for ESG audits, climate risk assessments, and sustainable investment decisions. Investors are now actively screening portfolios for methane performance indicators, while regulators are tightening emission disclosure and reduction mandates, including methane-specific standards like the Oil and Gas Methane Partnership (OGMP 2.0).

Against this backdrop, aligning methane capture technologies with ESG metrics becomes both a necessity and a strategic opportunity. Technology providers and adopters must frame their products and services not just in terms of technical performance or compliance, but as instruments of ESG value creation (FAGBORE *et al*., 2020; Nwani *et al*., 2020). Product positioning must evolve to reflect stakeholder expectations for transparency, environmental stewardship, and long-term sustainability.

This proposes a strategic framework for ESG-aligned product positioning of methane capture technologies. The objective is to explore how technology developers, service providers, and corporate adopters can integrate ESG priorities into their market strategies, thereby improving adoption rates, investment attractiveness, and policy alignment. This investigates four core dimensions: understanding the methane technology landscape; mapping ESG requirements and disclosure practices; identifying target market segments; and designing value propositions that resonate with ESG-conscious stakeholders. By linking product positioning with ESG impact narratives, the framework aims to enhance the visibility, credibility, and scalability of methane mitigation technologies (Olajide *et al*., 2020; Akinbola *et al*., 2020). Ultimately, this approach supports broader climate goals while enabling competitive differentiation in an increasingly sustainability-driven market.

2. Methodology

The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) methodology was used to systematically review literature and industry reports in order to develop a strategic framework for ESG-aligned product positioning of methane capture technologies. This methodology ensured a structured and transparent process for identifying, screening, and synthesizing evidence related to the intersection of environmental, social, and governance (ESG) imperatives and methane mitigation innovations across energy, agriculture, and waste management sectors.

An extensive literature search was conducted using databases including Scopus, Web of Science, ScienceDirect, and Google Scholar, as well as industry-specific platforms such as the Environmental Protection Agency (EPA), the International Energy Agency (IEA), and the Global Methane Initiative. The search covered documents published from 2000 to 2025 to encompass the evolution of methane mitigation technologies alongside the rise of ESG frameworks in corporate strategy. Keywords used included combinations of "methane capture", "emissions reduction technologies", "ESG strategy", "product positioning", "carbon markets", "decarbonization", and "sustainability metrics". Boolean operators and truncations were applied to broaden the scope while maintaining relevance.

Inclusion criteria required that selected studies focus on (i) technological solutions for methane capture and utilization, (ii) integration of environmental or sustainability performance in product development, and (iii) market, regulatory, or stakeholder engagement dimensions of methane-related innovations. Eligible documents included peer-reviewed articles, industry white papers, market analyses, corporate ESG disclosures, and policy briefs. Studies that lacked a clear connection to methane mitigation technologies or ESG-aligned business practices were excluded.

The review followed the standard PRISMA four-stage process: identification, screening, eligibility, and inclusion. Initially, 612 documents were identified. After removing 128 duplicates, 484 titles and abstracts were screened for relevance. Of these, 162 full-text documents were reviewed for eligibility, and 69 were included in the final synthesis. Reference lists of key articles were also examined to ensure the inclusion of any high-impact but initially missed publications.

Data extraction focused on extracting information related to methane capture technology types (e.g., landfill gas recovery, anaerobic digestion, leak detection and repair, methane pyrolysis), ESG integration strategies, product differentiation tactics, stakeholder perception, policy drivers, and investment trends. Key thematic areas were identified, including the alignment of methane capture technologies with ESG scoring frameworks, monetization through carbon credits or sustainable finance, and strategic communication for enhancing investor and consumer engagement.

The methodological quality of included studies was evaluated using criteria adapted from the CASP (Critical Appraisal Skills Programme) checklist, assessing clarity of objectives, data transparency, methodological rigor, and practical relevance to ESG-oriented product strategies. High-quality sources clearly articulated the ESG value proposition of methane capture technologies and provided empirical or model-based evidence of market or environmental impact.

Findings from the review highlight that the successful positioning of methane capture technologies within ESG frameworks requires a multidimensional approach involving verifiable environmental impact, clear value articulation to stakeholders, and alignment with emerging regulatory and financial disclosure norms. The PRISMA methodology provided a rigorous and replicable structure for distilling diverse literature into a coherent strategic framework that integrates environmental innovation with market and policy incentives. This lays the groundwork for guiding technology developers, ESG strategists, and investors in scaling methane capture solutions as credible, investable, and high-impact contributions to global decarbonization and sustainability goals.

