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EXPLORING CARBON OFFSETTING IN MONGOLIA'S MINING SECTOR: OPPORTUNITIES AND INTEGRATION INTO GLOBAL MARKETS

Bachelor's Thesis

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Statutory Declaration

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I hereby affirm in lieu of an oath that I provided the submitted bachelor thesis

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I did not use any sources other than those stated. In case that the work is additionally submitted on a data medium, I declare that the written and the electronic form are completely identical. The work was not submitted in the same or similar form to any examination authority.

May 28, 2025

Place, Date

Signature

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Abstract

This thesis explores the potential of carbon offsetting within Mongolia’s mining sector, focusing on two major companies: Oyu Tolgoi (OT) and Erdenes Tavan Tolgoi (ETT). As the mining sector is one of the largest sources of greenhouse gas (GHG) emissions in Mongolia, implementing carbon offsetting strategies is seen as a viable option to mitigate its environmental impact while potentially engaging with global carbon markets. This research aims to assess the feasibility of carbon offset projects, including renewable energy, methane capture, afforestation, and reforestation, for both companies.

The research is based entirely on secondary data collected from published reports, company documents, government publications, and academic papers. The analysis primarily involves document analysis to extract relevant information regarding the emissions profiles of OT and ETT, as well as their current and potential carbon offset initiatives. Emissions data, such as those reported in the companies' annual environmental reports, were used to model the potential for carbon offset generation. In addition, financial viability was assessed using Marginal Abatement Cost (MAC) analysis, comparing the cost of reducing emissions to the potential revenues from carbon credits.

The findings indicate that OT has a higher level of institutional readiness for carbon market integration, with ongoing renewable energy projects and established emissions reporting processes. In contrast, ETT, while having a higher potential for carbon offset generation, faces challenges such as the lack of verified emissions data and limited internal monitoring and verification (MRV) systems. Both companies, however, show significant potential for generating carbon credits through methane capture, reforestation, and renewable energy initiatives. If integrated into international carbon markets, these projects could provide both environmental and financial benefits for the companies.

This study highlights the need for strengthening institutional capacity, developing robust MRV systems, and creating clear regulatory frameworks to enable Mongolia’s mining sector to effectively participate in carbon offsetting and carbon trading schemes. It also provides valuable insights into the economic feasibility of carbon offset projects and their potential role in Mongolia’s transition to a low-carbon economy

Contents

List of Abbreviations

ADB - Asian Development Bank
CCRCC - Climate Change Research and Cooperation Centre
ESG - Environmental, Social, and Governance
ETS - Emissions Trading System
ETT - Erdenes Tavan Tolgoi
EU - European Union
GDP - Gross Domestic Product
GEC - Global Environmental Consultant
GGGI - Global Green Growth Institute
GHG - Greenhouse Gas
ICAP - International Carbon Action Partnership
ICVCM - International Carbon Voluntary Carbon Market
IESC - Independent Environmental and Social Consultant
IPCC - Intergovernmental Panel on Climate Change
ISO - International Organization for Standardization
JSC - Joint Stock Company
LLC - Limited Liability Company
LNG - Liquefied Natural Gas
MAC - Marginal Abatement Cost
MET - Ministry of Environment and Tourism
MGCF - Mongolia Green Credit Fund
MMC - Mongolian Mining Corporation
MRV - Monitoring, Reporting, and Verification
MW - Megawatt
NDC - Nationally Determined Contribution
OECD - Organisation for Economic Co-operation and Development
OT - Oyu Tolgoi
PR - Public Relations
ROM - Run-of-Mine
SWOT - Strengths, Weaknesses, Opportunities, and Threats
UNDP - United Nations Development Programme
UNFCCC - United Nations Framework Convention on Climate Change
USD - United States Dollar
VCM - Voluntary Carbon Market
VCS - Verified Carbon Standard

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Introduction

1.1 Background

Mongolia's mining sector is the backbone of its economy, contributing approximately 23% of GDP, accounting for over 90% of exports, and employing more than 60,000 people directly and indirectly. The sector is driven by major projects such as Oyu Tolgoi (OT), a copper-gold mine responsible for more than 10% of Mongolia's GDP, and Erdenes Tavan Tolgoi (ETT), the world's largest undeveloped coking coal deposit, exporting over 50 million tonnes of coal annually [29, 33].

These economic benefits come with environmental costs. According to Mongolia's 2022 GHG Inventory, the industrial sector emits approximately 13.7 million tonnes CO_2e annually, with the extractive industries contributing over 30% of total industrial emissions [7]. OT alone reported 346,089 tonnes of Scope 1 and 865,088 tonnes of Scope 2 GHG emissions in 2023, primarily due to imported, coal-based electricity [29, 32]. ETT's annual emissions are estimated at 4.5 million tonnes CO_2e, derived from mining operations, transport, and methane leakage from coal seams [33].

In response to climate concerns, the Government of Mongolia has ratified the Paris Agreement and submitted its Updated Nationally Determined Contribution (NDC), pledging to reduce national emissions by 22.7% by 2030 [11]. However, implementation remains slow. There is no national cap-and-trade framework, few accredited verifiers, and limited carbon finance infrastructure.

Recent developments—including Mongolia's collaboration with Verra, the creation of the Mongolian Green Credit Fund (MGCF) with support from GGGI, and the emergence of platforms like URECA, a blockchain-based MRV and carbon registry—signal growing readiness. A 2024 memorandum between Verra and the Climate Change Research and Cooperation Centre (CCRCC) outlines plans to build technical capacity for carbon project development and registry operations, further strengthening institutional readiness [34].

1.2 Problem Statement

While Mongolia has initiated steps toward building a voluntary carbon market (VCM), its mining sector lacks the institutional and technical architecture needed to meaningfully participate. Major players like OT and ETT have mitigation potential—estimated at over 2 million tCO_2e per year combined—but there is no framework to verify, monetize, or trade these offsets [29, 33].

In the absence of a national emissions cap, verification capacity, or policy clarity, Mongolia risks missing the opportunity to mobilize carbon finance. For mining firms, this means forgone revenue streams, regulatory uncertainty, and exposure to rising global ESG pressures. Without a clear carbon pricing roadmap, the sector cannot contribute to nor benefit from Mongolia's broader climate commitments.

1.3 Research Objectives and Questions

This thesis explores how Mongolia's mining sector can enter the global carbon economy through verified offset projects and future cap-and-trade integration. It focuses on two major firms—OT and ETT—and evaluates their technical, financial, and institutional readiness for generating carbon credits under voluntary or compliance systems.

Research Questions:

1. Which carbon offset strategies are technically suitable for OT and ETT based on their emissions profiles?

2. What is the financial value of these strategies, using modeled carbon prices and reduction volumes?

3. How ready is Mongolia's institutional ecosystem (e.g., MRV, finance, regulation) for a cap-and-trade system?

4. What risks and barriers exist, and how can they be addressed through market design or policy support?

1.4 Methodology Overview

This study employs a document-based comparative case study approach to examine carbon offset opportunities in Mongolia's mining sector. The focus is on two major mining companies—Oyu Tolgoi (OT) and Erdenes Tavan Tolgoi (ETT)—selected as case studies due to their economic significance and contrasting characteristics. A comparative design enables analyzing differences in emissions profiles (copper-gold vs. coal mining), ownership (joint venture vs. state-owned), and reporting.

This study relies entirely on secondary data, with all information drawn from publicly available reports, company documents, academic research, and industry publications. No primary data was collected through surveys or interviews. Instead, existing documents were used, as they provided the essential data required, including emissions figures, company policies, and financial information. This approach is effective, allowing for in-depth analysis of the available data without the need for primary research.

1.4.1 Data Sources

All data used in this research were gathered from **secondary sources**, meaning no direct data was collected from interviews, surveys, or field experiments. The choice to use documented sources is justified by the availability of reliable information and the exploratory nature of the topic. The following categories of documents were analyzed:

- **Company Reports and Audits:** Official sustainability reports, annual environmental reports, and third-party audit documents from OT and ETT. These provided data on greenhouse gas (GHG) emissions, operational details, and existing mitigation efforts.
- **Policy and Regulatory Documents:** Government policy papers, national emissions inventories, and draft proposals related to carbon pricing (e.g. cap-and-trade frameworks) were reviewed to understand the context.
- **Academic Literature:** Peer-reviewed studies and scholarly articles on carbon offsetting, mining emissions, and environmental economics provided theoretical background and methodology guidance. This literature helped in identifying standard modeling approaches and in interpreting results against global findings. It also ensured the research builds upon established knowledge in the field.

- **Industry Publications and Databases:** Publications from industry associations, consulting reports, and international organizations (e.g. Asian Development Bank studies, World Bank reports) were used for data such as default emission factors, cost benchmarks, and case examples. For example, default values for emissions and cost estimates for mitigation measures were cross-referenced with these sources to enhance accuracy. Data from these publications, when available, were preferred if they were recent and specific to mining or Mongolia.

By using a variety of sources, this study cross-checks information to enhance the reliability and depth of the analysis. All documents were accessed through public domains or academic libraries, and each was evaluated for credibility.

1.4.2 Limitations

Every research methodology has limitations, and this document-based analysis is no exception. It is important to acknowledge these constraints to contextualize the confidence and generalizability of the results:

- **Reliance on Secondary Data:** Since the study uses only existing documents and no primary data, it is limited by what information is publicly available. Companies may not disclose all relevant data, or reports could be outdated. The analysis had to work with the best available figures (e.g. the latest annual reports), which might not capture real-time changes or unpublished details.
- **Data Quality and Consistency:** The two case studies had different levels of data granularity. Oyu Tolgoi's disclosures are extensive and externally audited, whereas ETT's public data are somewhat more limited. This discrepancy means the modeling for ETT may rely on more assumptions (such as industry-average values) than that for OT. As a result, the precision of the emissions estimates and MAC calculations may differ between the cases.
- **Scope of Financial Analysis:** The MAC analysis is based on cost estimates gleaned from literature and global benchmarks, not on the companies' internal financial data. Actual costs for implementing a given mitigation project at OT or ETT could vary widely due to site-specific conditions, operational constraints, or economic factors in Mongolia (e.g. cost of capital, availability of technology). Additionally, the carbon price scenarios used for comparison are hypothetical and for analytical purposes; real market prices could be influenced by policy changes,

market dynamics, or project-specific quality of credits. Therefore, conclusions about profitability or viability are indicative rather than definitive – they show what Could be viable under certain price conditions, but not what will happen.

