2025 Executive Summary

ENUGU CLEAN COMMODITIES HUB

COAL REIMANGINED

JEVKON MINING

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Legal Disclaimer

This document has been prepared solely for informational and analytical purposes in support of the preliminary assessment of the Integrated Enugu Coal Project in Nigeria. It is intended to facilitate stakeholder engagement, policy dialogue, and strategic planning in alignment with national development priorities and the Sustainable Development Goals (SDGs).

The contents of this report, including all data, projections, and recommendations, are based on publicly available information, stakeholder consultations, and indicative assumptions as of the date of publication. While reasonable efforts have been made to ensure the accuracy and relevance of the information presented, no representation or warranty, express or implied, is made as to its completeness, accuracy, or fitness for any particular purpose.

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Parties interested in pursuing any of the options outlined in this report are advised to seek independent professional advice and to engage directly with the relevant authorities and project sponsors.

Document is not a solicitation and all estimates are Class 5 AACE International and GARP recommended practice.

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SEDC
Southeast Development Commission

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NEEDS ANALYSIS

OPTIONS ANALYSIS

Enugu Clean Commodities Hub Concept

1. Executive Summary

The Integrated Enugu Coal Project is a proposed public-private partnership (PPP) between **Jevkon Mining & Power Ltd** and the **Southeast Development Commission (SEDC),** designed to transform Nigeria's underutilized coal reserves into a driver of clean industrialization, energy security, and regional economic development. This report presents a *structured needs analysis* aligned with **UNDP** and **World Bank** PPP methodologies and evaluates strategic options for coal valorization in support of Nigeria's **Sustainable Development Goals (SDGs).**

2. Project Context

Enugu State holds significant coal reserves that have remained largely untapped due to legacy environmental concerns, limited infrastructure, and policy inertia. The proposed project seeks to unlock these resources through a vertically integrated model that includes mine-mouth power generation, downstream industrial processing, and infrastructure development. The PPP structure enables risk-sharing and alignment with regional development priorities under the Southeast Development Commission.

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3. Needs Analysis

Category	Current State (Needs)	Desired State (Outcomes)
Energy Access	Unreliable grid power in SE Nigeria	Stable, dispatchable power from mine-mouth generation with CCUS
Stranded Assets	Underutilized coal reserves	Coal valorized through clean conversion technologies
Employment	High youth unemployment	5,000+ direct and indirect jobs created
Industrialization	Limited downstream processing	Integrated industrial park with cement, fertilizer, and carbon materials
Public Services	Weak infrastructure and social services	Roads, clinics, and training centers delivered through PPP
Environmental Risk	Legacy degradation from artisanal mining	Modern, monitored extraction with environmental remediation
SDG Alignment	Fragmented progress on SDGs	Measurable contributions to SDGs 7, 8, 9, 12, and 13

4. Stakeholder Mapping

- **Private Sponsor**: Jevkon Mining & Minerals Ltd
- **Public Partner**: Southeast Development Commission (SEDC)
- **Regulatory Authorities**: Federal Ministry of Mines and Steel Development; Ministry of Environment
- **Investment Promotion**: Nigerian Investment Promotion Commission (NIPC)
- **Host Communities**: Local governments and civil society in Enugu State
- **Technical Partners**: Prospective Chinese EPC+F firms
- **Development Partners**: UNDP Nigeria, AfDB, and potential DFI co-financiers

5. Project Objectives and Expected Outputs

Objectives:

- Monetize stranded coal assets through clean, high-value applications
- Establish a regional industrial hub with energy and materials security
- Deliver measurable SDG-aligned development outcomes

Expected Outputs:

- 300–600 MW mine-mouth power plant with CCUS
- Coal-to-methanol or coal-to-carbon fiber facility
- Industrial Park with cement, fertilizer, and rare earth processing
- Over 5,000 jobs created
- $500M+ in foreign direct investment mobilized
- Upgraded infrastructure and public services in host communities

6. Options Analysis

A multi-criteria evaluation was conducted to assess the viability of various coal utilization pathways.

Option	Economic Impact	Environmental Risk	Job Creation	Tech Readiness	SDG Alignment	Composite Score (1–5)
Coal-to-Electricity (w/CCUS)	High	Medium	High	High	SDG 7, 9, 13	4.2
Coal-to-Methanol (w /CCUS)	High	Low	Medium	Medium	SDG 7, 12	4.0
Coal-to-Carbon Fiber	Medium	Low	Medium	Low	SDG 9, 12	3.6
Coal-to-Rare Earth Extraction	Medium	Medium	Low	Low	SDG 9, 12	3.2
Coal-to-Acid (e.g. sulfuric)	Low	Medium	Low	High	SDG 9	2.8

Preferred Option: Coal-to-Electricity with CCUS is the most viable anchor due to its immediate energy benefits, high employment potential, and alignment with Nigeria's Energy Transition Plan.

Complementary Options: Methanol and carbon fiber production offer medium-term diversification and export potential. Rare earth extraction may be explored as a strategic niche.

7. Recommendations and Next Steps

- Finalize feasibility studies and environmental assessments
- Engage EPC+F partners and development finance institutions
- Structure a bankable PPP with clear risk allocation and community benefit-sharing
- Align with UNDP Nigeria and SDG Impact Standards for monitoring and reporting
- Initiate stakeholder consultations and secure regulatory approvals

CERTIFICATION

Terry L. Easley
Chairman & CEO
Tenet DFS LLC
Registered Investment Banker (RIB) -US
Member London Institute of Banking & Finance (MLIBF)-UK
OECD Certified
UNDP PPP Certified
World Bank PPP Certification
Member AACE, GARP and AFIO

Lawrence W. Rougeux
Managing Director - USA
Tenet DFS, LLC
Engineer

Cc: Lawrence W. Rougeux, Managing Director, Tom Thornhill, Outside Counsel, Taj Miah Director London Office.

JEVKON Mining

2025/26

COAL REIMAGINED... INTEGRATED H.E.L.E POWER PLANT & CCUS

This proposed US$ 3.25 Bn Public/Private Project envisions the *expansion and modernization* of an existing 4+ million MTPA coal mine, dedicated rail transport infrastructure, and a 600 MW state-of-the-art High-Efficiency, Low-Emissions (HELE) coal-fired power plant in Enugu State - Nigeria's Coal Hub. Other profitable verticals include Coal to Methanol (CTM), Coal to Carbon Fiber (CTCF), Coal to Rare Earth Extraction (CTREE) and Activated Charcoal Production.

Show Me the Money

Rank	Opportunity	Revenue Potential	EBITDA (Est.)	CapEx	OpEx ./ year	ESG Rating	Permits Required
1	Coal-to-Methanol + CCUS	$150M–$180M/year	$60M–$75M/year (~40% margin)	~$400M	$25M–$35M	High (with CCUS, ZLD)	EIA, CCUS, NESREA, Air/Water permits
2	Activated Carbon Plant	$10M–$20M/year	$4M–$10M/year (~50% margin)	$8M–$15M	$1.5M–$2.5M	Very High (bio-blended, circular)	Streamlined EIA, NESREA, Fire safety
3	REE Extraction from Ash	$10M–$50M/year (speculative)	$5M–$20M/year (30–50% margin)	$20M–$50M	$5M–$10M	Moderate–High (if ash concentration viable)	EIA, Hazardous Waste, NNRA, Water discharge
4	Coal-Based Carbon Fiber	$30M–$100M/year	$10M–$35M/year (20–35% margin)	$50M–$100M	$7M–$12M	Medium (VOC + chemical handling)	EIA, VOC, Chemical storage, Safety
5	Humic Acid Extraction	$2M–$5M/year	$1M–$3M/year (50–60% margin)	$2M–$5M	<$1M	Very High (soil health, regen ag)	EMP, Water use/discharge, Fertilizer reg.

Coal to Chemicals

Coal-to-Methanol + CCUS

Mission Critical Data

Enugu Coal Profile

Coal Type

- **Rank**: Sub-bituminous to bituminous
- **Carbon Content**: Moderate to high
- **Sulfur Content**: Low (advantageous for ESG compliance)
- **Ash Content**: Moderate; manageable with beneficiation
- **Geological Formation**: Mamu Formation (Lower Coal Measures) within the Anambra Basin

Suitability

- **Gasification** (for methanol, ammonia, DME)
- **Activated Carbon** production
- Potential **Rare Earth** element (REE) extraction from ash
- **Humic Acid** extraction for regenerative agriculture

Enugu Coal is relatively high in carbon content and low in sulfur, making it suitable for chemical processing (like methanol synthesis) and activated carbon production, rather than combustion for power. Some seams also show signs of natural coke formation due to historical igneous intrusions, which could be valuable for metallurgical applications

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Value for Money Framework

EICCP stands for Enugu Integrated Clean Commodities Project.

