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Fossil Energy in the Era of Resurgent Demand An Examination of the Evolving Role of Fossil Energy in the Knowledge-Driven Economy

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Abstract
Global energy demand has entered a renewed phase of growth driven by rapid industrialisation, digitalisation, and the expansion of artificial-intelligence infrastructure. This resurgence has prompted a re-examination of the role of fossil energy in meeting near-term and transitional energy needs. While policy narratives continue to emphasise decarbonisation and net-zero trajectories, fossil fuels—particularly natural gas and oil—remain essential for energy security, reliability, and industrial development. This paper analyses the factors underpinning the continuing relevance of fossil fuels, explores their evolving functions within knowledge-driven economies, and proposes a knowledge-management and artificial-intelligence (AI) framework for managing fossil-fuel assets during the global energy transition. It concludes that fossil energy will persist as a strategic enabler of industrial and digital growth in emerging regions, provided that enterprises adopt intelligent, knowledge-based management systems to mitigate environmental and transition risks.

Executive Summary

The global energy system is at a critical inflection point. While the push for decarbonisation intensifies, worldwide energy demand continues to surge—fuelled by industrialisation in emerging economies, digital transformation, and the exponential energy requirements of artificial intelligence and data-centre infrastructures. This paradoxical resurgence has restored fossil energy, particularly natural gas and oil, to a position of short- to medium-term prominence despite growing commitments to net-zero targets.

This paper examines the evolving role of fossil energy within this new resurgence. It highlights how fossil fuels remain indispensable to energy security, industrial growth, and economic stability, especially across developing regions such as Africa where renewable-energy infrastructure is still maturing. At the same time, it acknowledges the environmental, financial, and policy constraints reshaping fossil-fuel usage. The analysis recognises that the challenge of the 2020s is not merely to replace fossil fuels, but to manage them intelligently optimising efficiency, reducing emissions, and capturing operational knowledge for future transition.

A core contribution of this paper is the introduction of an AI–KM (Artificial Intelligence – Knowledge Management) Framework for managing fossil-fuel producing and services companies in transition. The framework integrates knowledge capture, AI-enabled analytics, organisational learning, and data-driven strategic decision-making support to transform traditional fossil-energy operations into adaptive, knowledge-driven systems. It illustrates how data, expertise, and technology can converge to enhance resilience, reduce environmental impact, and prepare organisations for hybrid energy futures.

Empirical data and trend analysis drawn from the International Energy Agency (IEA), Energy Transitions Commission (ETC), and regional African energy outlooks show that by the end of 2025, fossil fuels will still account for about 74 % of global primary-energy demand, even as renewables more than double their share since 2015. In Nigeria, gas remains the dominant energy source for power generation, with renewable integration accelerating but still limited in scale.

The study posits that fossil energy will continue to play a strategic, transitional, and enabling role in the knowledge-driven economy, particularly for nations leveraging AI and knowledge-management systems to capture maximum efficiency and sustainable value. For such economies, the key competitive advantage will no longer lie solely in resource ownership, but in the intelligent governance of energy knowledge that determines how resources are deployed, optimised, and evolved in an increasingly digital and decarbonised world.

I. Introduction

The global energy landscape is undergoing simultaneous transformation and resurgence. After a decade of climate-policy advances and renewable-energy investment, the world faces a paradox: energy demand continues to rise faster than low-carbon supply capacity. Population growth, industrial expansion, electrification, and the energy intensity of AI-driven technologies have combined to revive short- to medium-term reliance on fossil fuels (Energy Transitions Commission, 2023).

This duality defines the current energy epoch: the need to decarbonise while sustaining growth. For developing economies—particularly in Africa—fossil energy remains foundational to industrialisation, transport, and power reliability. Yet these same economies must simultaneously cultivate knowledge infrastructures that enable efficiency, innovation, and adaptation. Within this context, fossil energy's role is no longer static but strategic: it becomes both a bridge and a platform for the knowledge-driven energy economy.