- **No Primary Stakeholder Input:** The research did not include interviews or surveys with company officials, regulators, or other stakeholders. While this avoids any subjective bias that interviews might introduce, it also means the analysis may miss contextual insights such as on-the-ground challenges, stakeholder attitudes, or upcoming plans known internally. The absence of direct stakeholder perspectives limits the ability to validate assumptions. The study compensates by drawing on secondary stakeholder analyses (like news, workshops, or third-party commentaries) when available, but this is not a full substitute for primary engagement.
- **Generalizability:** As a comparative case study of two companies in Mongolia, the findings are context-specific. the results and conclusions are most applicable to operations similar to OT and ETT. The aim is to provide insight and a framework that could be relevant beyond these cases, but the numerical results (emissions figures, costs) are unique to the selected context. Moreover, the evolving nature of the field (carbon markets and technologies) means that the analysis provides a snapshot based on current secondarydata. Changes in technology performance or policy could alter the outcomes if the study were repeated in the future.

1.5 Significance of the Study

This study is one of the first in Mongolia to quantify carbon offset potential within the mining sector and to map out pathways for integrating these offsets into future compliance markets. It offers actionable insights for:

- Mining companies seeking to future-proof operations
- Policy institutions designing Mongolia's emissions trading infrastructure
- Carbon platforms like URECA that aim to scale digital MRV and credit issuance
- International donors evaluating Mongolia's carbon finance readiness

Ultimately, this thesis demonstrates how the mining sector—typically seen as an obstacle to climate goals—can instead become a central actor in Mongolia's transition to a low-carbon economy.

Literature review

2.1 What is Carbon offsetting?

Carbon offsetting refers to the practice of compensating for greenhouse gas (GHG) emissions by funding activities that either remove carbon dioxide from the atmosphere or prevent new emissions from occurring [1,4]. It plays a crucial role in climate change mitigation, especially for industries that cannot fully eliminate emissions from their operations.

The principle behind offsetting is rooted in "additionality"—meaning the emissions reductions would not have happened without the funding from offset buyers [4]. Projects commonly include afforestation and reforestation, renewable energy, methane capture from landfills or coal seams, and improvements in energy efficiency. Each project generates offset credits, typically equal to one metric tonne of CO_2-equivalent (tCO_2e) [4,5].

Offset projects are verified by independent third-party entities and are tracked through recognized registries such as Verra’s Verified Carbon Standard (VCS), the Gold Standard, or the American Carbon Registry. These systems apply rigorous MRV (Monitoring, Reporting, and Verification) procedures to ensure that emission reductions are real, measurable, and permanent [4,8].

The benefits of carbon offsetting are multi-dimensional. Economically, offsets can create a revenue stream for project developers and offer cost-effective compliance options for emitters. Environmentally, they support biodiversity, reforestation, and clean technology adoption. Socially, they can deliver co-benefits like rural employment, improved air quality, and sustainable land use. In Mongolia’s context, offsets could incentivize post-mining land restoration, energy efficiency, and low-carbon innovation in resource-heavy sectors like mining [29,33].

Globally, the voluntary carbon market surpassed USD 2 billion in transaction volume in 2022, indicating increased demand from companies pursuing net-zero targets and sustainability credentials [2].

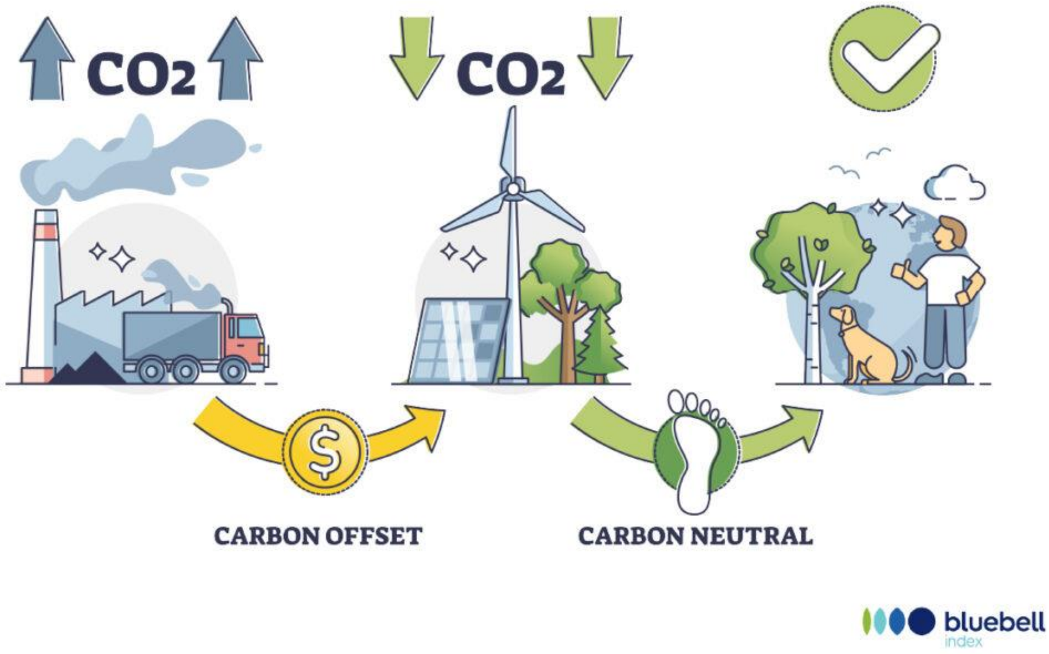

Figure 1. Carbon Offsetting Mechanism Source: Bluebell index

2.2 Global Carbon Markets (Compliance and Voluntary)

Carbon markets are mechanisms designed to put a price on carbon emissions and incentivize reductions across sectors. These markets are broadly categorized into two types: compliance markets and voluntary carbon markets (VCMs).

Compliance carbon markets are created and governed by national or regional regulatory systems. The most widely known is the European Union Emissions Trading System (EU ETS), which covers over 10,000 installations and around 40% of the EU's greenhouse gas emissions. In this system, a cap is set on total allowable emissions, and companies receive or purchase allowances. They can trade these allowances in a market, creating a price signal for carbon [10]. Similar cap-and-trade systems exist in South Korea, California, New Zealand, and China. These markets offer emissions certainty but can introduce price volatility.

Carbon taxes, on the other hand, place a fixed price on each tonne of CO_2e emitted. This approach offers price certainty but does not ensure specific emissions outcomes. Several countries, such as Sweden, have adopted this model, achieving high carbon prices of over \$100/tCO_2e while maintaining economic growth [2].

Voluntary carbon markets (VCMs) operate outside of government mandates and allow companies, NGOs, and individuals to purchase carbon credits to offset their emissions. These credits are generated by projects such as afforestation, renewable energy, improved cookstoves, or methane recovery. Standards like Verra's Verified Carbon Standard (VCS) and Gold Standard ensure that credits are real, measurable, and additional [4,8]. The voluntary carbon market reached USD 2 billion in transactions in 2022, with expectations to grow significantly due to increasing corporate net-zero pledges [2].

Mongolia currently operates outside a formal compliance market but has shown growing engagement in the voluntary carbon space. The government has partnered with Verra and ICVCM to develop domestic capacity and has launched digital platforms like URECA to facilitate MRV and credit trading [4,23,24]. Mongolia's Updated NDC (2021) outlines a commitment to reduce emissions by 22.7% by 2030, and there is potential to link with international mechanisms under Article 6 of the Paris Agreement [11,26].

Feature	**Compliance Market (e.g., EU ETS)**	**Voluntary Market (e.g., Verra)**
Governing Body	Government/Regulator	Non-governmental Standards
Legal Requirement	Yes	No
Project Types	Limited (sector-based)	Broad (energy, land use, community)
Verification	Mandatory, strict MRV	Verified by approved third parties
Credit Pricing	Market-driven, allowance-based	Voluntary pricing
Example Systems	EU ETS, Korea ETS, California	Verra, Gold Standard, ACR

Source: Adapted from [2], [4], [8], [10]

These distinctions are crucial as Mongolia develops its carbon market infrastructure. Voluntary systems can act as a stepping stone toward a compliance framework, especially in sectors like mining where early pilot projects can build credibility, attract finance, and develop MRV capacity.

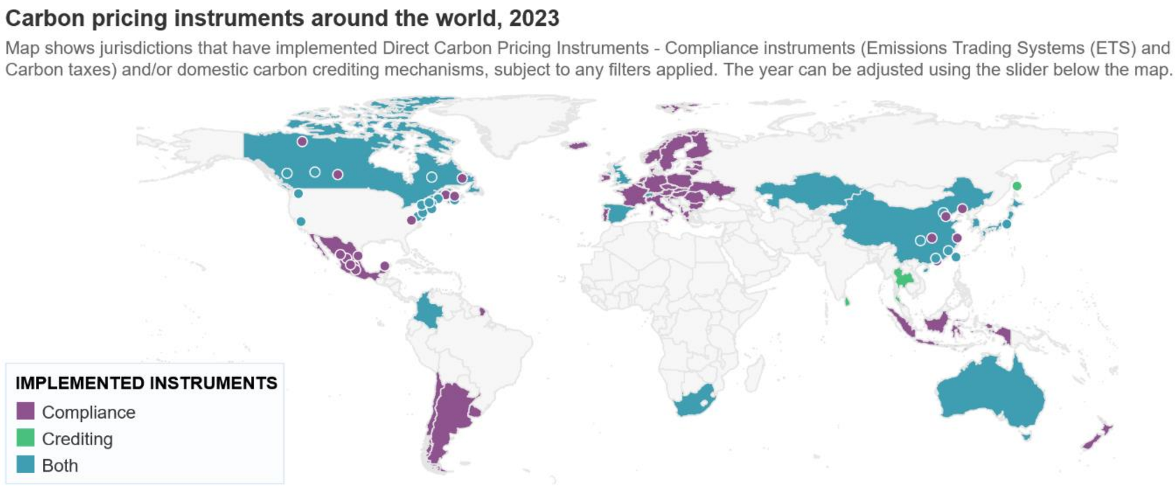

Figure 2*. Global Carbon Pricing Initiatives (2023)*. Countries shaded represent those with active carbon taxes, ETS, or both. Data reflects over 70 pricing instruments covering 23% of global GHG emissions.
Source: [2] World Bank. State and Trends of Carbon Pricing 2023.

2.3 Greenhouse Gas Emissions from Mining

2.3.1 Emissions by Type (Scope 1, 2, and 3)

Greenhouse gas (GHG) emissions from mining activities are typically categorized into:

- **Scope 1**: Direct emissions from owned or controlled sources (e.g., fuel combustion in machinery, blasting).
- **Scope 2**: Indirect emissions from purchased electricity, steam, or heat (e.g., power supplied to processing plants).
- **Scope 3**: Other indirect emissions from the value chain, including transportation of materials, outsourced services, and product use [21].

Mining is energy-intensive and often operates in remote areas where diesel power is dominant, leading to high Scope 1 emissions. Scope 2 is also significant, especially in countries like Mongolia where power generation is heavily coal-based.

2.3.2 Emissions Across the Mining Life Cycle

Emissions occur throughout the mining life cycle:

- **Exploration**: Minimal, mostly from transportation and drilling.
- **Development and Construction**: Moderate, due to land clearing, infrastructure, and fuel use.
- **Extraction and Processing**: Highest emissions stage; includes blasting, hauling, crushing, grinding, and chemical processing.
- **Transport and Export**: Significant emissions from haul trucks, rail, and sea shipping.
- **Mine Closure and Rehabilitation**: Emissions may arise from machinery and long-term land-use changes.