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It all starts with...

Coal

We leverage Nigeria's Abundant Natural Resources
To create Jobs & Sustainable Economic Development

It's the umbrella name we've developed to frame the full industrial vision in Enugu—combining **Carbon-Neutral Coal-to-Methanol Production**, **Activated Carbon manufacturing**, and potentially **Rare Earth Extraction** and **Humic Acid valorization**. The emphasis is on "integrated" because the facilities share infrastructure, ESG frameworks, permitting paths, and feedstock logistics—positioning the whole initiative as **a cohesive, world-scale clean industry hub.**

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Enugu Integrated Clean Commodities Project

The Enugu Integrated Clean Commodities Project (EICCP) in Enugu, Nigeria is Designed for *Carbon Neutrality* through CCUS, biomass integration, and circular production empowered by the latest Chinese Technologies.

Eligible for green bonds, carbon credits, and SDG-linked funding under Article 6 and the *Voluntary Carbon Market*. Directly creating over 1,200 high-quality jobs; enabling thousands more through downstream industries, logistics, and agro-waste supply chains.

We will Revitalizing Enugu's mining communities through safe, modern, and ESG-certified coal operations..

Sustainability & Carbon Credentials

Coal Reimagined...

Impact & Differentiation

Our planned **Methanol & Carbon** products are globally traded, fungible commodities—with strong demand across fuel, water, mining, and chemical sectors. Unlike traditional coal use, **EICCP valorizes coal as a chemical feedstock—not a fuel. This maximizes profit and minimizes emissions.**

#CleanCommoditiesFromCoal

Investor-Ready: Low-Risk Feedstock. High-Margin Outputs. Global Long-Term Offtakes.
Fully Bankable: Supported by Blended Finance strategy, Sovereign Alignment, and independently Verified Impact Metrics.

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OBJECTIVE:

Reopen and modernize underground coal mines in Enugu as a sustainable, integrated feedstock source for methanol and activated carbon production.

Reopening the Mines Challenges & Opportunities

Challenges

Legacy Infrastructure: Most mines (e.g., Onyeama, Okpara, Iva Valley) were underground and abandoned without proper closure.

Environmental Hazards: Ground subsidence, water contamination, and methane buildup have been reported in communities like Nsude and Umulumgbe.

Community Concerns: Past neglect of miners and environmental degradation have created trust deficits.

Regulatory Complexity: Requires full EIA, mine safety audits, and community development agreements under Nigeria's Minerals Act.

Opportunities

Existing Shafts & Access Roads: Reduces upfront development costs if rehabilitated properly.

Government Re-engagement: Enugu State has signaled interest in revitalizing coal assets under new ESG frameworks.

Modern Mining Tech: Battery-electric loaders, methane capture systems, and digital ventilation controls can make underground mining safer and cleaner.

Integrated Project Synergy: Reopening mines as part of the **Enugu Integrated Clean Commodities Project (EICCP)** ensures shared infrastructure, ESG oversight, and feedstock security.

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COAL IS THE CLEAR WINNER!

Factor	Coal-to-Methanol (CTM)	Gas-to-Methanol (GTM)
Feedstock Cost	Lower in coal-rich regions like Enugu; stable long-term pricing	Volatile pricing; sensitive to global LNG and pipeline gas markets
CAPEX	Higher due to gasification, ash handling, and CCUS integration	Lower—simpler reforming process
OPEX	Higher (solid feedstock handling, slag disposal, CO_2 capture)	Lower (cleaner feedstock, fewer byproducts)
Carbon Intensity	High without CCUS; moderate with CCUS (~1.5–2.0 tCO_2/t methanol)	Lower baseline emissions (~0.5–1.0 tCO_2/t methanol)
Carbon Credit Potential	High—CCUS can generate 1–1.5 $MtCO_2$/year = $30M–$75M/year in credits	Moderate—limited CCUS potential unless paired with blue hydrogen
Product Yield	~1 tonne methanol per 1.5–2.0 tonnes coal	~1 tonne methanol per 30–35 MMBtu natural gas
Strategic Fit (Nigeria)	Strong—leverages domestic coal, supports industrialization, aligns with INFF & CCUS goals	Weaker—Nigeria's gas is often flared or exported; domestic pricing can be uncertain

In the key dimensions—cost, carbon intensity, scalability, and strategic fit—Our considered assessment is that coal-to-methanol (CTM) stacks up well against natural gas-based methanol (GTM) production metrics.

Enugu Project

Techno-Economic Comparison: Coal vs. Natural Gas Methanol

GTM is cheaper and more efficient in mature markets with abundant, low-cost gas (e.g. U.S., Qatar).

CTM becomes competitive when Natural gas prices exceed ~$4/MMBtu.

Carbon credits or green finance mechanisms are monetized.

Domestic coal is underutilized and infrastructure exists (like in Enugu).

CTM + CCUS offers a compelling climate-smart industrialization pathway for coal-rich, Enugu.

JEVKON will produce **globally traded, fungible commodities**

That are in **High and Growing Demand**

Tenet DFS LLC

Our Advanced Critical Analysis

CTM is the highest and best use of Enugu's Coal

Implications for Enugu

- If Nigeria's domestic gas price trends above $4.50/MMBtu and carbon credits are monetized, CTM can rival GTM economically.
- Enugu's untapped coal + CCUS potential gives it a policy-enabled cost advantage under INFF-aligned carbon finance.
- Pairing CTM with downstream derivatives (e.g. acetic acid, DME, SAF) increases overall returns.

Note: A gas price above the breakeven level means CTM becomes competitive or preferred, especially if gas availability is limited or monetized through LNG exports.

Scenario Matrix – Break-Even Gas Prices

Carbon Credit ($/tCO$_2$)	Effective CTM Net Cost	Breakeven GTM Gas Price
$0	$330/tonne	~$6.50–$7.00/MMBtu
$30	$285/tonne	~$5.50/MMBtu
$50	$255/tonne	~$4.50–$5.00/MMBtu
$75	$215/tonne	~$3.50–$4.00/MMBtu

> Note: A gas price above the breakeven level means CTM becomes competitive or preferred, especially if gas availability is limited or monetized through LNG exports.

Assumptions for World-Scale CTM Plant (1 Mt/year methanol):

- Coal cost: $20–$30/tonne
- Gas price: Variable ($2–$8/MMBtu)
- CTM production cost: ~$250–$350/tonne methanol (with CCUS)
- GTM production cost: ~$180–$280/tonne methanol
- Carbon credit from CTM: $30–$75/tonne CO_2 captured (assume 1.5 tCO_2/tonne methanol)
- Enugu's untapped coal + CCUS potential gives it a policy-enabled cost advantage under INFF-aligned carbon finance.

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Enugu State: A low-cost region to produce Coal Products

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MINING

Vision:

Transform Enugu's underutilized coal reserves into **World-Scale Production of high-value, globally traded, low-emissions commodities** that align with Nigeria's energy transition and Sustainable Development Goals.

Enugu Integrated Clean Commodities Hub

OPPORTUNITY VERTICLES

Vertical	Use Case / Market	Estimated Output	Revenue Potential	Carbon or Strategic Advantage
Coal-to-Methanol + CCUS	Chemical feedstock, hydrogen fuel	~1 Mt/year	$300M–$400M/year	CO_2 credits: $30M–$75M via CCUS (1.5 Mt/year)
Coal-to-Carbon Fiber	EVs, drones, aerospace, construction	5,000–10,000 t/year	$100M–$200M/year	High-tech export diversification
Rare Earth Recovery (from coal ash)	Electronics, magnets, renewables	1,000–2,000 t/year (mixed)	$50M–$100M/year	Strategic critical minerals sourcing
Activated Carbon Production	Water treatment, air purification, industry	20,000–30,000 t/year	$40M–$60M/year	Circular economy, ESG-aligned
Coal-to-Acetic/Formic Acid	Textiles, plastics, agro-food industries	~100,000 t/year	$80M–$120M/year	Import substitution + regional chemical hub

Unlocking Coal's Strategic Potential Beyond Power Generation

Transforming Enugu's reserves into Clean Methanol with CCUS & Climate Finance.