2.1 Methane Capture Technologies Landscape

Methane (CH_4) is a potent greenhouse gas, with a global warming potential approximately 84–87 times greater than that of carbon dioxide over a 20-year period. As such, its mitigation has become a critical focus in climate policy and technology development. Methane capture technologies offer strategic solutions to limit emissions across several high-impact sectors. These include biogas systems, carbon-negative innovations, leak detection and repair (LDAR) programs, and advanced catalytic or adsorptive capture methods (Onifade *et al*., 2021; ODETUNDE *et al*., 2021). This explores the current landscape of methane capture technologies, the deployment sectors they target, their levels of technical and commercial maturity, and the key barriers to widespread adoption.

Methane capture technologies vary in mechanism and application. Biogas systems, among the most mature, involve anaerobic digestion of organic waste—such as manure, food waste, or agricultural residue—to produce biogas, a mixture of methane and carbon dioxide. This biogas can be upgraded to biomethane for use as a renewable natural gas (RNG). Carbon-negative solutions include biochar production and enhanced methane oxidation, wherein methane is biologically or chemically converted and sequestered (Waqas *et al*., 2018; Daggash *et al*., 2019). Emerging systems also integrate methane pyrolysis, which splits methane into solid carbon and hydrogen gas, thereby avoiding CO_2 emissions entirely.

Leak detection and repair (LDAR) technologies have gained particular traction in the oil and gas sector. These systems include infrared cameras, laser-based sensors, drones, and satellite monitoring to detect fugitive methane emissions from pipelines, valves, and compressor stations. In addition to identification, LDAR programs emphasize timely repair protocols to minimize leakage duration. Advanced approaches, such as continuous monitoring networks and AI-enhanced analytics, further enhance LDAR capabilities.

Methane capture technologies are deployed across several high-emission sectors. In the oil and gas industry, which accounts for roughly 40% of anthropogenic methane emissions, LDAR and vapor recovery units are extensively used (ODETUNDE *et al*., 2021; SHARMA *et al*., 2021). Technologies such as gas flaring reduction systems and sealed storage tanks also contribute to emissions control.

In agriculture, particularly livestock operations, anaerobic digesters are employed to process manure and other organic wastes, producing biogas while mitigating methane release. Covered lagoon digesters and plug-flow systems are common in large-scale dairies and piggeries. Additionally, enteric fermentation reduction technologies—such as feed additives—are being explored to limit methane emissions from ruminant digestion (Haque, 2018; McCauley *et al*., 2020).

Landfills represent another major source of methane, produced through anaerobic decomposition of organic waste. Here, landfill gas capture systems, which consist of wells and piping networks to collect and combust or upgrade methane, are standard. Similarly, wastewater treatment facilities use digesters to manage sewage sludge and generate usable biogas. The captured methane can be utilized for on-site energy generation, reducing operational emissions and enhancing energy self-sufficiency.

The technical readiness levels (TRLs) and commercial maturity of methane capture technologies vary considerably. Biogas systems and landfill gas capture are well-established, with TRLs of 8–9, indicating deployment-ready status and widespread commercialization (Onifade *et al*., 2021; Ogeawuchi *et al*., 2021). Many agricultural and municipal applications already benefit from these systems, especially in regions with supportive policy environments.

LDAR technologies range from moderate to high TRLs. Conventional infrared and handheld gas detectors are fully commercial, while newer tools such as drone-mounted sensors and satellite surveillance are still advancing, typically at TRLs 6–8. Methane pyrolysis and other carbon-negative technologies are generally at lower TRLs (3–6), still undergoing pilot testing and scale-up validation.

Integration across sectors remains uneven, often constrained by infrastructure, technical complexity, and market access. For instance, while RNG markets are expanding in North America and Europe, they remain underdeveloped in many regions of the Global South due to limited grid connectivity and financing.