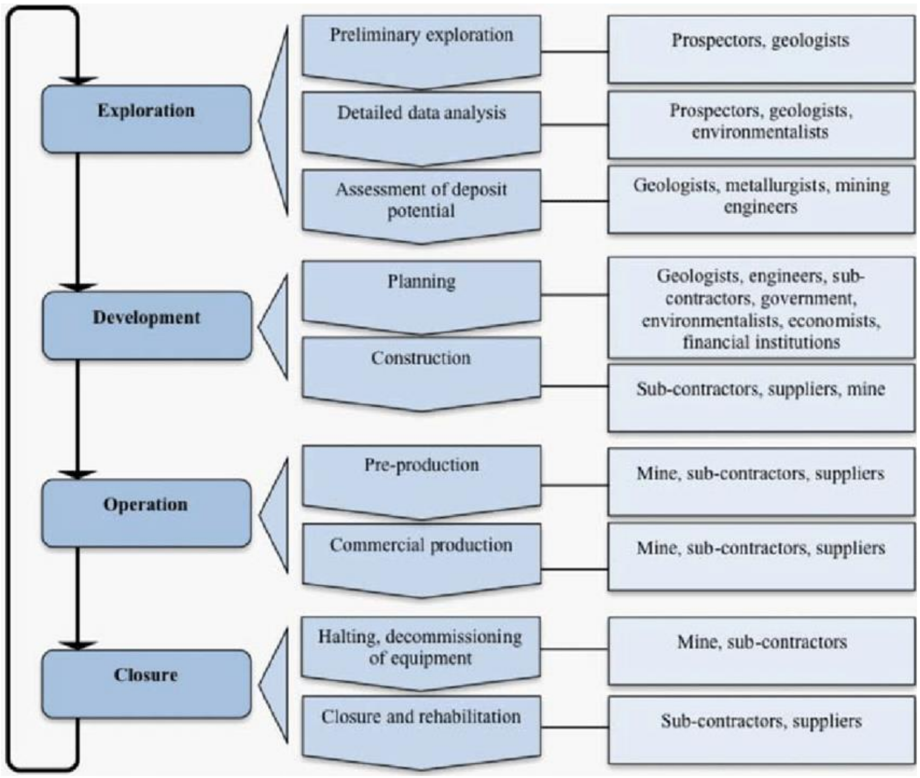

Figure 3. Life cycle of a mining project showing emissions sources at each stage.

Source: Ninti One Limited [Internet]. ResearchGate; 2015

Life cycle analyses suggest GHG intensity in mining ranges from 0.5 to 4.5 tCO_2e per tonne of mineral output, depending on energy sources and mineral type [6]. For example, copper and gold production typically have lower per-tonne emissions than coal mining, which also releases fugitive methane—a potent GHG with 25–28 times the warming potential of CO_2 [14].

Mineral Type	**Emissions (tCO_2e/tonne)**	**Notes**
Coal (bituminous)	2.5 – 4.5	Includes methane leakage [14]
Copper	1.5 – 3.0	Energy-intensive ore processing [6]
Gold	3.5 – 5.0	High emissions from chemical use [6]
Iron Ore	0.5 – 2.0	Lower relative intensity [5]

Source: Adapted from [5], [6], [14].

2.3.3 Global Emissions Benchmarks

Globally, mining contributes 4–7% of total anthropogenic GHG emissions, including:

- 1–2% from direct operations
- 3–5% from downstream energy use and refining [5,6]

In Australia, mining accounts for 11% of national emissions, driven by coal and LNG extraction. In Chile, copper mining emits ~28 $MtCO_2e$ annually, 60% from electricity use [5]. In South Africa, emissions are dominated by coal mining and refining, contributing ~14% of national GHGs [6].

These benchmarks show that Mongolia's mining sector—though smaller in scale—shares similar characteristics: high reliance on fossil energy, and limited renewable integration.

2.3.4 Mongolia in Context

Mongolia's 2022 GHG Inventory reports ~13.7 million tonnes CO_2e from the industrial sector, with over 30% attributable to mining [7].

- Oyu Tolgoi (OT) reported 346,089 tCO_2e (Scope 1) and 865,088 tCO_2e (Scope 2) in 2023 [29,32].
- Erdenes Tavan Tolgoi (ETT) is estimated to emit ~4.5 million tCO_2e annually, including methane leakage [33].

These emissions place Mongolia's mining firms above the global median in emissions intensity, reinforcing the urgency of developing offset strategies and MRV systems.

2.4 Carbon Offset Strategies for Mining

The mining sector, given its high energy demands and significant land-use footprint, presents several viable opportunities for carbon offsetting. These offset strategies not only help reduce emissions but also allow companies to monetize carbon reductions by registering them under credible standards such as Verra's Verified Carbon Standard (VCS) or the Gold Standard. This section outlines four primary offsetting strategies that can be applied within mining operations, drawing on both global benchmarks and Mongolia-specific data.

2.4.1 Afforestation and Reforestation

Afforestation and reforestation are widely used nature-based solutions, particularly suitable for restoring post-mining landscapes. According to the Asian Development Bank and UNDP, afforestation projects in temperate drylands like Mongolia can sequester approximately 4.2 tCO_2e per hectare per year [30]. Globally, mining companies such as BHP and Vale have implemented post-mining reforestation projects, sometimes achieving over 200,000 tCO_2e/year in offsets.

In Mongolia, degraded grasslands surrounding coal mines like ETT represent a substantial area for potential reforestation. A project covering 2,000 hectares could sequester roughly 84,000 tCO_2e per year, assuming full survival and growth of tree species adapted to steppe conditions. These projects can also deliver biodiversity and social co-benefits, such as rangeland restoration and community forestry.

2.4.2 Renewable Energy Integration

Diesel generators are often used in remote mining areas, emitting high levels of CO_2. Replacing diesel with solar, wind, or hybrid systems presents a high-yield abatement strategy. For instance, every 1 MWh of electricity from diesel emits approximately 0.9 tCO_2e, while renewables are virtually zero-emission [30].

Oyu Tolgoi is currently exploring wind power options estimated to generate up to 300,000 tCO_2e/year in emissions reductions [29]. Similar initiatives in Chile and South Africa show that large-scale solar and wind installations have reduced mining operational emissions by 15–25%.

2.4.3 Methane Capture from Coal Mining

Coal mines are significant sources of fugitive methane emissions. Methane is a potent GHG, with a global warming potential 28 times greater than CO_2 over a 100-year period [14]. According to the IPCC, methane emissions from underground coal mining can reach up to 90 kg CO_2e per tonne of coal extracted [21].

At ETT's current output of ~50 million tonnes/year, this implies a methane emissions potential of 4.5 million tCO_2e, of which approximately 1.4 million tCO_2e could be captured using standard gas drainage and flaring technologies [33]. Projects in China and Australia have successfully monetized captured methane under both voluntary and compliance markets, generating revenue and reducing health and safety risks.

2.4.4 Electrification of Mining Operations

Another viable strategy is the electrification of mining equipment, including haul trucks, drills, and support vehicles. Transitioning from diesel to electric fleets can reduce direct Scope 1 emissions significantly. While the upfront capital costs are high, reductions in fuel use and maintenance can improve long-term cost-efficiency.

For instance, replacing a diesel haul truck consuming 1,000 liters/day could save ~2.7 tCO_2e/day, or ~1,000 tCO_2e annually per vehicle [6]. Electrification is particularly effective when paired with renewable power sources, ensuring that indirect emissions are also minimized (Scope 2).

Strategy	Potential Reduction (tCO_2e/year)	Applicability	Barriers	Global Examples
Afforestation	40,000–100,000	Post-mining lands	Water, land tenure	Brazil, Mongolia
Renewable Energy	200,000–500,000	Power substitution	High CapEx, grid constraints	Chile, South Africa
Methane Capture	1–1.4 million	Coal mining	Equipment cost, safety	China, Australia
Electrification	50,000–150,000	Transport/fleet	Power infrastructure	Canada, Sweden

Sources: Adapted from [14], [21], [29], [30], [33]

2.5 Financial Aspects of Carbon Offsetting

Carbon offsetting isn't just about helping the environment—it can also generate revenue, reduce compliance costs, and improve a company's reputation. In today's carbon markets, verified emission reductions (called carbon credits) can be sold or traded just like other financial assets. Their value depends on how they're generated, the standards used, and how trustworthy the project is.

In the voluntary carbon market (VCM), where most of Mongolia's projects would currently fall, prices have ranged between USD 5 and 15 per tonne of CO_2e, though some high-quality nature-based credits (like reforestation) have sold for over USD 20 per tonne [2, 4, 8]. Prices in compliance markets, such as the EU ETS or Korea ETS, are typically higher. For instance, Korean ETS allowances exceeded USD 22/tCO_2e in 2023 [10].

For major Mongolian mining companies, this creates a real financial opportunity. If we take a conservative estimate of USD 10/tCO_2e, the two leading firms could generate the following revenue:

- Oyu Tolgoi (OT): With around 440,000–500,000 tCO_2e in potential offsets, that's USD 4.4–5 million/year.
- Erdenes Tavan Tolgoi (ETT): With up to 1.6 million tCO_2e/year, that's a potential of USD 16 million/year or more [29, 33].

These estimates are for the voluntary market. If Mongolia eventually connects to international compliance markets—like through bilateral deals under Article 6 of the Paris Agreement—these revenues could double or more.
On the cost side, projects vary:

- Afforestation can cost USD 800–1,200 per hectare, including planting and maintenance [30].
- Methane capture systems for coal mines can cost USD 10–15 million upfront, depending on scale and depth [14].
- Renewable energy installations (solar or wind) cost around USD 1–1.5 million per MW, depending on the site and infrastructure needs [30].

Offset Strategy	**Estimated CapEx**	**Annual Offsets (tCO_2e)**	**Cost per tCO_2e**	**Market Price (avg)**
Afforestation	$1,000/ha	4.2 tCO_2e/ha	~$7–12	$10–20
Methane Capture	$10–15M	1.4M tCO_2e	~$7–11	$10–22
Renewable Energy	$1M/MW	300,000 tCO_2e	~$8–10	$8–15
Electrification	Varies by fleet size	50,000–100,000 tCO_2e	$10–15	$10–15

Source: Adapted from [14], [30], [33], [35]

To assess whether a project is worth it, companies use something called Marginal Abatement Cost (MAC). This tells them how much it costs to reduce one tonne of CO_2e. This approach is widely supported in decarbonization planning and helps firms prioritize the most cost-effective emission reductions [35].

In Mongolia, early projects could be funded using blended finance, which mixes grants, loans, and future credit sales. Institutions like the Mongolian Green Credit Fund (MGCF) and international groups like the ADB or GGGI are already exploring this [12, 30].