- ✅ Unlocks globally traded, low-emissions commodity markets
- ✅ Integrates carbon credit monetization and blended finance
- ✅ Anchors industrial growth, job creation, and ESG compliance
- ✅ Aligns with Nigeria's INFF and Green Bond Framework

Domestic Coal Monetization — Adds value to stranded assets

Global Commodity Integration — Methanol, DME, SAF as exports

Industrial Diversification — Chemicals, materials, carbon fiber

Climate-Aligned Capital — Green bonds, carbon markets, INFF tools

JEVKON's proposal possesses the **Quality & Clarity** needed to Be in Full Compliance with Legal, Technical & Financial requirements

ENUGU / 2025

Roadmap to Execution

Technical Feasibility & Pre-FEED - 2026

Permitting, Green Financing, EPC - 2027–28

FID + Construction - 2029-2030

Commercial Methanol Exports Begin

Enugu Clean Commodities Project: Coal-to-Methanol + CCUS
A Clean Industrial Breakthrough for Nigeria's Energy Transition

"We're not asking the public purse to carry this burden. We're offering a bankable platform where private capital delivers public returns—jobs, decarbonization, export value."

-Dr. Mkgeorge Okon Onyung MD, Project Sponsor

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The initial proposals from **JEVKON** appear to meet or exceed the **Quality & Cost Based Selection (QCBS)** criteria of **UNDP** under **Project** & **EPC&F** Finance models

Dr. Mkgeorge O. Onyung, MD

MEDICAL DOCTOR
BUSINESSMAN
ENTREPRENEUR

Dr. "O" is a respected medical professional, ship owner & businessman in Nigeria. He provides legal and political cover for his foreign partners and insights into the domestic business environment. He is known for his leadership and management skills related to local content requirements for Foreign Direct Investment (FDI)

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In Public / Private Partnership with the Southeast Development Commission of Nigeria

Strong Local Relationships

Dr. "O" is a highly valued partner who possess deep, established relationships with local and federal government entities.

Content Expertise & Compliance

Nigeria increasingly emphasizes local content requirements, which can be complex and vary by sector. Dr. O is a partner who understands these mandates intimately and can ensure full regulatory compliance.

Project Sponsorship

A partner who can actively "sponsor" the project through its development stages, bearing pre-financial close costs, taking ownership of project development risks and providing a stable local counterpart.

Highly Educated & Habituated to the Contest

Dr. Onyung is an experienced leader in the Nigerian Economy and Political Scene who can leverage decades of business activity for his foreign partners from China. He is currently serving in his second term as president of the Ship Owners Association of Nigeria (SOAN) elected from the membership. SOAN is one of the most important associations in the counry

Dr. Onyung
Your Trusted Local Partner

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www.tenetdfs.com

This project lays the foundation for an ***Investment-Class Industrial Transformation*** aligned with ***National Development***

Where Climate Finance Meets Industrial Strategy

"This isn't just a methanol plant—it's a blueprint for how Nigeria's untapped resources can power sustainable growth. The Enugu Clean Commodities Hub is designed from the ground up to align with Nigeria's **Integrated National Financing Framework (INFF),** creating a bridge between industrial ambition, climate commitments, and public-private capital flows.

Through INFF Pillar 1, we're anchored in the nation's development priorities: clean energy, job creation, and industrial diversification. With Pillar 2, we've structured the project for green bond eligibility, carbon market monetization, and blended finance—unlocking both domestic and international capital.

We've built in transparency and results through INFF Pillar 3, with climate-tagged outcomes that speak to both ministries and markets. And our approach to governance under Pillar 4 ensures this isn't just another project—it's a platform for coordinated institutional delivery.

The result: an investable, export-ready, *ESG-compliant* infrastructure play that turns Enugu's stranded coal into a low-carbon, globally traded commodity—methanol—while capturing and monetizing over 1.5 million tonnes of CO_2 annually.This is how we turn Nigeria's climate commitments into bankable assets. And this is how INFF thinking becomes INFF doing."

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Coal-to-Methanol + CCUS

Business Case: World-scale facility producing globally traded, fungible methanol. Marketable as carbon-neutral with CCUS integration.

By-products: CO_2 (for urea or EOR), slag (construction), sulfuric acid

Environmental: High baseline impact, but dramatically improved with carbon capture and zero-liquid discharge

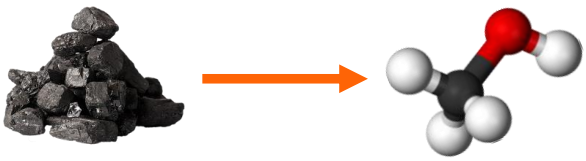
Key Permits: Federal EIA approval (through FME)CCUS licensing (if injecting or commercializing CO_2)NESREA air/water emission permits, Green bond certification (optional).

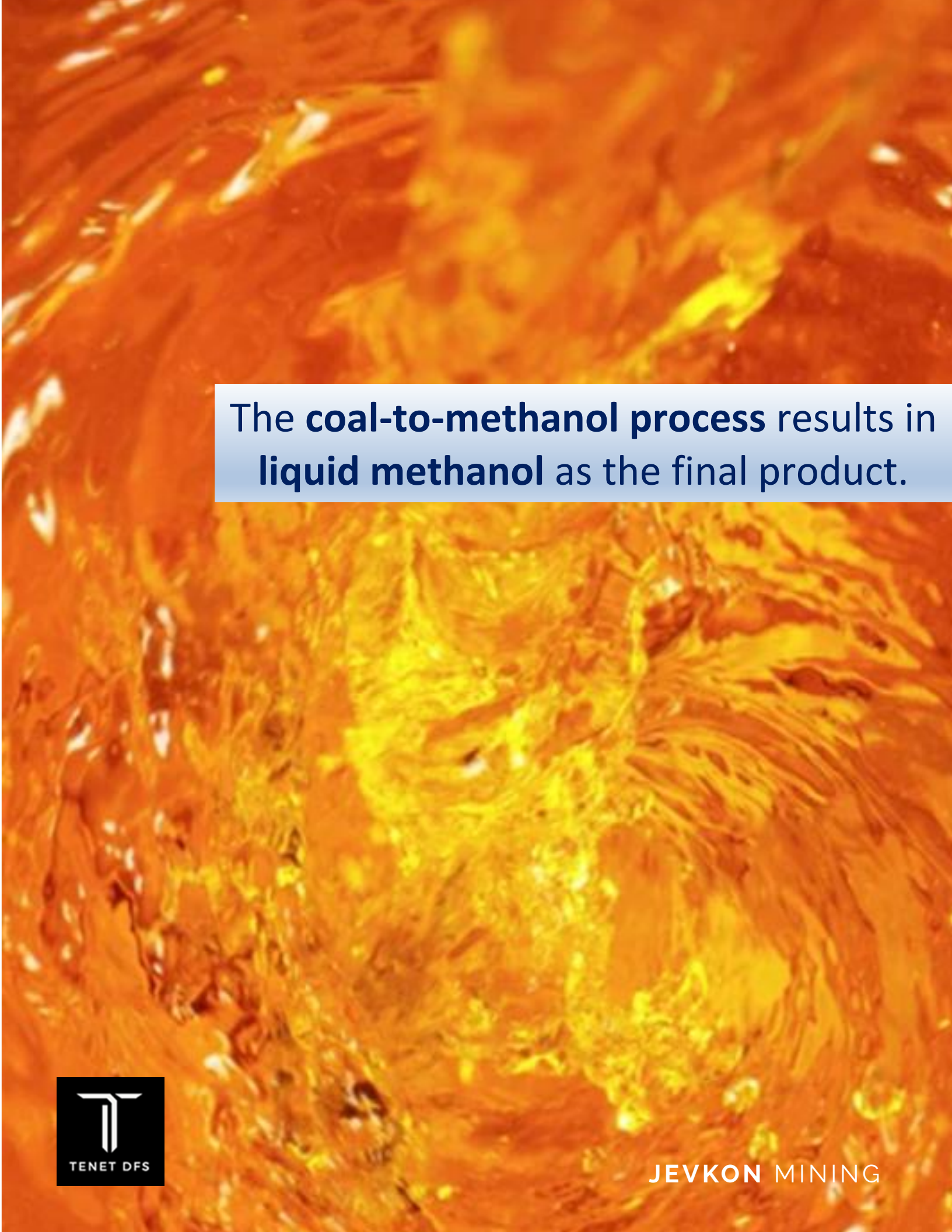
Output: ~1 million tonnes/year methanol
Revenue Potential: $300–$400 million/year (at $300 –$400/tonne)
Carbon Credits: Up to 1.5 $MtCO_2$/year captured = potential $30 –$75 million/year (at $20–$50/tCO_2)