Despite technological progress, several barriers hinder the widespread adoption of methane capture systems. Chief among these is cost. Capital expenditures for anaerobic digesters, gas upgrading units, or advanced monitoring equipment can be prohibitive, particularly for small- and medium-scale operations (Ghose and Franchetti, 2018; Nisbet *et al*., 2020). The lack of clear economic incentives or carbon pricing mechanisms further limits return on investment.

Policy gaps also persist. In many jurisdictions, methane regulations are either non-existent or poorly enforced, leading to limited accountability. Conversely, inconsistent policy frameworks can deter private sector participation due to regulatory uncertainty.

Technical integration poses another hurdle. In oil and gas operations, retrofitting existing infrastructure with LDAR or capture systems can be logistically complex and require operational downtime (Olajide *et al*., 2021; Ojika *et al*., 2021). In agriculture, technical expertise and maintenance requirements can overwhelm smallholder farmers. Additionally, the variable quality of feedstocks (e.g., moisture content in manure or municipal waste) can impact the efficiency of biogas systems.

Lastly, measurement and verification (M&V) of methane reductions remains a technical and institutional challenge. Accurate M&V is essential for generating carbon credits or claiming regulatory compliance, yet standardization is still lacking across methodologies and jurisdictions.

Methane capture technologies represent a diverse and rapidly evolving field, critical for achieving near-term climate goals. While mature systems such as biogas digesters and LDAR tools have demonstrated effectiveness in reducing emissions across oil and gas, agriculture, landfills, and wastewater sectors, significant challenges remain. These include high upfront costs, policy fragmentation, and technical barriers to integration. Overcoming these obstacles will require coordinated policy support, financial incentives, and investment in innovation and capacity-building (Papamichail *et al*., 2019; Ponka *et al*., 2020). As global attention increasingly turns to short-lived climate pollutants, methane capture technologies are poised to play a central role in the transition to a low-carbon future.

2.2 ESG Frameworks and Regulatory Trends

The rising urgency of climate change mitigation has catalyzed the evolution and adoption of Environmental, Social, and Governance (ESG) frameworks globally. As investors, regulators, and consumers increasingly demand environmental transparency and accountability, methane emissions have emerged as a high-priority indicator due to their substantial climate impact. ESG frameworks now serve as foundational tools guiding corporate sustainability disclosures, investment screening, and environmental risk assessment (Daraojimba *et al*., 2021; Ojika *et al*., 2021). For methane capture technologies, alignment with these frameworks offers significant opportunities for strategic positioning, compliance, and investment mobilization.

Several major ESG reporting standards provide the structure for evaluating and communicating environmental performance, with increasing specificity around greenhouse gas (GHG) emissions. The Task Force on Climate-related Financial Disclosures (TCFD) is one of the most influential global initiatives, recommending that companies disclose governance, strategy, risk management, and metrics related to climate-related risks and opportunities. TCFD emphasizes scenario analysis and quantification of Scope 1, 2, and increasingly, Scope 3 emissions—where methane is often a substantial component, particularly in oil and gas, agriculture, and waste sectors.

The Sustainability Accounting Standards Board (SASB) offers sector-specific ESG disclosure standards tailored to financially material issues. In energy and agricultural sectors, SASB includes explicit references to methane emissions, flaring intensity, leak detection practices, and mitigation efforts. The Global Reporting Initiative (GRI) provides a comprehensive sustainability reporting standard that addresses environmental impact, including methane, with detailed metrics on emissions intensity, abatement strategies, and environmental compliance.

Additionally, the EU Taxonomy for Sustainable Activities has introduced a classification system for green economic activities, linking methane mitigation to sustainable energy, agriculture, and waste management projects. Activities that contribute substantially to climate change mitigation—such as methane capture and utilization—can qualify under this taxonomy for green finance eligibility, creating a strong incentive for alignment (Damerow, 2018; Warren, 2019).

Complementing these voluntary frameworks are increasingly stringent climate disclosure regulations and methane-specific mandates. The Oil and Gas Methane Partnership (OGMP) 2.0, led by the United Nations Environment Programme (UNEP), is the gold standard for methane emissions reporting in the oil and gas sector (Owobu *et al*., 2021; Otokiti *et al*., 2021). It requires participants to report actual measured emissions, including from non-operated assets, and to commit to continuous improvement pathways. OGMP 2.0 is being adopted by major oil companies and is shaping methane reporting expectations globally.