Carbon offsetting isn't just good PR—it can help finance environmental improvements, attract international partnerships, and even prepare companies for future emissions regulations. But success depends on doing the basics right: reliable MRV systems, credit verification, and strong project design.

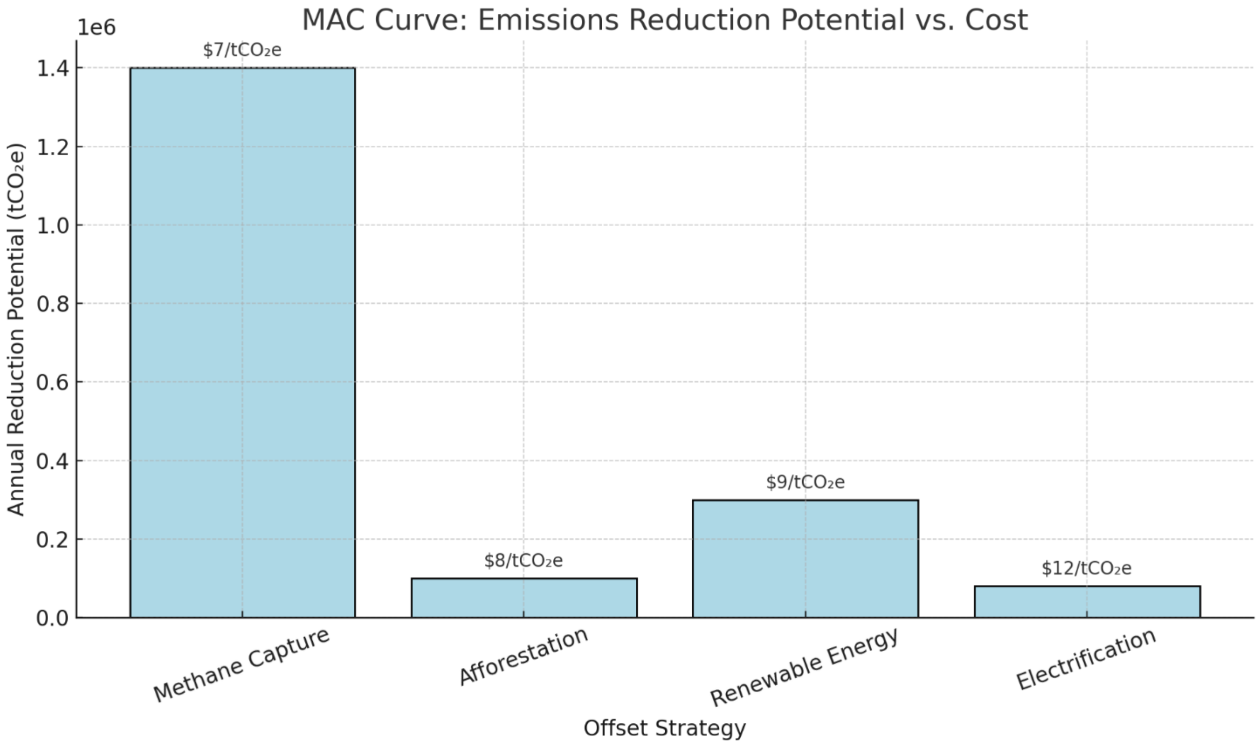

Figure 4. Revenue vs. Marginal Abatement Cost (MAC) Curve for Selected Offset Strategies

Source: Author's calculations based on data from [14], [30], [33], [35]

2.6 Barriers to Applying Carbon Offsets in Mining

Despite the rising interest in carbon markets, mining companies—especially in developing economies—face significant challenges in adopting and monetizing carbon offset strategies. These barriers fall into four main categories: regulatory, technical, financial, and social.

2.6.1 Regulatory and Policy Gaps

One of the most critical barriers in Mongolia is the absence of a dedicated legal framework for carbon trading. As of 2024, Mongolia has no binding emissions cap, national carbon pricing law, or domestic emissions trading scheme (ETS) legislation. Without these legal pillars, mining firms lack the regulatory certainty needed to invest in long-term offset projects. Additionally, the absence of standardized approval procedures for offset projects adds further ambiguity [26].

2.6.2 Technical and Institutional Capacity

Accurate measurement, reporting, and verification (MRV) of emissions and offsets is essential for credit issuance. However, Mongolia currently has very few accredited verification bodies, and most mining companies lack internal MRV expertise. For example, while OT has internationally audited MRV systems, ETT has no public GHG inventory and relies on modeled estimates [17, 33]. This gap weakens credit credibility and raises transaction costs, especially for firms new to carbon accounting.

2.6.3 Financial and Infrastructure Barriers

Offset projects—such as afforestation, renewable energy installations, or methane recovery—often require significant upfront capital. Methane capture systems alone can cost over USD 10 million for medium-scale coal mines [14]. In the absence of domestic carbon finance institutions or guaranteed carbon buyers, these investments are difficult to justify. Furthermore, Mongolia's reliance on coal-based power and limited grid flexibility constrains the deployment of renewable offsets.

2.6.4 Social and Land Use Conflicts

Nature-based solutions like afforestation or reforestation, while appealing from a carbon sequestration perspective, may trigger social resistance. In Mongolia, vast areas of steppe are used for traditional herding. Afforestation on these lands can lead to grazing conflicts, legal disputes over land tenure, and mistrust between communities and project developers [31]. Without inclusive planning and benefit-sharing mechanisms, such projects risk stalling or being revoked.

Barrier Type	Description	Example (Mongolia)	Mitigation Strategy
Regulatory	No emissions cap or carbon pricing law	No cap-and-trade legislation [26]	Pilot voluntary market, develop phased C&T law
Technical	Lack of MRV capacity and verifiers	ETT lacks verified emissions data [33]	Train local verifiers, use digital MRV (URECA)
Financial	High upfront costs for projects	Methane capture ≥ USD 10M [14]	Blended finance via MGCF, carbon pre-purchase
Social/Land Use	Resistance to afforestation in rangelands	Community mistrust of land use change [31]	Stakeholder engagement, benefit-sharing models

Source: Adapted from [14], [26], [31], [33]

2.7 Mongolia's Carbon Market Efforts

Mongolia's NDC outlines a 22.7% reduction target by 2030 [11]. Efforts toward carbon market development include:

- Partnership with Verra for VCS adoption [4]
- Establishment of URECA, a digital registry and MRV platform [24]
- Launch of the MGCF to support green infrastructure [12]
- Capacity-building with ICVCM and CCRCC [34]

These developments form the institutional foundation for carbon trading readiness.

2.8 Cap-and-Trade Systems in Focus

Cap-and-trade (C&T) systems are a foundational mechanism in compliance carbon markets and may offer a critical path forward for Mongolia's emissions reduction strategy. Under a cap-and-trade system, the government sets a maximum emissions limit (cap) for specific sectors. Entities receive or buy allowances corresponding to this cap and can trade them as needed. Those that emit less than their quota can sell allowances, while high emitters must buy more or face penalties [2,3].

Cap-and-trade promotes cost-effective emissions reductions by creating a financial incentive for companies to lower emissions where it is cheapest to do so. Over time, the total cap typically declines, pushing down national emissions in alignment with climate goals.

International examples provide tested models:

- **EU ETS**: Covers over 10,000 facilities across 30 countries; pioneered allowance auctions and offset limits.
- **Korea ETS**: Asia's first nationwide system, focused on manufacturing and energy.
- **California's C&T**: Integrates with Québec, includes carbon offsets and leakage prevention mechanisms [10].

Mongolia could adapt a phased C&T model, starting with large emitters such as OT and ETT. This would allow pilot testing of allocation rules, MRV processes, and offset integration.

Potential benefits for Mongolia include:

- Monetization of voluntary credits under a compliance regime
- Alignment with Article 6 of the Paris Agreement
- Strengthened investment signals for low-carbon technologies

Challenges include developing emissions baselines, legal authority, allocation mechanisms, and a domestic carbon registry. However, platforms like URECA and partnerships with Verra and ICVCM offer promising groundwork for future implementation [24,26,28].

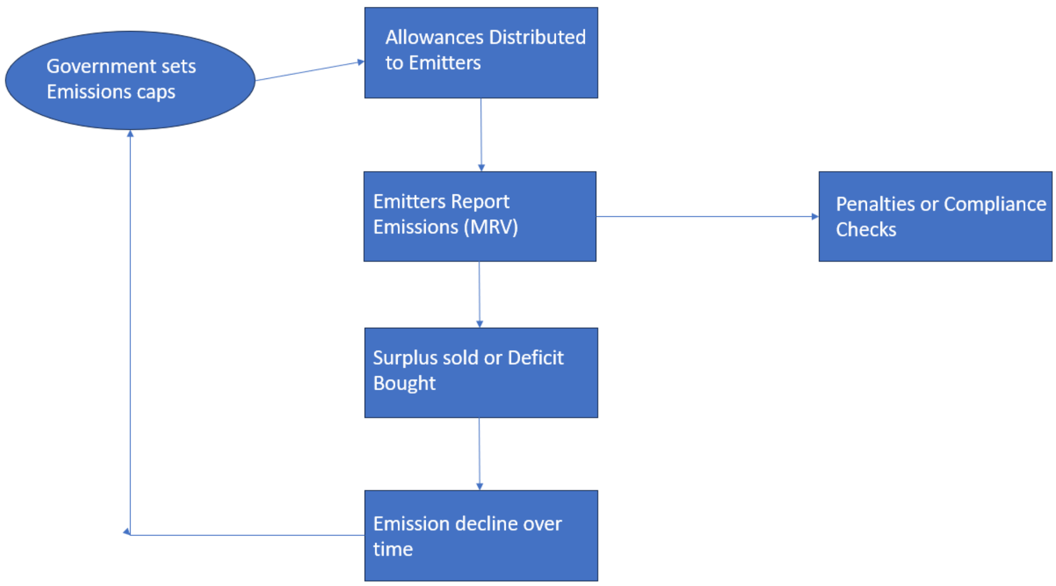

Figure 5. Cap-and-Trade mechanism Flowchart modelling Source: Own illustration

Chapter 3: Methodology and Case Analysis

3.1 Research Design and Philosophy

This thesis adopts a pragmatic, mixed-methods approach to explore the carbon offsetting potential in Mongolia's mining sector under a proposed cap-and-trade (C&T) system. It focuses on two leading mining firms—Oyu Tolgoi (OT) and Erdenes Tavan Tolgoi (ETT)—as case studies, providing empirical grounding for comparative analysis. The research employs a blend of qualitative policy review, emissions modeling, and evaluative frameworks such as SWOT analysis and stakeholder mapping.

3.2 Case Study Justification

The rationale for selecting OT and ETT is based on:

- Their national economic significance
- Contrasting emissions profiles (copper-gold versus coal mining)
- Differing ownership structures (private-joint venture vs. state-owned)
- Variability in transparency, governance, and reporting maturity

Together, these companies contribute substantially to Mongolia's industrial greenhouse gas emissions, making them ideal test cases for offsetting integration and early-stage carbon trading participation.