1

Globally Traded, Fungible & In Demand Products

MultipleVerticals




The **coal-to-methanol process** results in **liquid methanol** as the final product.
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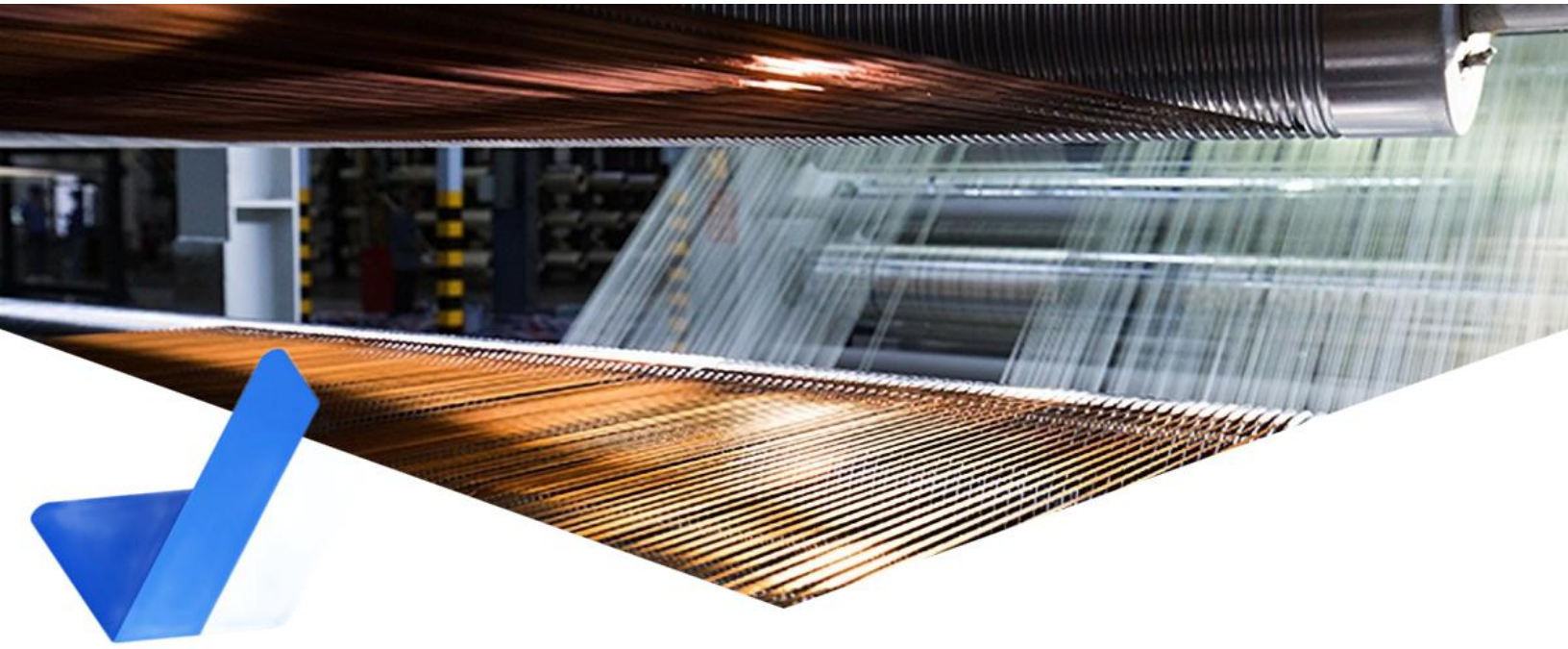

Carbon Fiber Production from Enugu COAL

Business Case: Coal-to-Carbon Fiber Production in Nigeria

1. Overview

Coal-derived carbon fiber is produced using **coal tar pitch**—a byproduct of coal processing—as a precursor. This approach is being advanced by U.S. institutions like the **National Energy Technology Laboratory (NETL)** and **Oak Ridge National Laboratory (ORNL)** to create **low-cost, high-performance carbon fiber** for industrial applications.

2. Profitability and Value Proposition

✅ **Economic Viability**

- **Lower Feedstock Cost**: Coal tar pitch is significantly cheaper than traditional precursors like polyacrylonitrile (PAN), which accounts for ~50% of carbon fiber production cost.
- **High-Value Output**: Carbon fiber sells for $10–$20/kg (aerospace grade), with potential for **$5–$8/kg** in automotive and construction markets using coal-based inputs.
- **Byproducts**: Residual char can be converted into **silicon carbide**, **activated carbon**, or **battery-grade carbon**, enhancing revenue streams.

✅ **Market Demand**

- Global carbon fiber demand is growing at **>10% CAGR**, driven by:
  - Aerospace and defense
  - Automotive lightweighting
  - Wind energy and hydrogen tanks
  - Construction and infrastructure

Leveraging Private Finance at Scale

Nigeria and West Africa currently **import 100%** of carbon fiber and composites, creating a strong import substitution opportunity.

✅ **Scalability**

- Pilot and semi-production scale facilities have been demonstrated in the U.S. (e.g. ORNL's Carbon Fiber Technology Facility).
- Modular production units can be co-located with coal beneficiation plants in Enugu.

3. Alignment with Nigeria's SDGs

SDG	Relevance
SDG 8 (Decent Work & Economic Growth)	High-value manufacturing and skilled job creation
SDG 9 (Industry, Innovation & Infrastructure)	Establishes advanced materials industry
SDG 12 (Responsible Consumption & Production)	Converts a stranded resource into sustainable industrial input
SDG 13 (Climate Action)	Enables lightweight materials that reduce emissions in transport and energy

4. Strategic Advantages for Nigeria

- **Industrial Diversification**: Moves Nigeria beyond raw material exports into advanced manufacturing
- **Technology Transfer**: Opportunity to partner with U.S. labs (e.g. ORNL, NETL) for process licensing and training
- **Regional Hub Potential**: Nigeria could become West Africa's first carbon fiber producer, supplying regional automotive, construction, and energy sectors

5. Risks and Considerations

- **Technology Maturity**: Coal-to-carbon fiber is at **TRL 6–7**; commercial-scale deployment requires further investment
- **Capital Intensity**: Initial capex for pilot-scale production is moderate ($20–50M), but full-scale plants may exceed $100M
- **Environmental Compliance**: Requires robust emissions control and waste management systems

Conclusion

Producing carbon fiber from coal in Nigeria presents a **strong business case** with high value-added potential, import substitution benefits, and alignment with national industrialization and SDG strategies. While not as immediately scalable as coal-to-power, it offers a **strategic diversification pathway** for the Enugu project and could attract blended finance from innovation funds, DFIs, and climate-aligned investors.

"This industrial vertical exemplifies Nigeria's shift toward private provision of public good—delivering infrastructure, jobs, and emissions reductions through commercially viable assets that relieve pressure on the public purse. By aligning with INFF principles and leveraging climate-aligned finance, the project anchors national development priorities without adding to sovereign debt or fiscal stress." - Dr. Mkgeroge Okon Onyung, M.D.

Industrial Charcoal Making Machine

Activated Charcoal Production from Enugu COAL

Case: Coal-to-Activated Charcoal Production in Nigeria

1. Overview

Activated charcoal (also known as activated carbon) is a high-value, porous carbon material used in water purification, air filtration, gold recovery, pharmaceuticals, and industrial processing. It can be produced from coal through controlled carbonization and activation processes. Nigeria's underutilized coal reserves—particularly in Enugu—offer a domestic feedstock for import substitution and industrial diversification.

2. Profitability and Value Proposition

✅ **Economic Viability**

- **High Market Value**: Activated charcoal sells for $1,000–$2,500 per metric ton depending on grade and application.
- **Low Feedstock Cost**: Coal is significantly cheaper than coconut shells or wood, which are commonly used in Nigeria.
- **Strong Margins**: Profit margins can exceed 30% with efficient processing and access to industrial buyers.

✅ **Market Demand**

- **Domestic Demand**: Nigeria imports activated carbon for:
  - Water treatment (urban utilities, bottled water)

  - Pharmaceutical and food-grade applications
  - Gold mining and chemical industries
- **Regional Export Potential**: West Africa lacks a major producer, creating a regional supply gap.