In the United States, the Environmental Protection Agency (EPA) has reintroduced and expanded methane emission standards under the Clean Air Act. The 2023 EPA rule mandates rigorous leak detection and repair (LDAR), limitations on flaring, and real-time monitoring technologies for oil and gas operators. Similarly, Canada, the EU, and other jurisdictions are implementing national-level methane strategies aligned with the Global Methane Pledge, which targets a 30% reduction in methane emissions by 2030.

Investor and stakeholder expectations are increasingly aligned with these frameworks. Institutional investors are incorporating methane metrics into ESG screening tools, shareholder proposals, and engagement practices. Asset managers such as BlackRock and pension funds are calling on portfolio companies to disclose methane intensity and adopt science-based targets. Methane performance is now viewed as a proxy for operational efficiency, regulatory risk exposure, and management quality, influencing capital allocation decisions.

For methane capture technology providers, these developments offer strategic alignment opportunities. Technologies that reduce or utilize methane emissions can be positioned as enablers of ESG compliance and climate leadership. Solutions such as anaerobic digesters, vapor recovery units, and methane oxidation systems can help companies achieve TCFD and OGMP 2.0 targets, improve SASB-aligned disclosures, and gain eligibility under the EU Taxonomy for sustainable financing.

To capitalize on this alignment, product developers should integrate ESG-compatible metrics into their offering—quantifying avoided emissions, carbon intensity reductions, and lifecycle environmental benefits. Certification programs, third-party verification (e.g., MRV—Measurement, Reporting, and Verification systems), and integration with ESG reporting platforms can further enhance credibility and marketability (Alonge *et al*., 2021; Otokiti *et al*., 2021).

The convergence of ESG frameworks, regulatory mandates, and investor scrutiny is creating a robust ecosystem where methane mitigation is not only an environmental imperative but also a competitive differentiator. Methane capture technologies that align with these frameworks will be better positioned to attract capital, comply with evolving regulations, and contribute meaningfully to global climate objectives.

2.3 Strategic Product Positioning Model

Effectively positioning methane capture technologies within an ESG (Environmental, Social, and Governance) framework requires a deliberate and multi-dimensional strategy. The growing importance of sustainability in corporate strategy, regulatory compliance, and capital allocation demands that methane mitigation solutions articulate value beyond technical performance. A strategic product positioning model must therefore define clear value propositions anchored in ESG outcomes, target differentiated market segments, leverage certifications and verification systems, and develop pricing structures that reflect the environmental and social value delivered by the technology as shown in figure 1(Alonge *et al*., 2021; Owobu *et al*., 2021).

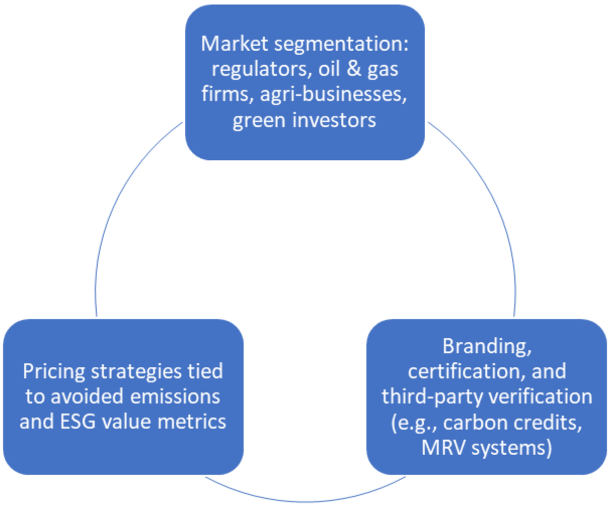

Fig 1: Strategic Product Positioning Model

At the core of this model is the value proposition, which must go beyond emissions abatement to encompass a broader set of ESG-aligned outcomes. For environmental metrics, methane capture solutions must quantify and communicate their potential to reduce greenhouse gas (GHG) emissions, thereby contributing directly to Scope 1 and Scope 3 emissions reductions under TCFD and SASB reporting standards. Resource recovery—such as converting methane to electricity, heat, or renewable natural gas (RNG)—adds another layer of value by displacing fossil fuels and creating circular energy systems. Social benefits, such as reduced air pollution, job creation in rural areas, or improved health outcomes, also strengthen the ESG proposition, appealing to community-focused stakeholders and enhancing a company's social license to operate.