3.3 Emissions Baseline and Analysis

Establishing a credible emissions baseline is essential for modeling carbon offset potential. This section quantifies the GHG emissions of OT and ETT, disaggregating by scope and activity source, using company-reported data and IPCC default emission factors. The analysis supports the identification of high-impact mitigation and offsetting opportunities tailored to each firm's operational characteristics.

3.3.1 Oyu Tolgoi (OT)

OT reported **346,089 tCO_2e** in Scope 1 emissions and **865,088 tCO_2e** in Scope 2 emissions for the year 2023, totaling over **1.21 million tCO_2e** [29]. Scope 1 emissions include on-site fuel combustion, industrial processes, and blasting activities. Scope 2 emissions are dominated by imported electricity from Mongolia's central grid, which remains over 90% coal-powered [32].

Source	**Estimated Emissions (tCO_2e/year)**
Diesel combustion (vehicles and gensets)	140,000
Blasting and process emissions	80,000
Grid electricity (coal-based)	865,088
Miscellaneous and minor sources	125,000
Total (Scope 1 + 2)	~1.21 million

The emissions intensity is roughly **0.93 tCO_2e per tonne of copper concentrate** based on 2023 production figures [29]. OT has historically aligned its GHG reporting with ISO 14064 and IPCC Tier 2 methodologies and is audited annually by independent environmental consultants [30].

3.3.2 Erdenes Tavan Tolgoi (ETT)

Erdenes Tavan Tolgoi, through its operator Mongolian Mining Corporation (MMC), reported **1,185,370 tCO_2e** in direct (Scope 1) and indirect (Scope 2) emissions for 2023, based on verified GHG inventory disclosures [36]. This total represents the **GHG baseline year** declared by the company and was calculated using the operational control boundary and third-party verification.

Source	**Estimated Emissions (tCO_2e/year)**
Diesel combustion (mobile equipment and power generation)	1,168,554
Purchased electricity (Scope 2)	16,816
Total (Scope 1 + 2)	**~1.19 million**

Scope 1 emissions are primarily attributed to **diesel fuel use** in heavy-duty mining equipment, transport fleets, and backup generators. Fugitive methane emissions from coal seams are also captured in the Scope 1 estimate. Scope 2 emissions are relatively low, as MMC relies minimally on external electricity, instead using diesel-based generation for most operations.

The reported emissions intensity is approximately **0.081 tCO_2e per tonne of Run-of-Mine (ROM) coal**, based on a ROM output of 14.7 million tonnes in 2023 [36].

3.3.3 Comparison OT vs ETT

Metric	**Oyu Tolgoi (OT)**	**Erdenes Tavan Tolgoi (ETT)**
Scope 1 Emissions	346,089 tCO_2e	1,168,554 tCO_2e
Scope 2 Emissions	865,088 tCO_2e	16,816 tCO_2e
Total (Scope 1 + 2)	~1.21 million tCO_2e	~1.19 million tCO_2e
Emissions Intensity	~0.93 tCO_2e/t copper concentrate	~0.081 tCO_2e/t ROM coal
Primary Emission Source	Imported coal-based electricity	Diesel combustion and fugitive methane
Electricity Source	Imported from national grid (coal)	On-site diesel generators
Primary Offset Opportunities	Wind power, afforestation, electrification	Methane capture, revegetation, electrification

3.4 Offset Strategy Modeling

3.4.1 Methodological Approach

The modeling framework draws on established carbon methodologies from Verra's Verified Carbon Standard (VCS) and default emission factors from the IPCC 2019 Refinement Guidelines [4,21]. Each offset category was selected based on sector applicability, technical feasibility, and co-benefits in the Mongolian mining context. The following strategies were modeled:

- **Afforestation/Reforestation (A/R)**: Post-mining land use
- **Methane Capture**: Open-pit coal mining (fugitive emissions)
- **Renewable Energy Substitution**: Wind power and solar integration
- **Fleet Electrification**: Replacing diesel-powered haul trucks

3.4.2 Modeled Offset Scenarios – Oyu Tolgoi

Strategy	**Scale Assumption**	**Annual Offset Potential (tCO_2e)**	**MAC Estimate (USD/tCO_2e)**
Wind Power (50 MW)	300,000 MWh displacing grid	~300,000 [30]	~8–12
Afforestation (1,000 ha)	4.2 tCO_2e/ha/year	~4,200 [30]	~7–9
Electrification (20% fleet)	500,000 L diesel avoided	~100,000 [30]	~10–15

Total potential: ~404,200 tCO_2e/year, with most reduction coming from renewable substitution.

3.4.3 Modeled Offset Scenarios – ETT

ETT's emissions are dominated by diesel combustion and fugitive methane. The modeled offset strategies are:

Strategy	Scale Assumption	Annual Offset Potential (tCO_2e)	MAC Estimate (USD/tCO_2e)
Methane Capture	Capture from 40% of coal seams	~1.4 million [14]	~7–11
Revegetation (2,000 ha)	4.0 tCO_2e/ha/year	~8,000 [30]	~5–8
Electrification (partial fleet)	800,000 L diesel avoided	~200,000 [30]	~10–14

Total potential: **~1.61 million tCO_2e/year**, primarily from methane mitigation. Methane capture projects could align with methodologies such as ACM0008 (coal mine methane recovery) under UNFCCC frameworks [37].

3.4.4 Financial and Market Considerations

1. OT (Oyu Tolgoi):

- **Initial Offset Volume (2023):** 404,200 tCO_2e/year
- **Annual Growth Rate:** 2% (compounded)
- **Total Offset Volume (10 years):** ~4,425,877 tCO_2e

Scenario	Total Revenue (USD)
Conservative	$44,258,770
Moderate	$88,517,540
Aggressive	$132,776,310

2. ETT (Erdenes Tavan Tolgoi):

- **Annual Offset Volume:** 1,610,000 tCO_2e/year (flat)
- **Total Offset Volume (10 years):** 16,100,000 tCO_2e

Scenario	Total Revenue (USD)
Conservative	$161,000,000
Moderate	$322,000,000
Aggressive	$483,000,000

3. Combined Totals (OT + ETT):

Scenario	Total Revenue (USD)
Conservative	$205,258,770
Moderate	$410,517,540
Aggressive	$615,776,310

- **OT Contribution:** Grows from 404,200 tCO_2e/year to ~483,056 tCO_2e/year by 2034 (2% annual growth).
- **ETT Contribution:** Flat at 1,610,000 tCO_2e/year.
- **Revenue Drivers:** Carbon price scenarios dominate total revenue, with ETT contributing ~75% of total offsets due to its larger volume.

3.5 Stakeholder and SWOT Analysis

3.5.1 Stakeholder Analysis

The key stakeholders in Mongolia's carbon market development are:

1. **Mining Companies (Oyu Tolgoi and Erdenes Tavan Tolgoi)**
   - **Role:** Primary emitters and potential offset generators. They are pivotal in shaping Mongolia's participation in global carbon markets.
   - **Readiness:** OT has a high level of preparedness with robust MRV systems and established sustainability practices. ETT, though a larger emitter, lacks the internal infrastructure for carbon market participation.

2. **Government of Mongolia**
   - **Role:** Regulator and facilitator of the carbon market infrastructure. The government is responsible for creating policy frameworks, including carbon pricing, MRV regulations, and cap-and-trade legislation.
   - **Readiness:** The government has shown commitment through its 2021 NDC, which targets a 22.7% reduction in emissions by 2030, but lacks a formal carbon pricing mechanism.

3. **Carbon Credit Registries and Verification Bodies (e.g., Verra, URECA)**
    - **Role:** Entities responsible for verifying emissions reductions, registering projects, and issuing carbon credits.
    - **Readiness:** URECA is emerging as a key player in Mongolia, offering a blockchain-based registry that ensures transparency and digital traceability of carbon credits. Verra has partnered with Mongolia to build capacity.
4. **International Buyers and Carbon Finance Institutions**
    - **Role:** Purchasers of carbon credits, including multinational corporations and carbon finance organizations.
    - **Readiness:** International buyers are increasingly seeking to offset their emissions through high-quality carbon credits from emerging markets. The interest in Mongolia's potential as an offset supplier is growing.
5. **Local Communities and NGOs**
    - **Role:** Affected parties from land-use changes and potential environmental co-benefits of carbon offset projects (e.g., afforestation).
    - **Readiness:** Communities may benefit from carbon offset projects through job creation and environmental restoration, but may also resist certain land-use changes (e.g., reforestation in rangelands).

3.5.2 SWOT Analysis

Factor	**Oyu Tolgoi (OT)**	**Erdenes Tavan Tolgoi (ETT)**
Strengths	High institutional readiness, strong MRV system, established international reputation (Rio Tinto)	Large-scale operations with significant offset potential (methane capture, reforestation)
Weaknesses	Relies on coal-based electricity (Scope 2 emissions), high cost of transitioning to renewables	Lack of internal MRV capacity, limited emissions data, dependence on diesel and coal

Opportunities	Potential for scaling renewables, afforestation projects, and international offset revenue	Large-scale methane capture, high offset potential in coal mining, government support through MGCF
Threats	Regulatory delays in carbon pricing, political and environmental risks related to mining operations	Lack of verified emissions data, resistance to land-use changes in mining areas, lower MRV capacity

3.5.3 Key stakeholders in Carbon offsetting strategies

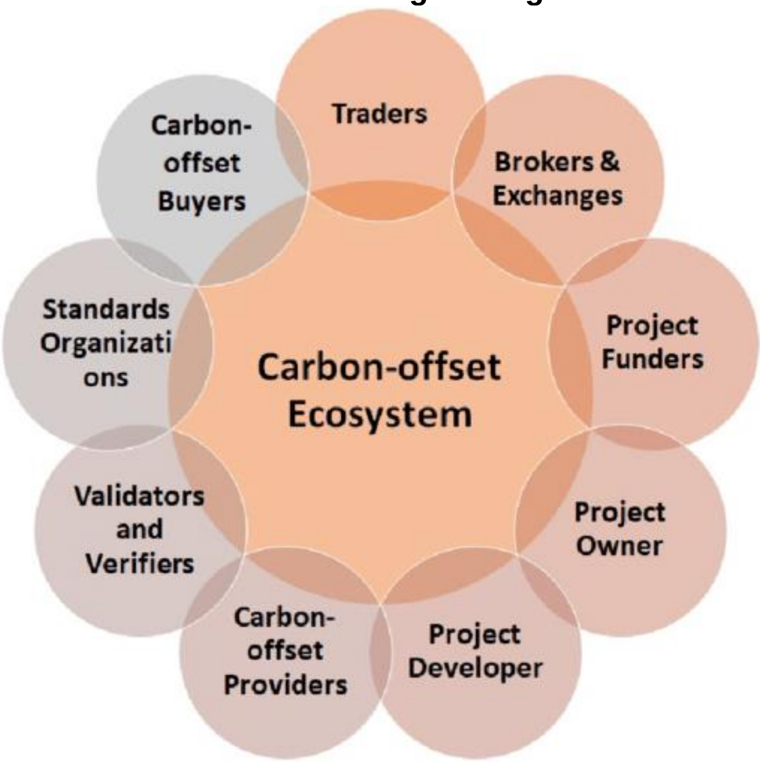

Figure 6. Key Stakeholders in the Voluntary Carbon-offset Ecosystem Source: Key Stakeholders in the Voluntary Carbon-offset Ecosystem, Dounia Marbouh

As shown in the diagram, carbon offset buyers purchase credits to neutralize their emissions, while traders and brokers facilitate the exchange of credits between sellers and buyers. The project developers and project owners create and manage the carbon offset projects, which generate the credits. These projects are verified and certified by validators and verifiers, who work in collaboration with standards organizations to ensure that the credits meet rigorous criteria.