✅ **Byproduct Utilization**

- Residual char and ash can be used in cement or brick manufacturing, reducing waste and improving circularity.

3. Alignment with Nigeria's SDGs

SDG	Relevance
SDG 6 (Clean Water & Sanitation)	Activated carbon is essential for water purification
SDG 8 (Decent Work & Economic Growth)	Creates skilled jobs in processing and logistics
SDG 9 (Industry, Innovation & Infrastructure)	Establishes a value-added industrial product from coal
SDG 12 (Responsible Consumption & Production)	Promotes resource efficiency and import substitution

4. Strategic Advantages for Nigeria

- **Import Substitution**: Nigeria currently imports most of its activated carbon, especially for water treatment and gold mining.
- **Industrial Linkages**: Can supply domestic industries (e.g. breweries, pharmaceuticals, mining) and reduce forex outflows.
- **Scalable Technology**: Modular production units can be deployed near coal beneficiation plants in Enugu.

5. Risks and Considerations

- **Environmental Compliance**: Requires emissions control and safe handling of chemical activators (e.g. phosphoric acid, steam).
- **Market Access**: Requires certification for food-grade or pharmaceutical-grade carbon.
- **Technology Transfer**: May require partnerships with firms experienced in activation technology.

6. Conclusion

Coal-to-activated charcoal production in Nigeria offers a **profitable, scalable, and SDG-aligned industrial pathway**. It leverages a stranded resource (coal) to meet growing domestic and regional demand for a critical industrial input. While not as capital-intensive as power generation or carbon fiber, it provides a **medium-tech, high-margin opportunity** that can be implemented in parallel with other coal valorization strategies.

When exploring coal valorization pathways for the Enugu project, these uses—especially gasification-to-chemicals, REE recovery, and carbon products—could position it as a **world-scale clean commodities hub**.

Nigeria can lead the world in clean industrialization by transforming its coal into climate-aligned, globally traded commodities. We don't have to burn coal...we can refine it into the building blocks of the global economy.

TENET DFS

Enugu Coal Project - Nigeria

Technical Evaluation

JEVKON MINING SPV

JEVKON as a PPP with SEDC – Nigeria, meets or exceeds Tenet's Preliminary Selection Criteria and is pre qualified for Support from Western Export Credit Agencies having passed the Qualification Stage of Evaluation

Quality of Management Plan & Staffing

Organizational Background & Reputation
Background Checks – Key Staff
Legal & Political Cover for FDI Partners
Investment Grade EPC&F – CHINA
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+1 (332) 529-1143, Main Ofc.
+1 (225) 960-8092, US Cell
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New York, NY 10001

OUR EMAIL
info@tenetdfs.com

Terry L. Easley – Chairman
Member London Institute of Banking & Finance
Registered Investment Banker – U.S.
Mbr. AACE International, GARP, & AFIO
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tleasley1961@gmail.com

Enugu

Nigerias' Coal Mining Hub

Turning a Mountain of COAL into a "*River of GOLD*"

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THANK YOU
From the Tenet Team

In London, New York, Dubai and Mumbai

TRANSACTION STRUCTURING NOTE (TSN)

Project Title: Enugu Integrated Coal and Clean Commodities Project

Country: Nigeria

Prepared for: Federal Ministry of Industry, Trade and Investment (FMITI), Infrastructure Concession Regulatory Commission (ICRC), and Enugu State Government , World Bank Group, UNDP, USDFC & SINOSURE

Prepared by: Tenet DFS, LLC for JEVKON MINING

Date: June 30, 2025

1. Project Overview

The Enugu Integrated Coal and Clean Commodities Project is a vertically integrated industrial initiative designed to transform stranded coal assets in southeastern Nigeria into a diversified portfolio of clean, export-grade commodities. The project leverages advanced coal valorization and emissions control technologies to position Enugu as a regional hub for clean industrialization and energy security.

2. Proposed PPP Model

- **Model:** Design-Build-Finance-Operate-Transfer (DBFOT)
- **Concession Period:** 25–30 years
- **Private Party Role:** Design, finance, construct, operate, maintain, and transfer assets
- **Government Role:** Provide land, regulatory facilitation, and potential Viability Gap Funding (VGF)
- **Revenue Model:** Primarily user-pay via export sales and electricity offtake; potential offtake agreements with global buyers

3. Revenue and Payment Structure

- **Primary Revenue Sources:** Export of ammonia, urea, methanol, activated carbon, carbon fiber, industrial acids, rare earth elements, and electricity
- **Optional Government Support:**
  - Viability Gap Funding (VGF) for early-stage infrastructure
  - Minimum Revenue Guarantee (MRG) for demand risk mitigation
- **Tariff/Price Setting:** Market-based with optional floor pricing in offtake contracts

4. Risk Allocation Framework

Risk Category	Allocated To	Mitigation Measures
Construction Risk	Private Party	EPC contracts, performance bonds
Demand/Revenue Risk	Private Party (with optional MRG)	Offtake agreements, market diversification
Regulatory Risk	Government	Stabilization clauses, fast-track permitting
Land Acquisition	Government	Pre-clearance and compensation
Environmental/Social Risk	Shared	ESIA compliance, community engagement
Force Majeure	Shared	Contractual provisions and insurance

5. Project Phasing and Vertical Integration

Phase	Vertical	Timeline
Phase 1	Coal beneficiation + gasification	Years 1–3
Phase 2	Ammonia, urea, methanol	Years 2–4
Phase 3	Activated carbon, carbon fiber, acids, REE	Years 3–5
Phase 4	HELE + CCUS electricity generation	Years 3–5
Phase 5	Export logistics + O&M ramp-up	Years 4–6

6. Financial Viability Snapshot (Illustrative)

Metric	Value
Estimated CAPEX	$1.5 billion
IRR (Project Level)	~17%
NPV (at 12% discount rate)	~$500 million
Payback Period	~9 years
Debt-Equity Ratio	70:30 (indicative)

7. Strategic and Economic Rationale

- Job Creation: 5,000+ direct and indirect
- Export Revenue: $500M+/year
- Industrialization: Supports Nigeria's clean energy transition and economic diversification
- SDG Alignment: SDGs 8, 9, 13

8. Next Steps

Milestone	Timeline	Responsibility
Finalize OBC	Month 1	Project Sponsor
Secure government approvals	Month 2	Government
Engage transaction advisor	Month 2–3	Government
Conduct market sounding	Month 3–4	Project Sponsor & Advisor
Launch PPP procurement	Month 5–6	Government
Financial close	Month 12–15	Private Partner


Overproduction
can be exported
to Asia
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Project Title: Enugu Integrated Coal and Clean Commodities Project

Country: Nigeria

Proposed PPP Model: Design-Build-Finance-Operate-Transfer (DBFOT)

Sector: Industrial Infrastructure / Clean Commodities

Prepared for: FMITI, ICRC, Enugu State Government, World Bank Group, UNDP & USDFC, SINOSURE

Prepared by: Tenet DFS, LLC for JEVKON MINING

Date: June 30, 2025

1. Strategic Context

- **Problem Statement:** Nigeria's stranded coal assets remain underutilized while demand for clean, globally traded commodities is rising.
- **Objective:** Establish Enugu as a clean industrial hub through coal valorization and advanced manufacturing.
- **Alignment:** Nigeria's Industrial Revolution Plan, Energy Transition Plan, and SDGs 8, 9, 13.