Market segmentation plays a critical role in tailoring value propositions and outreach strategies. Key market segments include; Regulators and policymakers, who are responsible for setting methane reduction targets and approving new technologies. Positioning products as compliant with regulatory requirements (e.g., EPA rules, OGMP 2.0) and supportive of national climate pledges enhances policy adoption and potential access to subsidies or preferential permitting. Oil and gas firms, who face growing pressure to reduce methane emissions from upstream and midstream operations. These companies seek turnkey technologies that are scalable, compatible with existing infrastructure, and improve ESG scores for investors.

Agri-businesses and food processors, particularly in livestock, dairy, and waste management, benefit from solutions such as anaerobic digesters that reduce methane while generating biogas for internal energy use. Green investors and climate-focused financial institutions, who require verifiable ESG performance data. Methane capture providers can position their solutions as investment-grade climate technologies eligible for sustainability-linked loans, green bonds, or impact investment portfolios (Edwards, 2018; Gallo, 2020).

To support these value propositions, effective branding, certification, and third-party verification are essential. Technologies that demonstrate verifiable emissions reductions can access carbon markets through the issuance of carbon credits under voluntary or compliance schemes. Accreditation bodies such as Verra and Gold Standard, along with methane-specific methodologies, enable technologies to generate revenue from avoided emissions. MRV (Measurement, Reporting, and Verification) systems, whether through sensor-based monitoring or satellite analytics, enhance credibility and transparency—key concerns for ESG-oriented stakeholders.

Certification not only bolsters brand legitimacy but also facilitates market differentiation. Products certified as carbon-negative, low-carbon, or ESG-compliant stand out in competitive procurement processes and investor evaluations. Incorporating ESG performance labels—similar to energy efficiency ratings or organic certifications—can influence procurement decisions, particularly by multinational corporations with supply chain sustainability targets.

A final pillar of the strategic model involves pricing strategies tied to environmental and ESG value. Traditional cost-plus pricing fails to reflect the broader societal and regulatory benefits offered by methane capture technologies. Instead, value-based pricing should consider the cost of avoided emissions (e.g., USD per tonne of CO_2-equivalent mitigated), potential carbon credit revenues, and cost savings from resource recovery (Zimmermann *et al*., 2020; Chavez, 2020). Bundled service models—such as methane abatement-as-a-service or shared savings agreements—can make upfront investment more attractive to risk-averse customers while aligning incentives for performance and impact.

A robust strategic positioning model for methane capture technologies must articulate quantifiable ESG outcomes, target sector-specific value drivers, and leverage market mechanisms for recognition and reward. By integrating these elements, providers can enhance market access, attract climate-aligned investment, and support accelerated deployment of methane mitigation solutions—an essential component of near-term climate action.

2.4 Integration with Corporate ESG Strategies

As global efforts intensify to address climate change, corporations are increasingly aligning their operations with Environmental, Social, and Governance (ESG) principles. Within this context, methane capture technologies offer a valuable avenue for companies seeking to meet decarbonization goals, manage regulatory risks, and enhance their reputational standing as shown in figure 2(Radunsky, 2018; Condon, 2020). By embedding these technologies into corporate ESG strategies and roadmaps, businesses not only reduce greenhouse gas (GHG) emissions but also signal environmental leadership, strengthen stakeholder trust, and open new opportunities for sustainable growth.

One of the most direct applications of methane capture technologies is their integration into corporate decarbonization and ESG roadmaps. As companies adopt science-based targets and commit to net-zero emissions, methane reduction becomes a priority—especially in sectors like oil and gas, agriculture, and waste management, where methane accounts for a significant share of emissions. Technologies such as leak detection and repair (LDAR) systems, anaerobic digesters, vapor recovery units (VRUs), and flare gas recovery systems allow companies to mitigate methane emissions at the source. These actions are readily quantifiable and reportable under ESG disclosure standards such as the Task Force on Climate-related Financial Disclosures (TCFD) and the Sustainability Accounting Standards Board (SASB), reinforcing transparency and accountability in environmental performance.