Project funders provide the financial backing necessary to implement carbon offset projects, ensuring that the projects are adequately funded and sustainable. The interaction between all of these stakeholders drives the voluntary carbon market, ensuring that emissions are reduced and that the projects generate verified carbon credits.

3.6 Limitations

1. **MRV System Limitations**: Mongolia's Monitoring, Reporting, and Verification (MRV) infrastructure is still developing, with limited local verification capacity, which can affect the reliability and transparency of carbon offset projects.
2. **Regulatory and Policy Gaps**: Mongolia's lack of a formal carbon pricing mechanism and clear carbon market regulations create uncertainty for businesses like OT and ETT, hindering long-term planning for carbon offset projects.
3. **Social and Community Challenges**: Local communities may resist land-use changes, such as afforestation, due to concerns over impacts on traditional livelihoods. Effective **community engagement** is needed to address these concerns.
4. **Modeling Assumptions**: The study relies on assumptions and IPCC default values for emissions modeling, which may not fully reflect the unique characteristics of ETT's operations, introducing potential inaccuracies.
5. **Temporal Scope**: The study's assumptions are based on current technology and market conditions, which may change over time as new technologies and regulations emerge.

Chapter 4: Institutional and Technical Readiness for Carbon Trading

4.1 Institutional Framework and Policy Commitments

Mongolia’s 2021 NDC commits to a 22.7% GHG reduction by 2030. This commitment is detailed in the Government of Mongolia’s NDC submission [11]. In support, the government has:

- **Partnerships with Verra and ICVCM** to build domestic carbon market capacity and standardize **carbon offset protocols** [4, 23].
- The establishment of the **Mongolian Green Credit Fund (MGCF)** to provide financial support for green projects, including carbon offset initiatives [12].
- Collaboration with **URECA**, a digital MRV platform that integrates blockchain technology for carbon credit tracking, showcasing Mongolia's early-stage infrastructure for carbon trading [24].

Despite this progress, no formal cap-and-trade legislation or emissions ceiling currently exists. However, preliminary studies suggest future development of a phased emissions trading scheme is feasible based on global best practices [28].

4.2 Technical Readiness and MRV Capacity

One of the most critical components of successful carbon offset projects is MRV capacity. Accurate measurement, monitoring, reporting, and verification of emissions are essential for ensuring the integrity of carbon offset projects.

The need for a domestic MRV framework is evident. Mongolia's URECA platform, which provides digital carbon credit issuance and transparent tracking, is a promising development. However, capacity building for local verification bodies is necessary to ensure high-quality verification for a large number of offset projects.

Global best practices from markets such as the EU ETS, California’s Cap-and-Trade, and South Korea’s ETS emphasize the importance of transparent, independent MRV systems that are aligned with international standards to maintain market integrity.

4.3 MRV System as a Strategic Bottleneck

Mongolia's share of global GHG emissions is small (~0.1%) but its per-capita emissions are among the highest due to coal dependence. The mining and metals sector contributes roughly 4–7% of global emissions, making robust MRV systems essential [38,39]. However, MRV processes impose significant costs and delays. System development can range from USD 210,000 to 2.44 million depending on system complexity [40], with annual MRV operations averaging USD 50,000 for large-scale programs [41]. Monitoring and verification themselves cost between USD 0.15–1.40 per tCO_2, which can absorb up to 20% of total project budgets [42].

Carbon registries also impose financial and procedural burdens. Verra, for instance, charges USD 5,000 per initial validation (USD 2,500 credited back upon project registration) and collects USD 0.20–0.23 per issued carbon credit [43]. Meanwhile, their standard project review and issuance process takes ~20 business days per round—meaning full credit delivery often takes 3 to 6 months [44]. These costs and durations are significant, especially for new entrants with limited MRV experience or internal verification staff.

Fig 7. Conceptual stages of strategic MRV readiness (adapted from standard readiness frameworks).

OT vs. ETT MRV Scorecard

Metric	OT (Advanced MRV)	ETT (Traditional MRV)
Emissions inventory	Audited, ISO-aligned	Modeled estimates, unverified
ISO/Verra alignment	Compliant with ISO 14064 & VCS	None formally documented
Audit frequency	Annual third-party audit	None or ad hoc
Digital integration	URECA + internal sensors	Limited or absent
Verifier access	Accredited (external access)	No in-country verification

Sources: Adapted from [47], [46], [43], [39]

Estimated MRV Cost and Timeline Breakdown. *Typical MRV expenditures and durations by activity (all values approximate).*

Component	Estimated Cost (USD)	Typical Timeline
System setup	210,000 – 2,440,000	6–12 months
Annual reporting	50,000/year	Ongoing
Verification & validation	5,000–10,000	3–6 months
Credit issuance (Verra)	0.20–0.23 per credit	1–3 months

Overcoming MRV barriers requires Mongolian mining firms to strategically invest in institutional and technological capacity. Digitalization—such as the use of continuous emissions monitoring systems (CEMS), satellite-based remote sensing, and automated data platforms—can significantly improve inventory quality and reduce field labor costs [39,48]. Adopting internationally aligned protocols such as ISO 14064/14065 and Verra's Verified Carbon Standard (VCS) methodologies streamlines compliance with audit requirements and improves credit credibility [41,43]. Collaborative approaches—such as industry-wide MRV platforms or pooled verification contracts—can lower transaction costs by distributing fixed overhead across multiple projects [39].

International support programs can also accelerate readiness. The World Bank's open-source Programmatic MRV Infrastructure (PMI-MRV), already deployed in countries like Jordan and Sri Lanka, offers scalable blueprints for GHG tracking and offset accounting [48]. Aligning MRV systems with the expectations of leading frameworks—such as the EU Emissions Trading System (EU ETS) and the ICVCM Core Carbon Principles—can reduce review cycle durations and ensure that credits meet the most stringent international integrity benchmarks [43,44]. In sum, elevating MRV maturity through targeted investment and institutional collaboration is essential for Mongolia's mining sector to unlock access to global carbon finance and high-integrity offset markets.

4.4 Carbon Market Architecture: Lessons from Global Examples

Carbon Market Components in Global C&T Systems

Component	European Union Emissions Trading System (EU ETS)	California Cap-and-Trade (California ETS)	South Korea Emissions Trading System (KETS)	Mongolia (Proposed)
Regulatory Body	European Commission (EC)	California Air Resources Board (CARB)	Korea Ministry of Environment (MOE)	To be established (e.g., in collaboration with Verra, ICVCM)
Coverage	Power generation, heavy industry, aviation, and some sectors	Power generation, industrial emissions, transportation	Power generation, industrial emissions, transportation	Mining, power generation, and other key sectors
Emission Cap	Decreasing annually (set through allocation)	Decreasing cap, with a steady decline in allowances	Decreasing cap for all sectors with a 5% reduction target by 2025	Proposed cap based on national emissions reduction target (22.7% by 2030)
Allowance Allocation	Primarily auctioned, some free allowances for industries at risk of carbon leakage	Primarily auctioned with some free allocation to specific sectors	Primarily auctioned, with some free allocation for energy-intensive industries	Initially free allocation or auction based on sectoral needs
Market Mechanism	Trading of carbon allowances (permits) through EU ETS	Auctioning of allowances, trading within California's market	Auctioning of allowances and trading in Korea's ETS	Similar to EU ETS, potentially adopting auction and trading models
Offset Project	Only certain projects	Offset projects include	Limited offset projects; focus	Initially renewable

Types	approved by the EC (e.g., forestry, renewable energy)	renewable energy, forestry, methane capture, and others	on forestry, waste management, and renewable energy	energy, methane capture, and land restoration (e.g., afforestation)
Price Volatility	Moderate, with price floors to ensure minimum price stability	Moderate, with an established price floor and price ceiling	Lower volatility with a price ceiling to protect industry competitiveness	To be determined; price floors and ceilings might be introduced
Linkages with Other Markets	Linked with other systems (e.g., Switzerland, Norway, Iceland) through bilateral agreements	Potential linkage with Quebec and other North American systems	Potential linkage with China ETS in the future	Potential linkages with Article 6 of the Paris Agreement and voluntary carbon markets
Use of Offsets	Up to 10% of total emissions reduction target can be met using offsets	Up to 8% of emissions reduction target can be met using offsets	Up to 10% of emissions reductions can be met through international offsets	Initial reliance on domestic offsets, with potential for international credits through Article 6
Monitoring, Reporting, and Verification (MRV)	Robust MRV framework based on EU regulations	CARB-enforced MRV system, with third-party verification	Comprehensive MRV based on international standards	Proposed MRV systems, potentially aligned with international frameworks (e.g., Verra, ICVCM)
Compliance Penalties	Non-compliance results in fines and mandatory purchase of excess allowances	Penalties for non-compliance, including fines and auction purchases	Penalties for non-compliance, including the purchase of additional allowances	Penalties for exceeding carbon cap, with potential fines and mandatory credit purchases

Sources: [4], [26], [28], [23]

Mongolia can draw valuable lessons from global carbon markets that have successfully implemented cap-and-trade systems:

1. **EU ETS** – The largest and most established cap-and-trade system globally, providing critical insights into emissions cap setting, allowance allocation, and auction-based pricing.

2. **California's Cap-and-Trade Program** – A successful market that integrates offsets from projects like afforestation/reforestation and methane capture. California's offset system provides a model for including the mining sector in carbon trading schemes.[10]

3. **South Korea's ETS** – A hybrid system that combines auctioned and free allocation of allowances, providing a balance between incentivizing emissions reductions and protecting industries from excessive compliance costs.

These systems offer Mongolia important policy design considerations, particularly in terms of allocation methods, offset verification standards, and emission cap design.
Mongolia could adopt a voluntary phase for carbon markets, allowing projects like OT and ETT to test the market, refine MRV processes, and engage international buyers. As the market matures, the government could introduce more mandatory regulatory frameworks with gradually reduced emissions caps, similar to the EU ETS.