2. Project Description

The project includes the following verticals:

- Coal beneficiation and gasification
- Ammonia and urea production
- Methanol and derivatives
- Activated carbon
- Coal-to-carbon fiber
- Coal-to-acid (sulfuric, nitric)
- Rare earth element extraction
- Electricity generation using HELE + CCUS

3. Options Analysis

Option	Description	Assessment
Public Sector Delivery	Fully government-funded	High fiscal burden
Traditional Procurement	EPC + government O&M	Limited risk transfer
PPP (Recommended)	DBFOT with private financing and operation	Strong VfM, risk transfer, innovation

4. Commercial Viability

- Revenue Model: Export-based user-pay + electricity sales
- Market Sounding: Positive interest from global players
- Risk Allocation: Construction, performance, and demand risks to private party
- PPP Structure: 25-year concession, performance-based KPIs, optional VGF

5. Financial Viability

Metric	Value
Estimated CAPEX	$1.5 billion
IRR	~17%
NPV (12% discount rate)	~$500 million
Payback Period	~9 years

6. Economic Viability

- Jobs: 5,000+
- Export Revenue: $500M+/year
- Local Development: Skills transfer, SME growth
- Environmental Impact: Cleaner than raw coal use; CCUS integration

7. Value for Money (VfM)

Dimension	Assessment
Cost Efficiency	Lifecycle savings via private sector innovation
Risk Allocation	Construction and demand risks transferred
Service Quality	Performance-based KPIs
PSC Comparison	PPP shows lower net present cost
Affordability	Government support limited to land and VGF

8. Affordability and Fiscal Impact

- Government Support: Land, permits, possible VGF
- No long-term fiscal liabilities under user-pay model
- Contingent liabilities managed via risk-sharing

9. Implementation Plan

Phase	Timeline	Activities
Preparation	0–12 months	Land, EIA, transaction advisory
Procurement	12–24 months	Bid documents, tender
Construction	24–60 months	Concurrent vertical development
Operations	60+ months	Commercial operations, monitoring

10. Risk Management

- Key Risks: Land, regulatory, demand
- Mitigation: Stakeholder engagement, phased development, offtake agreements

11. Stakeholder Engagement

- Community: Local employment, environmental safeguards.
- Private Sector: Global partners for technology and offtake
- Government: FMITI, ICRC, Ministry of Environment, Enugu State

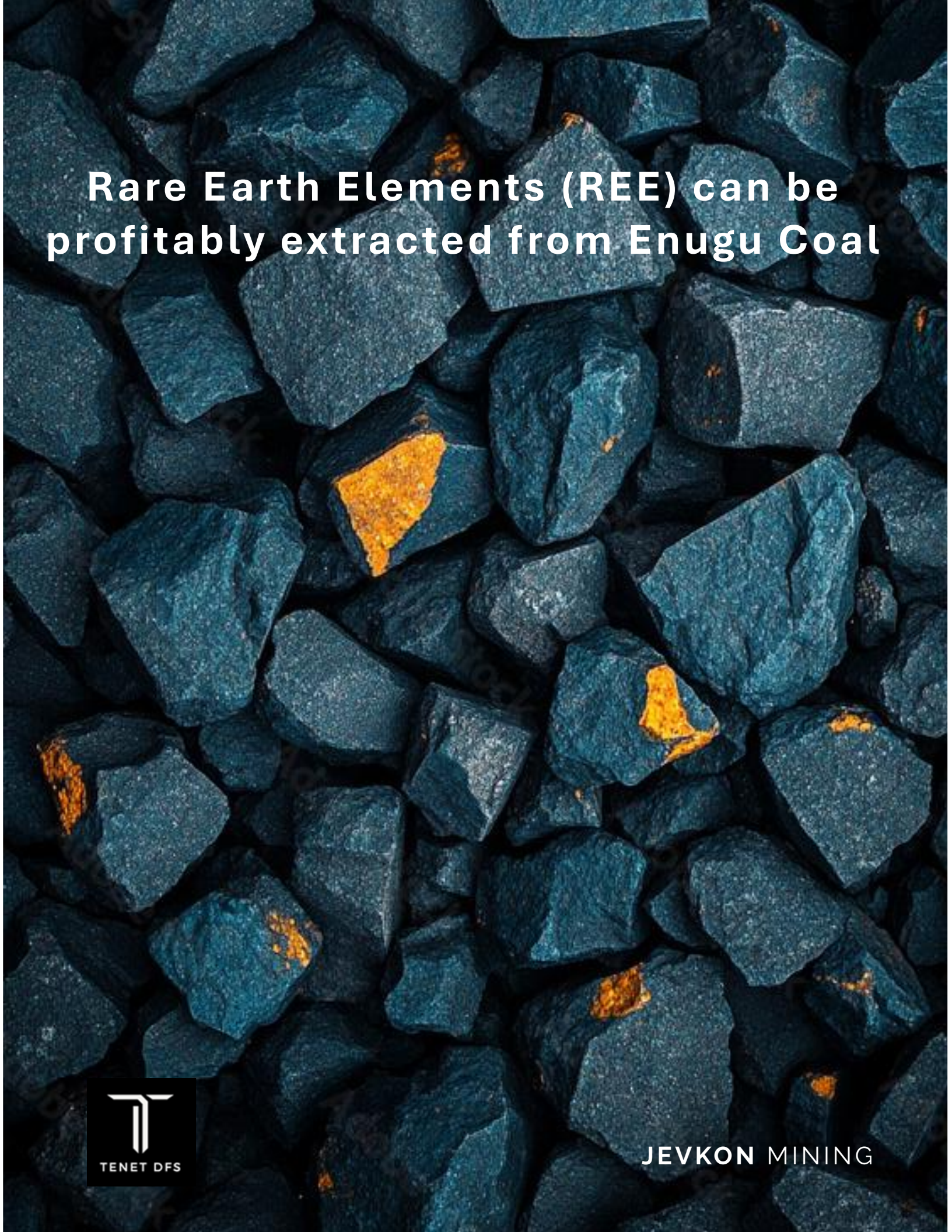
12. Combined Summary Statement

The Enugu Integrated Coal and Clean Commodities Project presents a robust, world-scale industrial opportunity that transforms Nigeria's stranded coal assets into a diversified portfolio of clean, export-grade commodities. Anchored in a DBFOT PPP structure and aligned with national development priorities, the project demonstrates strong commercial, financial, and economic viability across all key metrics. With an estimated IRR of 17%, a net present value exceeding $500 million, and projected annual revenues of over $500 million, the project offers a compelling value proposition for both public and private stakeholders. Its vertically integrated design—including ammonia, urea, methanol, activated carbon, carbon fiber, industrial acids, rare earth elements, and HELE+CCUS-based electricity—ensures resilience, scalability, and long-term competitiveness in global markets. The project is highly **insurable and bondable**, with a structure that qualifies for **non-recourse project finance** and **EPC+F (Engineering, Procurement, Construction, and Financing)** arrangements. It includes provisions for an **interest impound account**, **miscellaneous and contingency reserves** for each vertical, and dedicated **reserve accounts** for environmental rehabilitation, legal compliance, and operational stabilization—consistent with regional and international norms. Furthermore, the project is expected to generate **significant carbon credits,** through its integration of CCUS and clean conversion technologies, aligning directly with the **global consensus on decarbonization** and sustainable industrial development. Supported by strong institutional interest, a risk-optimized PPP framework, and a phased implementation strategy, the Enugu project stands as a fiscally responsible, technologically feasible, and strategically vital investment in Nigeria's clean industrial future.

CERTIFICATION

Yvonne Ashmore
Project Lead/Primary Contributor
TENET DFS USA

Rare Earth Elements (REE) can be profitably extracted from Enugu Coal



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EQUIPMENT LIST

Based on available data, standard industrial procurement practices, and Chinese EPC norms, here is a **preliminary equipment list with cost estimates** for each vertical in the Enugu Integrated Coal and Clean Commodities Project. This list is structured according to international project finance standards and assumes **Chinese procurement**, which typically offers competitive pricing and bundled EPC+F options.

Project: Enugu Integrated Coal and Clean Commodities Project **Procurement Focus:** Chinese EPC+F suppliers **Currency:** USD (estimates based on 2025 pricing) **Delivery Timeline:** 9–18 months (ex-works to site commissioning, concurrent deployment)

1. Coal Beneficiation and Gasification

Equipment	Qty	Unit Cost (USD)	Total (USD)	Lead Time
Coal crushers and screens	4 sets	500,000	2,000,000	6–9 months
Dense media separators	2 lines	1,200,000	2,400,000	9–12 months
Coal dryers	2 units	800,000	1,600,000	9 months
Gasifiers (entrained flow or fluidized bed)	4 units	5,000,000	20,000,000	12–15 months
Syngas cleanup systems	2 trains	3,500,000	7,000,000	12–15 months

Subtotal: $33,000,000

2. Ammonia and Urea Production

Equipment	Qty	Unit Cost (USD)	Total (USD)	Lead Time
Ammonia synthesis loop	1 unit	25,000,000	25,000,000	12–15 months
Urea reactor and granulation unit	1 unit	18,000,000	18,000,000	12–15 months
CO_2 recovery unit	1 unit	6,000,000	6,000,000	9–12 months