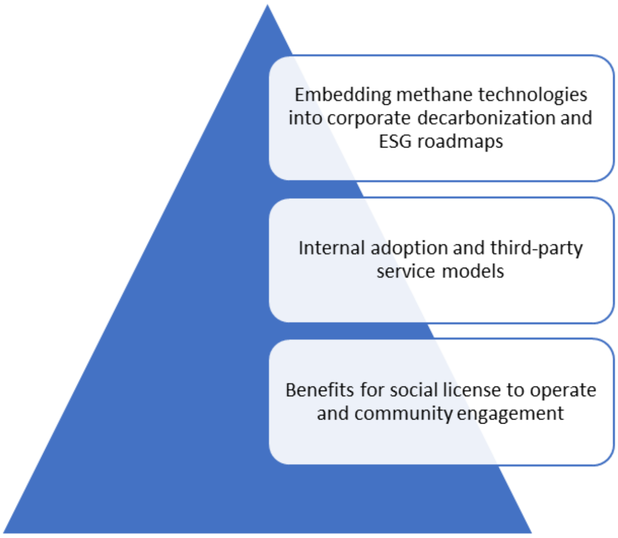

Fig 2: Integration with Corporate ESG Strategies

Companies can pursue methane mitigation through internal adoption or third-party service models, depending on their operational capabilities and capital constraints. Internal adoption involves direct investment in infrastructure and integration into existing operations, providing long-term control and alignment with in-house ESG targets. This approach suits large corporations with the technical capacity and long-term investment horizons. Alternatively, third-party service models—such as methane capture-as-a-service or performance-based contracts—enable companies to outsource installation, monitoring, and maintenance to specialized providers. This model reduces upfront costs and accelerates deployment, making it especially suitable for small and medium-sized enterprises (SMEs) or operations in low-margin industries. Regardless of the model chosen, the key lies in embedding methane capture into core operational practices and aligning performance metrics with ESG goals.

Methane capture technologies also play a critical role in achieving net-zero targets and reducing Scope 1 and Scope 3 emissions. Scope 1 emissions, which arise from a company's direct operations, often include fugitive methane emissions in industries such as oil and gas extraction, landfills, and livestock farming. Capturing these emissions directly contributes to Scope 1 reductions. Scope 3 emissions, which encompass the broader value chain—including suppliers and product end-use—can also be addressed through collaborative methane mitigation strategies (Thornley and Mohr, 2018; Li *et al*., 2019). For example, food and beverage companies may partner with their agricultural suppliers to deploy anaerobic digestion systems that reduce methane from manure, while energy companies may support low-emission technologies at the consumer level. In both cases, methane capture initiatives serve as a measurable and impactful strategy to advance net-zero ambitions.

Beyond environmental performance, methane mitigation generates significant co-benefits for social license to operate and community engagement. In many regions, methane emissions contribute to local air pollution, odor nuisances, and safety hazards, all of which negatively affect surrounding communities. Technologies that eliminate leaks, flares, or decomposing waste improve local air quality and health outcomes, fostering goodwill and trust among residents. Moreover, methane capture projects often create local employment opportunities in installation, monitoring, and maintenance. When designed with community engagement in mind—such as incorporating local ownership, training programs, or benefit-sharing mechanisms—these projects enhance the company's social impact narrative, reinforcing its legitimacy and long-term presence in the region.

Integrating methane capture technologies into corporate ESG strategies offers a multi-dimensional value proposition: environmental compliance, emissions reduction, investor alignment, and strengthened community relationships. Whether implemented through internal investment or third-party service models, these technologies support key ESG disclosures and climate commitments, while delivering operational and reputational benefits (Ho and Park, 2019; Hsueh, 2019). As expectations around ESG performance continue to rise, methane mitigation will be increasingly recognized not only as an environmental imperative but also as a strategic differentiator in the pursuit of sustainable and inclusive corporate growth.

2.5 Case Studies and Industry Practices

Methane capture technologies are increasingly being adopted across energy, waste, and agriculture sectors to reduce emissions and align operations with environmental, social, and governance (ESG) goals. Examining real-world case studies provides valuable insights into both the successes and challenges of implementation. These examples demonstrate how effective deployment strategies, technological innovation, and supportive policy frameworks contribute to sustainable outcomes, while also highlighting the pitfalls that can hinder progress.