4.5 Sectoral Integration and Opportunity Windows

The mining sector presents unique challenges and opportunities for carbon trading integration. Key players like Oyu Tolgoi (OT) and Erdenes Tavan Tolgoi (ETT) have different capacities and needs, but both are critical to Mongolia's efforts in the global carbon market.

4.5.1 Oyu Tolgoi (OT)

OT is a highly advanced mining operation in terms of emissions reporting and MRV maturity.

Opportunities for OT:

1. Renewable Energy Integration: OT's ongoing renewable energy projects, such as wind power and solar integration, offer substantial emissions reduction potential. For example, wind power could offset up to 300,000 tCO_2e/year from the grid. Transitioning to renewable energy for its power needs could further reduce OT's reliance on fossil fuels, increasing its capacity to generate carbon credits.

2. Afforestation and Reforestation: OT has the opportunity to develop post-mining land rehabilitation projects, where reforestation could sequester approximately 4.2 tCO_2e per hectare annually. Expanding this program to include native species would provide environmental co-benefits, such as improved biodiversity and land restoration, while generating carbon credits.

3. International Carbon Market Integration: OT, with its established MRV systems, is well-positioned to participate in carbon markets, especially once Mongolia introduces a cap-and-trade system. The company can engage in international carbon markets and offset generation, monetizing emission reductions from projects like renewable energy and afforestation.

4.5.2 Erdenes Tavan Tolgoi (ETT)

ETT is a significant emitter within Mongolia's mining sector, primarily due to diesel combustion and methane emissions from coal seams.

Opportunities for ETT:

1. Electrification of Mining Fleet: Like OT, ETT can transition its fleet from diesel-powered machinery to electric haul trucks and mining equipment. This transition would reduce emissions from diesel combustion and could be incentivized through carbon finance mechanisms, particularly under future carbon trading systems.
2. Carbon Market Participation: Once Mongolia establishes its cap-and-trade system and carbon market infrastructure, ETT and OT, with its high carbon offset

potential, could play a key role in the carbon credit market. Projects like methane recovery and afforestation can generate high-quality carbon credits that are tradable in both domestic and international markets.

Chapter 5: Results and Discussion

5.1 Comparative Readiness and Financial Impact

Company	Offset Volume	Readiness	Market Value
OT	440-500kt	HIgh	$4.4–5M/year
ETT	1.6mt	Low	$16–25M/year

Oyu Tolgoi (OT) and Erdenes Tavan Tolgoi (ETT) both have substantial offset potentials, but their market readiness differs sharply. OT's internal analysis estimates roughly 440–500 ktCO_2e/year of offset capacity with a high readiness rating (market value ~$4–5 M/yr at USD 10/t$CO_2$e). ETT's potential is much larger (~1.6 MtCO_2e), worth an estimated $16–25 M/yr, but its readiness is rated low. This disparity largely reflects the state of their MRV and governance systems. OT has long aligned its GHG accounting with ISO 14064 and IPCC Tier 2 methods and undergoes annual third-party audits. In contrast, ETT currently has no publicly audited emissions inventory and relies on modeled estimates. In practice, OT's mature MRV infrastructure and renewable-energy focus mean it can generate verifiable carbon credits more swiftly, whereas ETT's larger volume remains latent until its MRV and reporting capabilities are upgraded. Thus, despite ETT's higher offset volume, OT is poised to realize early revenue from carbon credits, while ETT must invest in MRV enhancements before tapping its full market value.

Carbon Offset Potential vs. Market Value

Company	Offset Volume (tCO_2e/year)	Market Value at USD 10/tCO_2e	Market Value at USD 20/tCO_2e	Market Value at USD 30/tCO_2e
Oyu Tolgoi (OT)	404,200	USD 4.0–4.5 million/year	USD 8.0–9.0 million/year	USD 12.0–13.5 million/year
Erdenes Tavan Tolgoi (ETT)	1,610,000	USD 16 million/year	USD 32 million/year	USD 48 million/year

5.2 Key Risks and Mitigation Measures

Risk	Description	Mitigation Strategy
Legal Void	Lack of carbon pricing laws	Voluntary pilots and staged rollout
MRV Gap	Few accredited verifiers	Domestic MRV training and international partnerships
Social Risks	Land-use conflicts in reforestation	Community engagement and benefit-sharing
CapEx Costs	High cost for methane capture	Carbon finance and blended financing models

5.3 Interpreting the Findings

OT's mature infrastructure and financing enable high feasibility for wind, solar, and electrification projects. For example, wind energy at OT is rated *high* feasibility given existing grid plans, whereas ETT's remote location makes large-scale wind *low* feasibility. Afforestation on post-mining lands is *highly feasible* for OT compared to *moderate* feasibility at ETT. Methane capture at ETT is the single largest carbon source, but its feasibility is *moderate* due to the need for advanced capture technology and measurement systems, whereas OT's methane emissions are relatively minor.

OT, with its advanced MRV systems and substantial renewable energy infrastructure, is well-positioned to participate in both voluntary and compliance carbon markets. The company's focus on wind power, solar energy, and electrification makes it a prime candidate for carbon credit generation. Moreover, OT's extensive reporting and international audits give it an edge in the global carbon market, allowing it to generate verifiable carbon credits with relative ease.

On the other hand, ETT presents a much larger emissions profile, but its potential is somewhat constrained by the lack of MRV infrastructure and limited internal verification systems. While the company has substantial opportunities in methane capture and land restoration, it must overcome challenges such as the high capital costs of technology investments and the need for external verification to ensure the credibility of its emissions reductions.

Carbon Offset Strategy Viability and Feasibility

Offset Strategy	OT Feasibility	ETT Feasibility	Challenges/Barriers
Wind Power	High	Low	Requires significant upfront capital for infrastructure, grid integration
Afforestation	High (Post-mining land)	Moderate (Land availability)	Land availability, community engagement, long-term management
Methane Capture	Moderate (Some potential)	High	High capital investment, MRV systems needed
Electrification	High (Transition to renewables)	Moderate (Investment needed)	High CapEx for electric equipment, infrastructure limitations

5.4 Benefits of Cap-and-Trade Integration

Integrating carbon offset projects and transitioning to a cap-and-trade (C&T) system would offer several economic, environmental, and social benefits for Mongolia’s mining sector. Both Oyu Tolgoi (OT) and Erdenes Tavan Tolgoi (ETT) stand to gain from such integration, which could foster significant advances in emissions reductions, sustainable development, and financial opportunities.

5.4.1 Monetization of Emissions Reductions

One of the core benefits of cap-and-trade integration is the monetization of emissions reductions. Under a C&T system, OT and ETT could generate carbon credits by reducing or offsetting emissions, which they could then sell to international buyers or use to meet their own compliance obligations.

- OT, with its renewable energy projects and afforestation programs, could significantly increase its revenue streams by selling verified carbon credits.
- ETT, primarily focused on methane capture from coal mining, holds substantial potential to generate credits, especially considering its large methane emissions and the global emphasis on reducing methane as a potent greenhouse gas.

The establishment of a carbon market would therefore create a valuable opportunity for mining companies to financially benefit from their emissions reductions, providing a new revenue stream that could offset the costs of transitioning to cleaner technologies.

Company	**Offset Strategy**	**Annual Offset Potential (tCO_2e)**
Oyu Tolgoi (OT)	Wind Power	~300,000 tCO_2e
	Afforestation (1,000 ha)	~40,000 tCO_2e
	Electrification	~100,000–160,000 tCO_2e
Erdenes Tavan Tolgoi (ETT)	Methane Capture	~1.4 million tCO_2e
	Revegetation (2,000 ha)	~80,000 tCO_2e
	Electrification	~50,000–100,000 tCO_2e

5.4.2 Private Sector Innovation and Technology Adoption

Cap-and-trade systems incentivize private-sector innovation by providing economic signals that reward companies for reducing emissions in the most cost-effective ways. The market-driven nature of a C&T system encourages mining companies to invest in clean technologies, such as renewable energy sources, energy efficiency measures, and low-carbon equipment.

- OT, with its already advanced focus on wind power and solar integration, stands to benefit from further incentives to innovate, reducing reliance on fossil fuels and positioning itself as a leader in green mining.

- ETT, while currently lagging in technology adoption, could use the financial returns from carbon credit sales to invest in methane capture technologies, electrification of its fleet, and other emissions-reducing measures.

By driving innovation in energy production and emissions reduction technologies, the C&T system aligns financial incentives with environmental outcomes, creating a self-reinforcing cycle of improvement and progress within the mining sector.

5.4.3 Flexible Compliance Options

Cap-and-trade systems provide flexible compliance options for companies by allowing them to either reduce emissions internally or purchase carbon credits from other market participants. This flexibility allows companies to select the most cost-effective strategy to meet their emissions targets.

- OT could use its carbon credit generation capacity to meet internal emissions reductions, or alternatively, purchase credits if internal reductions are more costly.
- ETT, with its large methane capture potential, could generate a significant portion of its required credits through offset projects, allowing it to comply with emissions reduction goals without resorting to expensive external credits.

This flexibility lowers the overall cost of compliance with emissions reduction targets, offering companies the opportunity to manage their carbon liabilities more efficiently while still contributing to the global fight against climate change.

5.4.4 Alignment with Global Climate Frameworks

Integration into a cap-and-trade system would also align Mongolia's mining sector with global climate frameworks such as Article 6 of the Paris Agreement, which facilitates the transfer of carbon credits between countries. By participating in international carbon markets, both OT and ETT can access a broader range of buyers and markets for their carbon credits, increasing the demand for their offsets and driving up the price of credits.

This alignment would also place Mongolia in a stronger position to meet its nationally determined contributions (NDCs). With the country committed to reducing GHG emissions by 22.7% by 2030, active participation in carbon markets will help Mongolia leverage global climate finance and contribute to its international obligations. Moreover, as a developing economy, Mongolia can benefit from international climate funds that reward carbon market participation, unlocking further financial flows to support the green transition.

5.4.5 Supporting Sustainable Development and Local Communities

Cap-and-trade systems can also deliver social co-benefits through the integration of carbon offset projects that support sustainable development. Carbon offsetting projects such as reforestation, land restoration, and clean energy investments can provide local communities with access to new job opportunities, improved air quality, and enhanced environmental conditions.

- OT's afforestation projects, for example, can not only sequester carbon but also help restore ecosystems, prevent soil erosion, and create green spaces that benefit local communities.
- ETT's methane capture and land rehabilitation projects could provide economic opportunities for local herders and rural communities, who might otherwise face displacement due to mining activities.

By creating synergies between emission reductions and local development, cap-and-trade systems can align environmental goals with socio-economic growth, ensuring that carbon market mechanisms benefit both companies and communities.

5.4.6 Risk Mitigation and Long-Term Stability

Finally, cap-and-trade systems help mitigate risks by providing a long-term price signal for carbon, making emissions reduction investments more predictable. For companies like OT and ETT, this system can provide the stability needed to make long-term decisions about capital investments in clean technologies, energy transition, and land restoration.