Subtotal: $49,000,000

3. Methanol and Derivatives

Equipment	Qty	Unit Cost (USD)	Total (USD)	Lead Time
Methanol synthesis reactor	1 unit	12,000,000	12,000,000	12 months
Distillation and purification columns	3 units	2,000,000	6,000,000	9–12 months
Storage tanks and loading systems	5 units	500,000	2,500,000	6–9 months

Subtotal: $20,500,000

4. Activated Carbon Production

Equipment	Qty	Unit Cost (USD)	Total (USD)	Lead Time
Rotary kilns with steam activation	2 units	3,000,000	6,000,000	9–12 months
Crushing and screening systems	2 sets	500,000	1,000,000	6–9 months
Packaging and bagging lines	2 units	300,000	600,000	6 months

Subtotal: $7,600,000

5. Coal-to-Carbon Fiber

Equipment	Qty	Unit Cost (USD)	Total (USD)	Lead Time
Coal tar pitch processing unit	1 unit	4,000,000	4,000,000	12 months
Spinning and stabilization lines	1 line	6,000,000	6,000,000	12–15 months
Carbonization and graphitization furnaces	2 units	5,000,000	10,000,000	15 months

Subtotal: $20,000,000

6. Coal-to-Acid (Sulfuric/Nitric)

Equipment	Qty	Unit Cost (USD)	Total (USD)	Lead Time
Sulfuric acid plant (DCDA)	1 unit	10,000,000	10,000,000	12 months
Nitric acid unit	1 unit	8,000,000	8,000,000	12 months

Subtotal: $18,000,000

7. Rare Earth Element (REE) Extraction

Equipment	Qty	Unit Cost (USD)	Total (USD)	Lead Time
Leaching and solvent extraction lines	2 trains	4,000,000	8,000,000	12–15 months
Precipitation and drying units	2 sets	2,000,000	4,000,000	9–12 months

Subtotal: $12,000,000

8. HELE + CCUS Power Generation (300–500 MW)

Equipment	Qty	Unit Cost (USD)	Total (USD)	Lead Time
Ultra-supercritical boiler and steam turbine	1 set	150,000,000	150,000,000	15–18 months
Flue gas desulfurization (FGD) and CCUS unit	1 set	40,000,000	40,000,000	12–15 months
Balance of plant (BOP) and switchyard	1 lot	30,000,000	30,000,000	12 months

Subtotal: $220,000,000

Reserve Accounts and Contingencies (Across Verticals)

Category	Allocation (% of CAPEX)	Estimated Value (USD)
Interest Impound Account	3%	$12,000,000
Miscellaneous & Contingency Reserves	10%	$40,000,000
Environmental Rehabilitation Fund	2%	$8,000,000
Legal & Regulatory Reserves	1%	$4,000,000

Subtotal: $64,000,000

Grand Total (Preliminary Equipment + Reserves):
Estimated Total: $444,100,000

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ENUGU STATE:
Coal Reserves
$ 46 Billion
Proven & Implied
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VALUATION
MEMORANDUM

Prepared for: Investor and Stakeholder Engagement **Date:** July 2025

1. Executive Summary

This memo provides a preliminary valuation of coal reserves in Enugu State, Nigeria, using internationally accepted practices and market benchmarks. It distinguishes between proven reserves and non-proven (inferred) reserves, applying appropriate pricing and risk-adjusted discounting.

2. Proven Coal Reserves

- **Estimated Quantity:** 116 million tonnes
- **Coal Type:** Sub-bituminous B (non-agglomerating)
- **Calorific Value:** 24–26 MJ/kg
- **Indicative Market Price (2025):** $100–$120/tonne (FOB, adjusted for inland logistics and grade)
- **Valuation Method:** Direct multiplication of tonnage by average market price

Estimated Value: 116,000,000 tonnes × $110/tonne = **$12.76 billion**

3. Non-Proven (Inferred) Coal Reserves

- **Estimated Quantity (Enugu share of Anambra Basin):** 600 million tonnes (conservative estimate)
- **Valuation Discount:** 50% of proven reserve value per tonne (to reflect geological and commercial uncertainty)
- **Discounted Price:** $55/tonne

Estimated Value: 600,000,000 tonnes × $55/tonne = **$33.00 billion**

4. Total Estimated Reserve Value

Reserve Type	Quantity (tonnes)	Price/tonne (USD)	Estimated Value (USD)
Proven	116 million	$110	$12.76 billion
Inferred	600 million	$55	$33.00 billion
Total	—	—	**$45.76 billion**

5. Strategic Implications

- These reserves provide a secure, long-term feedstock base for the Enugu Integrated Clean Commodities Project.
- The valuation supports resource-backed financing, carbon credit monetization, and industrial off-take agreements.
- Enugu is positioned to become a regional hub for clean industrialization, aligned with global decarbonization and SDG 9 objectives.

-Yvonne Ashmore, Project Team Leader, Tenet USA

HIGHEST & BEST USE CASES

Based on globally accepted practices and market data, here are the **most profitable and globally traded fungible commodities** that can be derived from **coal processing**, particularly through **gasification and downstream synthesis**:

1. Methanol

- **Use:** Fuel blending, petrochemical feedstock, formaldehyde, acetic acid, olefins
- **Market:** Highly fungible and globally traded (e.g., ICIS, Methanex benchmarks)
- **Profitability:** High, especially when coal is low-cost and carbon capture is integrated

2. Ammonia (NH_3)

- **Use:** Fertilizers, explosives, hydrogen carrier, marine fuel (green/blue ammonia)
- **Market:** Traded globally via long-term contracts and spot cargoes
- **Profitability:** Strong, especially with rising demand for low-carbon ammonia

3. Urea

- **Use:** Nitrogen fertilizer, diesel exhaust fluid (DEF/AdBlue)
- **Market:** Traded on global fertilizer exchanges (e.g., FMB, Argus)
- **Profitability:** High in agricultural economies and during fertilizer supply shocks

4. Synthetic Natural Gas (SNG)

- **Use:** Pipeline injection, power generation, industrial fuel
- **Market:** Regionally traded; fungibility increases with LNG conversion
- **Profitability:** Moderate to high, depending on gas prices and infrastructure

5. Dimethyl Ether (DME)

- **Use:** LPG substitute, aerosol propellant, diesel alternative
- **Market:** Emerging global trade, especially in Asia
- **Profitability:** High in LPG-scarce regions or where clean cooking fuels are subsidized

6. Carbon Black / Activated Carbon

- **Use:** Tires, pigments, filtration, energy storage
- **Market:** Traded globally in industrial and specialty markets
- **Profitability:** High for specialty grades (e.g., battery-grade carbon)

7. Rare Earth Elements (REEs) *(if coal ash is valorized)*

- **Use:** Magnets, electronics, defense, EVs
- **Market:** Strategic and globally traded, often under bilateral agreements
- **Profitability:** Very high, especially for heavy REEs like dysprosium and terbium

8. Carbon Credits / Offsets

- **Use:** Compliance and voluntary carbon markets
- **Market:** Traded via exchanges (e.g., Verra, Gold Standard, EU ETS)
- **Profitability:** Increasing, especially with CCUS integration and ESG-linked financing

Summary Table

Commodity	Fungibility	Global Trade	Profit Potential
Methanol	High	Yes	High
Ammonia	High	Yes	High
Urea	High	Yes	High
SNG	Medium	Regional	Moderate–High
DME	Medium	Emerging	High
Carbon Black	Medium	Yes	High (specialty)
REEs (from ash)	Medium	Yes	Very High
Carbon Credits	High	Yes	High

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The Enugu Clean Commodities Hub will convert stranded coal into methanol, ammonia, and carbon products—fuels and feedstocks essential for global supply chains.

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Here is a list of **current market prices** for key rare earth elements (REEs) that are commonly recoverable from coal and coal ash, using the most standard unit of measurement—**USD per metric ton (USD/mt)** or **USD per kilogram (USD/kg)** depending on the element's market convention

Element	Form	Price (USD)	Unit
Neodymium Oxide	High-purity oxide	55,510	per metric ton
Praseodymium Oxide	High-purity oxide	56,990	per metric ton
Praseodymium-Neodymium Oxide	Mixed oxide blend	54,832	per metric ton
Dysprosium Oxide	99.5% purity	199.22	per kilogram
Terbium Oxide	99.9% purity	871.51	per kilogram
Europium Oxide	99.999% purity	19.74	per kilogram
Yttrium Oxide	99.9% purity	6,167.80	per metric ton
Lanthanum Oxide	99.9% purity	555.10	per metric ton
Cerium Oxide	99.9% purity	3,515.65	per metric ton
Samarium Oxide	99.9% purity	1,973.70	per metric ton
Gadolinium Oxide	99.9% purity	22,820.86	per metric ton
Erbium Oxide	99.9% purity	37,315.18	per metric ton
Holmium Oxide	99.9% purity	63,651.68	per metric ton
Lutetium Oxide	99.99% purity	635.28	per kilogram
Scandium Oxide	99.99% purity	635.28	per kilogram

Notes:

- **Heavy REEs** like dysprosium, terbium, and lutetium command higher prices due to their scarcity and critical role in magnets and defense applications.
- **Light REEs** like lanthanum and cerium are more abundant and lower in price but still valuable in catalysts and polishing compounds.
- Prices are indicative and can vary based on purity, form (oxide vs. metal), and delivery terms (FOB, EXW, etc.).