In the energy sector, Equinor's implementation of comprehensive Leak Detection and Repair (LDAR) systems in Norway's offshore oil platforms stands out as a benchmark case. By deploying infrared cameras, continuous gas monitors, and drone-based inspections, Equinor has significantly reduced fugitive methane emissions (Ravikumar *et al*., 2019; Fox, 2020). Their program aligns with OGMP 2.0 and TCFD disclosure standards, reflecting strong ESG commitments. Similarly, Chevron has adopted real-time monitoring systems in its Permian Basin operations, which contribute to transparent methane reporting and improved investor confidence. These examples show that technology adoption, combined with strategic disclosure, strengthens ESG positioning in capital-intensive industries.

In the waste management sector, the Puente Hills Landfill in California provides a notable success story. Once the largest landfill in the U.S., it now operates an advanced methane capture and utilization system. Landfill gas is collected through a network of wells and processed into renewable natural gas (RNG), powering thousands of homes and vehicles. The project, developed in partnership with Clean Energy Fuels Corp., exemplifies a circular economy model with measurable GHG reduction and energy recovery outcomes. Similar practices are observed at Veolia's landfill gas-to-energy projects across Europe, where ESG metrics are central to project design and stakeholder reporting.

The agriculture sector also offers promising cases. In Denmark, the large-scale deployment of anaerobic digesters for livestock manure has allowed farms to produce biomethane while eliminating major methane emissions. Companies like Nature Energy have successfully aggregated manure from multiple farms, increasing efficiency and economies of scale. Their ability to report methane mitigation through EU-recognized verification systems has enhanced their ESG credibility and attracted green financing.

Comparative analysis of technology providers reveals a growing divide between firms that integrate ESG metrics and those that do not. For example, companies like Quantum Energy Partners and Brightmark stand out for their integrated methane capture and valorization platforms, coupled with transparent ESG disclosures. These providers attract institutional investors seeking low-carbon investment opportunities. Conversely, firms with opaque emissions reporting or slow adoption of verification protocols struggle to gain market traction, particularly as climate-focused financial institutions raise expectations.

Despite these successes, there are lessons learned from cases of delayed or failed adoption. In Nigeria, several municipal biogas pilot projects have failed due to poor technical maintenance, limited operator training, and inadequate policy support. Similarly, in Argentina, attempts to scale up methane recovery from livestock operations stalled due to unreliable feedstock supplies and lack of integration with national gas infrastructure. These cases underscore the importance of localized planning, stakeholder engagement, and long-term maintenance strategies.

Industry case studies show that methane capture technologies can deliver significant environmental and economic benefits when effectively implemented (Hummel *et al*., 2018; Tao *et al*., 2019). Strong ESG alignment, transparent reporting, and collaborative stakeholder models enhance project success. However, failures and delays highlight the need for robust technical planning, institutional capacity, and policy support to ensure sustained impact.

2.6 Policy and Investment Enablers

The deployment of methane capture technologies is critical to achieving global climate goals, particularly in the short term, given methane's high global warming potential (GWP). However, market barriers—including high upfront costs, limited demand certainty, and fragmented regulations—often slow or discourage adoption. To overcome these constraints, a robust ecosystem of policy and investment enablers must be established. Strategic interventions such as carbon markets, fiscal incentives, public-private partnerships (PPPs), and innovation funding can drive the commercial viability and scalability of methane capture technologies, while aligning with ESG (Environmental, Social, and Governance) mandates and sustainable development objectives (Clark *et al*., 2018; David and Venkatachalam, 2019).

One of the most significant policy tools available is the carbon market, which places a financial value on greenhouse gas reductions. Methane, with its high GWP, is especially valuable in both compliance and voluntary carbon markets. Technologies that capture methane—such as anaerobic digesters, vapor recovery units, and landfill gas utilization systems—can generate carbon credits that are sold to emitters seeking to offset their emissions or meet regulatory caps. Programs like the Verified Carbon Standard (VCS) and Gold Standard have methodologies specifically tailored for methane abatement, providing a performance-based revenue stream that improves project bankability. As carbon prices rise globally, this market-driven mechanism becomes a more potent enabler of private sector investment in methane technologies.

In addition to carbon financing, government subsidies and green procurement policies play a pivotal role in catalyzing adoption. Tax incentives (e.g., investment tax credits or accelerated depreciation), capital subsidies, and performance-linked grants reduce capital expenditure and improve return on investment. Furthermore, green public procurement—where governments prioritize the purchase of low-emission and climate-positive technologies—creates early demand signals that help scale production and drive down costs. For example, municipal mandates to adopt methane-reducing waste management technologies or state-level incentives for agricultural methane recovery can stimulate industry-wide uptake.