Moreover, through engagement in carbon markets, companies can improve their environmental, social, and governance (ESG) profiles, making them more attractive to international investors and sustainability-focused stakeholders.

5.5 Remaining Challenges

While the foundational conditions for offset and C&T readiness are improving, several challenges persist:

- **Regulatory uncertainty**: The lack of enforceable emissions caps and sector-specific regulations delays private sector commitment.
- **Verification capacity**: Mongolia lacks accredited domestic VVBs (Validation and Verification Bodies), resulting in dependence on international certifiers.
- **Technical gaps**: Methane capture and renewable energy transitions require large capital investment and skilled labor.
- **Social equity**: Local resistance to afforestation projects in rangelands can threaten project success unless community co-benefits are transparently integrated.

These challenges can be mitigated through phased C&T introduction, pilot programs, blended financing, and robust community engagement through frameworks similar to those outlined by Climate Focus and the OECD [28,32].

5.6 Summary of Key insights

- **MRV is the Core Bottleneck**: OT is MRV-ready; ETT is not. This determines their respective carbon market readiness.

- **Offset Strategies Must Be Customized**: OT's comparative advantage lies in renewable energy and afforestation; ETT's lies in methane capture and electrification.

- **Financial Returns Are Uneven**: OT can realize early revenues. ETT's value depends on high-capacity investments and MRV system upgrades.

- **Cap-and-Trade Adds Structure**: Mongolia's cap-and-trade roadmap can institutionalize offsets and attract climate finance.

In summary, the results indicate that Mongolia's two largest mining companies can play pivotal roles in a nascent carbon market. Both OT and ETT have substantial offset potentials worth millions of dollars in carbon finance, but success hinges on robust institutional and technical foundations. These findings align with the carbon market literature: effective market-based mitigation requires credible MRV, clear regulation, and high-integrity credits. OT's advanced readiness and renewable focus mirror global best practices whereas ETT's scale offers greater leverage if capacity gaps are closed. Bringing these offsets into practice will require triangulating this quantitative potential with policy action. Continued evidence-based policy (as advocated by Article 6 readiness tools) and technology transfer can help overcome current barriers. In essence, the case study supports a cautious optimism: the theoretical gains from a carbon market – cost-effective abatement, innovation, and sustainable financing – are attainable for Mongolian mining, provided that emerging institutional readiness keeps pace with offset ambition.

Chapter 6: Recommendations for Mining Companies

6.1 Introduction

The transition to a low-carbon economy offers mining companies in Mongolia, such as Oyu Tolgoi (OT) and Erdenes Tavan Tolgoi (ETT), the opportunity to reduce their greenhouse gas emissions while simultaneously enhancing their financial performance. As the global demand for sustainability and carbon credits grows, mining companies must leverage their carbon offset potential to stay competitive in international markets. This chapter outlines recommendations for OT and ETT to strengthen their carbon offsetting capabilities and position themselves for success in future carbon markets.

6.2 Develop Internal Carbon Governance Structures

To effectively engage in carbon offsetting and participate in carbon trading systems, mining companies should first institutionalize carbon governance within their operations. This will ensure that sustainability is embedded into their corporate strategy and operations.

Recommendations:

- Establish a dedicated carbon management team: A team of experts within the company should be responsible for overseeing the company's carbon offset strategies and ensuring alignment with global standards (e.g., Verra and Gold Standard).

- Integrate carbon management into corporate strategy: Carbon reduction targets should be embedded in business plans, ensuring that carbon performance is a core component of overall company performance. This should include emission reduction targets, carbon credit generation goals, and financial planning to account for potential revenue streams from carbon credits.

- Implement a shadow carbon pricing mechanism: By incorporating internal carbon pricing (e.g., a shadow price on carbon), companies can better assess the cost-effectiveness of emission reduction strategies and prioritize projects that yield the highest returns in terms of both financial and environmental outcomes.

6.3 Invest in High-Integrity Offset Projects

For OT and ETT, investing in high-quality carbon offset projects is a critical step in ensuring long-term sustainability and marketability of their carbon credits. These projects should focus on activities with proven environmental and social benefits.

Recommendations:

- Afforestation and reforestation: Both OT and ETT can significantly benefit from land restoration and afforestation projects, particularly on post-mining land. These projects will generate carbon credits, improve local biodiversity, and provide ecosystem services such as soil stabilization and water retention.

- Methane capture projects: Which has substantial methane emissions from coal mining, implementing methane recovery systems will not only offset a large portion of their emissions but also prevent the release of a highly potent greenhouse gas.

- Renewable energy investments: Explore renewable energy sources like solar or geothermal energy to replace fossil fuels in its operations. These projects can help reduce Mining sector’s dependence on coal-based electricity and improve the environmental impact of its operations.

6.4 Strengthen MRV Capacity

To ensure that their carbon offset projects are credible and meet international standards, both OT and ETT must develop robust MRV systems. MRV is essential for verifying the amount of carbon sequestered or offset and ensuring compliance with carbon market regulations.

Recommendations:

- Invest in MRV infrastructure: OT and ETT should invest in advanced MRV tools and technologies that enable the real-time tracking of emissions reductions and the issuance of carbon credits.

- Collaborate with third-party verifiers: Both companies should work closely with accredited third-party verifiers (e.g., Verra, Gold Standard) to ensure that their emissions reductions are properly accounted for and verified according to global standards. These partnerships will enhance the credibility of their projects and make their carbon credits more attractive to buyers.
- Internal capacity-building: To avoid reliance on external parties, both companies should invest in building their own internal MRV capacity, training staff on best practices and ensuring compliance with international methodologies.

6.5 Engage with Policy and Pilot Programs

In addition to internal efforts, OT and ETT should actively engage with policy frameworks and pilot programs designed to facilitate the development of carbon markets in Mongolia. This engagement will help align their efforts with national goals and establish early credibility in the carbon market.

Recommendations:

- Participate in national carbon market consultations: Both companies should engage with the Mongolian government and international organizations like GGGI and Verra in the development of Mongolia's carbon market infrastructure. Participating in discussions and policy consultations will ensure that the companies' needs and challenges are considered in future regulations.

- Pilot carbon offset projects: OT and ETT should consider starting pilot programs for carbon offset projects in partnership with MGCF, Verra, or other international platforms. These projects will allow both companies to test their MRV systems, refine their strategies, and gain early market experience before the full implementation of Mongolia's carbon market.

- Advocate for a clear carbon pricing policy: Both companies should work with the Mongolian government to advocate for the introduction of a national carbon pricing mechanism, including emissions trading systems (ETS).

6.6 Leverage International Partnerships and Climate Finance

Given the capital intensity of carbon offset projects, it is crucial that both OT and ETT explore partnerships and financing opportunities to reduce the financial burden of their carbon offset programs.

Recommendations:

- Explore technology partnerships: Both companies could partner with technology providers specializing in methane capture, solar energy, or wind energy to reduce capital expenditure (CapEx) and gain access to the latest technologies for low-carbon solutions.

- Secure carbon pre-purchase agreements: OT and ETT can approach international buyers of carbon credits to establish pre-purchase agreements for future carbon credits, which would provide upfront capital for implementing offset projects.

6.7 Monitor Emerging Trends and Regional Markets

Lastly, OT and ETT should keep abreast of emerging trends in the global carbon market and regional emissions trading systems. This will ensure that they are positioned to take advantage of new opportunities and remain competitive in the evolving market landscape.

Recommendations:

- Track developments in global carbon pricing: As global carbon markets continue to evolve, OT and ETT must stay informed about changes to carbon pricing frameworks and cap-and-trade regulations. Monitoring systems such as ICVCM and Article 6 mechanisms will help the companies understand how they can integrate into the global carbon economy.

- Engage in regional carbon market collaborations: OT and ETT should consider potential partnerships with other Asian countries involved in carbon pricing, such as South Korea or China, to enhance regional market integration. This would provide opportunities for cross-border carbon trading and offset project exchanges.

Chapter 7: Conclusion and recommendation for future work

7.1 Conclusion

This study aimed to assess the feasibility and potential of carbon offsetting strategies for Mongolia’s mining sector, focusing on Oyu Tolgoi (OT) and Erdenes Tavan Tolgoi (ETT). Mongolia’s mining sector plays a vital role in the country's economy, contributing significantly to GDP, exports, and employment. However, the sector is also a major emitter of greenhouse gases (GHGs), making it critical for the country to explore avenues for carbon offsetting as part of its efforts to meet climate goals.

The findings from this thesis indicate that OT and ETT have considerable carbon offset potential, with projects such as afforestation, renewable energy adoption, and methane capture offering significant emission reduction opportunities. Specifically, OT's focus on renewable energy and ETT's potential in methane capture align with global trends in carbon offsetting and could serve as key contributors to Mongolia’s emissions reduction targets under the Paris Agreement.

However, the study also revealed significant challenges to implementing these strategies. Both companies face barriers related to monitoring, reporting, and verification (MRV) capacity, financial investments, and regulatory uncertainty. ETT, in particular, requires technological and financial support to develop robust MRV systems and capitalize on its methane capture potential. In contrast, OT is better positioned due to its existing MRV infrastructure and commitment to renewable energy.

This thesis underscores the importance of policy development and institutional readiness to support the integration of carbon offset projects into the Mongolian mining sector. Although the country has taken initial steps toward creating a voluntary carbon market, further regulatory clarity and institutional capacity are essential for successful market integration.

Mongolia’s progress toward establishing a cap-and-trade system and carbon pricing mechanisms is crucial to incentivizing offset projects and aligning with international carbon markets. As shown in the findings, both OT and ETT have the potential to generate revenue from carbon credits, improve their ESG profiles, and contribute to Mongolia’s national climate goals by integrating carbon offsetting into their operations.

7.2 Recommendations for Future Work

While this thesis provides a comprehensive analysis of the potential for carbon offsetting in Mongolia’s mining sector, several areas require further research and exploration:

1. Long-Term Economic Impact: Future studies could assess the long-term economic impact of carbon offsetting in Mongolia’s mining sector, particularly in terms of job creation, local development, and sectoral sustainability.
2. Integration with Global Carbon Markets: Further research should investigate the feasibility of linking Mongolia’s carbon market with global compliance systems like the EU ETS or California’s cap-and-trade system. This could provide more liquidity for Mongolia’s carbon credits and drive higher prices.
3. Carbon Finance and Investment Models: A deeper analysis of carbon finance mechanisms, such as green bonds, blended finance, and climate investment funds, could offer valuable insights into how to finance large-scale carbon offset projects in Mongolia’s mining sector.
4. Social Impact of Carbon Offset Projects: More studies are needed on the social impacts of carbon offset projects, particularly regarding community involvement in land restoration, afforestation, and energy access projects in mining regions.
5. Technological Innovation in Carbon Capture: Given the significant methane emissions from coal mining, further research could explore cutting-edge methane capture technologies and their potential for scaling up in Mongolia’s mining operations.

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