Based on recent studies and extraction trials, here's a focused summary of the **rare earth elements (REEs) found in Nigerian coal fly ash**, along with the **most promising extraction technologies** for recovery.

Common REEs in Nigerian Coal Fly Ash

A 2025 study analyzing fly ash from Nigeria's major coal belts found the following REEs to be most abundant:

Element	Typical Concentration Range	Primary Uses
Cerium (Ce)	300–600 ppm	Catalysts, glass polishing, fuel cells
Lanthanum (La)	200–400 ppm	Batteries, catalysts, optical lenses
Neodymium (Nd)	100–300 ppm	Permanent magnets, EV motors, wind turbines
Yttrium (Y)	50–150 ppm	LEDs, phosphors, superconductors
Praseodymium (Pr)	30–80 ppm	Magnets, alloys, aircraft engines
Samarium (Sm)	20–50 ppm	Magnets, nuclear control rods
Dysprosium (Dy)	10–30 ppm	High-temperature magnets, defense tech
Europium (Eu)	5–15 ppm	Red phosphors in screens and lighting

Total REE content in Nigerian fly ash samples ranged from **874 to 1127 ppm**, with **critical REEs** (Nd, Pr, Dy, Eu, Y) making up **28%–36%** of the total.

Recommended Extraction Technologies

Given the mineralogy and aluminosilicate matrix of Nigerian fly ash, the following technologies are most viable:

1. Acid Leaching (Hydrometallurgy)

- Uses dilute mineral acids (e.g., HCl, H_2SO_4) to dissolve REEs
- Effective for high-alumina fly ash
- Can be optimized for selective leaching of critical REEs

2. Ion Exchange and Solvent Extraction

- Used after leaching to separate individual REEs
- Solvent systems like D2EHPA or Cyanex 272 are common
- High purity but capital- and reagent-intensive

3. Bioleaching

- Uses microbes or bio-acids to extract REEs
- Environmentally friendly but slower kinetics
- Suitable for low-grade or complex ash matrices

4. Protein-Based Biosorption (Emerging)

- Uses engineered proteins (e.g., elastin-like polypeptides) to selectively bind REEs
- Recyclable and highly selective
- Promising for low-concentration REE recovery

Strategic Implications for Enugu

- **Cerium, lanthanum, and neodymium** are the most abundant and economically viable for early-stage recovery.
- **Yttrium, dysprosium, and europium** offer high-value niche markets, especially for clean tech and defense.
- **Hydrometallurgical extraction with CCUS integration** could be paired with coal gasification to create a zero-waste, multi-product industrial platform.

Based on current research and industry validation, here is a **techno-economic comparison** of rare earth element (REE) extraction technologies that are either at or approaching **Technology Readiness Level (TRL) 9**—meaning they are proven in operational environments and ready for commercial deployment.

Techno-Economic Comparison of REE Extraction Technologies (TRL 7–9)

Technology	TRL	CAPEX Estimate	OPEX Profile	Purity/Recovery	Scalability	Commercial Use Cases
Solvent Extraction	9	$50–100M (modular plant)	Moderate–High (reagents, energy)	99.9%+ (with multi-stage)	High (used globally)	China, Lynas (Malaysia), MP Materials (USA)
Ion Exchange	8–9	$30–80M	Moderate (resin cost, regeneration)	95–99%	Medium (batch-based)	Used in USA, Japan, and pilot plants in India
Acid Leaching + Solvent Extraction	8–9	$80–150M (integrated)	High (acid handling, neutralization)	90–98%	High (especially for coal ash)	NETL-supported projects in USA, China
Membrane Separation	6–7	$40–90M	Low–Moderate	85–95% (selective)	Medium (emerging)	Pilot stage in EU and Korea
Bioleaching	5–6	$20–50M	Low (slow kinetics)	60–85% (element-dependent)	Low–Medium	R&D and pilot in India, South Africa
Protein-Based Biosorption	4–5	TBD (early stage)	Low	90–99% (lab-scale)	Low	Lab-scale only (e.g., ORNL, NETL)

Key Takeaways for Enugu

- **Solvent extraction** and **acid leaching + solvent extraction** are the most mature and commercially proven technologies (TRL 9) for REE recovery from coal ash and overburden.
- **Ion exchange** is also commercially viable, especially for selective recovery of high-value REEs like neodymium and dysprosium.
- **Membrane and bioleaching** are promising but not yet at TRL 9—better suited for long-term R&D or blended approaches.
- U.S. DOE's **NETL-supported projects** have demonstrated integrated REE recovery from coal ash at pilot and pre-commercial scale, with some technologies showing up to **80% reduction in reagent use** and **ambient temperature/pressure operation**

Investment Brief: Rare Earth Element (REE) Recovery from Coal Ash in Enugu State, Nigeria

Positioning Nigeria as a Clean Tech Materials Hub for the Global Economy

Executive Summary

The Enugu Clean Commodities Platform proposes the commercial-scale recovery of rare earth elements (REEs) from coal ash and overburden using proven, TRL 9 extraction technologies. This initiative aligns with Nigeria's Energy Transition Plan, the African Union's Agenda 2063, and global clean tech supply chain diversification efforts. It offers DFIs a unique opportunity to support a climate-aligned, resource-based industrialization strategy with strong ESG credentials and export potential.

Strategic Rationale

Critical Minerals for Clean Tech: Neodymium, praseodymium, dysprosium, and yttrium—essential for EVs, wind turbines, and electronics—are recoverable from Nigerian coal ash at concentrations of 800–1100 ppm.
Proven Technology: Solvent extraction and acid leaching systems are commercially deployed in the U.S., China, and Malaysia. These systems are TRL 9 and can be modularized for phased deployment.
Circular Economy: The project valorizes waste streams from coal gasification and power generation, reducing environmental liabilities while creating high-value exports.
Industrial Diversification: Establishes Nigeria's first REE processing facility, reducing reliance on raw material exports and positioning Enugu as a clean materials hub.

Technical and Economic Highlights

Feature	Value/Status
Technology Readiness	TRL 9 (commercial solvent extraction + leaching)
Target REEs	Nd, Pr, Dy, Y, Ce, La, Eu
Feedstock	Coal ash, overburden, and tailings
Estimated CAPEX (Phase 1)	$80–120 million (modular, scalable)
IRR (base case)	18–22% (based on current REE prices)
Payback Period	4–6 years
ESG Profile	Zero-waste integration with CCUS-ready platform
Offtake Potential	Global magnet manufacturers, battery suppliers

Alignment with DFI Mandates

- **Climate and Just Transition**: Supports clean energy supply chains without new mining; creates skilled jobs in a coal-transitioning region.
- **Gender and Youth Inclusion**: Training programs for women and youth in clean chemistry, materials science, and process operations.
- **Regional Integration**: Potential to serve West African markets and export to EU/Asia under AfCFTA and GSP+ frameworks.
- **Blended Finance Ready**: Structured for concessional capital, guarantees, and green bond alignment.

Next Steps

- Conduct a **bankable feasibility study** with DFI co-financing
- Secure offtake agreements with global REE buyers
- Establish a **special-purpose vehicle (SPV)** with public-private governance
- Engage ESG certifiers and carbon credit verifiers for co-benefit monetization


Most of our processes are non-combustion, CCUS-integrated, and aligned with Nigeria's Energy Transition Plan and SDG targets.
.We're not exporting emissions—we're exporting solutions.
This project is insurable, bondable, and structured for non-recourse project finance. With global demand for clean hydrogen, fertilizers, and carbon materials surging, Enugu is poised to become a regional anchor for sustainable industrial growth.
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