Public-private partnerships (PPPs) and innovation grants are also crucial enablers, particularly in sectors where methane mitigation faces infrastructure or awareness constraints. PPPs can de-risk investment by sharing capital and operational costs, particularly in projects involving shared infrastructure like biogas pipelines, waste treatment facilities, or flare gas recovery systems. Governments can support project viability by providing land, grid access, or co-financing arrangements, while the private sector brings technology and operational expertise. Innovation grants and challenge funds—often provided by climate finance institutions, development banks, or philanthropic entities—can support early-stage pilots, capacity building, and the demonstration of unproven but promising methane mitigation technologies. These funds reduce technical risk and create pathways for future commercial scaling.

To maximize the effectiveness of these policy and financial mechanisms, targeted recommendations for regulators and ESG-focused investors are necessary. Regulators should prioritize the integration of methane into national climate strategies, with clear, enforceable targets for methane emission reductions across agriculture, energy, and waste sectors. They should also establish open-access methane monitoring platforms and require consistent, verifiable emissions data through measurement, reporting, and verification (MRV) systems. Regulatory clarity on carbon credit eligibility, streamlined permitting for methane infrastructure, and methane-specific disclosure requirements will provide critical market signals.

For ESG-focused investors, methane capture represents a high-impact opportunity aligned with climate, sustainability, and governance priorities. Investors should engage portfolio companies on methane disclosure and mitigation plans, prioritize methane projects in green bond frameworks, and support blended finance initiatives that crowd in commercial capital alongside concessional funds. Tools such as ESG scoring models and sustainability-linked loans can be updated to reflect methane-specific performance indicators, incentivizing companies to take early action (Kerr and Avendano, 2020; Deschryver and De Mariz, 2020). Moreover, investors can collaborate with technology providers and policymakers to create demand aggregation platforms that lower transaction costs and enable project bundling—enhancing scale and impact.

Enabling the widespread deployment of methane capture technologies requires a coordinated mix of policy instruments, financial incentives, and collaborative investment models. Carbon markets, subsidies, public procurement, and innovation funding create a supportive environment for private sector action, while regulators and investors play a vital role in shaping the risk-return profile of these technologies. With the right enablers in place, methane capture can become a cornerstone of near-term climate strategy and a key component of ESG-aligned sustainable investment (Laurikko *et al.*, 2020; Hillman and Baydoun, 2020).

3. Conclusion and Future Directions

Methane capture technologies offer strategic and ESG-aligned benefits that are essential to global climate mitigation efforts. By reducing emissions of a short-lived but highly potent greenhouse gas, these technologies contribute directly to achieving near-term climate targets while improving operational efficiency and enabling resource recovery. From biogas systems in agriculture to leak detection technologies in the energy sector and landfill gas utilization in waste management, successful deployments demonstrate the potential for methane mitigation to support environmental goals, enhance energy security, and generate economic value. In doing so, these technologies advance corporate ESG performance, particularly in areas of climate risk management, regulatory compliance, and sustainable innovation.

A critical next step is the deliberate integration of ESG alignment into product design, innovation, and commercialization strategies. Companies developing methane capture technologies should embed principles of transparency, circularity, and climate resilience into their business models. This includes aligning with recognized disclosure frameworks such as TCFD, GRI, and OGMP 2.0, while ensuring that products meet the evolving demands of investors, regulators, and sustainability-conscious customers. Such alignment can differentiate technology providers in a competitive landscape and unlock access to climate finance, carbon markets, and ESG-linked funding instruments.

However, key research gaps must be addressed to maximize the impact of methane capture systems. These include the development of standardized quantification methodologies, robust measurement, reporting, and verification (MRV) frameworks, and tools for assessing full value chain integration. Accurate emissions baselines and performance tracking are essential for credible climate reporting and carbon credit generation. Additionally, research should explore integrated digital platforms that combine remote sensing, IoT, and AI to enhance monitoring and decision-making. Moving forward, multidisciplinary research and policy innovation will be vital to scale methane mitigation and embed it as a cornerstone of global climate strategy.

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