II. Drivers of Resurgent Fossil-Energy Demand

2.1 Industrialisation and Urban Growth in Emerging Economies
Industrial expansion across Asia, the Middle East, and sub-Saharan Africa is driving energy intensity. Africa's annual electricity demand is projected to increase by over 30 % between 2023 and 2030 (IEA 2024). In Nigeria and other emerging producers, gas-to-power schemes remain the backbone of national grids because renewable intermittency and storage limitations constrain alternatives (Niang et al. 2024).

2.2 The Transition-Fuel Function of Natural Gas
Natural gas is increasingly framed as a "bridge fuel" that supports the decarbonisation pathway. It emits roughly 50 % less CO_2 than coal and offers operational flexibility for balancing variable renewables (IMF 2023). The abundance of gas reserves in regions such as West Africa, especially in Nigeria, ensures its continuing centrality in energy-security planning.

2.3 Energy Security and Geopolitical Stability
The disruptions caused by global conflicts and supply-chain shocks have reaffirmed the value of dispatchable fossil-fuel capacity. Governments perceive fossil fuels as strategic buffers that guarantee reliability against the volatility of international energy markets (OECD 2023).

2.4 AI, Data Centres, and the Digital-Energy Surge
The exponential growth of AI training, cloud computing, and digital infrastructure has created new baseload demand. Data centres require uninterrupted power, often supplied by gas turbines or diesel back-ups. Thus, even the digital economy, which is the symbol of the knowledge age, depends on fossil-fuel reliability (ETC 2023).

The Cooling Paradox — Why Data Centres Still Depend on Fossil Energy

The explosion of artificial intelligence, cloud computing, and digital services has transformed data centres into the industrial backbone of the knowledge economy. Yet, behind every digital transaction lies an immense and continuous demand for cooling. Maintaining optimal thermal conditions in high-density server farms consumes 30–50 % of total data-centre energy, primarily for chillers, compressors, and precision air systems that must operate non-stop.

In most regions—especially emerging economies where renewable penetration remains limited—fossil fuels, particularly natural gas and diesel, continue to offer the most affordable and dispatchable power source for these cooling systems. Gas-fired or diesel-backup generators provide immediate response capability, voltage stability, and cost predictability that renewable or intermittent sources cannot yet guarantee at scale.

While renewable integration is expanding, the cooling paradox persists: the digital technologies driving decarbonisation also deepen short-term dependence on carbon-based fuels for reliability. Thus, fossil energy remains an indispensable bridge for sustaining the data-driven economy's thermal and operational stability. The strategic imperative, therefore, is not to abruptly abandon fossil inputs but to optimise them intelligently—using AI-enhanced energy-management systems, waste-heat recovery, and hybrid configurations that progressively reduce emissions intensity while maintaining affordable uptime

Fossil Fuels and the Energy Economics of Data-Centre Cooling

As the global digital economy expands, the proliferation of artificial-intelligence workloads and cloud-computing infrastructures has sharply increased the demand for large-scale, energy-intensive data centres. A significant portion of this energy requirement—often exceeding 40 % of total facility consumption is dedicated to cooling systems that maintain optimal server temperatures. In most developing and emerging markets, fossil fuels, particularly natural gas and diesel, remain the most affordable, dispatchable, and infrastructure-ready energy sources to power these cooling systems. Renewable alternatives, while growing, face intermittency, storage, and grid-integration limitations that can compromise the 24/7 reliability critical to data-centre operations.

Consequently, fossil fuels provide both cost stability and operational security, ensuring continuous cooling and computational uptime while renewable capacity and grid resilience continue to evolve. Strategic integration of AI-driven energy-management systems can, however, optimise fossil-fuel use—reducing emissions intensity while preserving affordability and reliability in this era of digital energy acceleration.

2.5 Legacy Infrastructure and Path Dependence

Existing fossil-fuel infrastructure such as pipelines, refineries, and LNG terminals, represents trillions in sunk investment. The cost and time required to replace these assets reinforce fossil fuels' persistence during the transition phase (Kulagin et al. 2020).

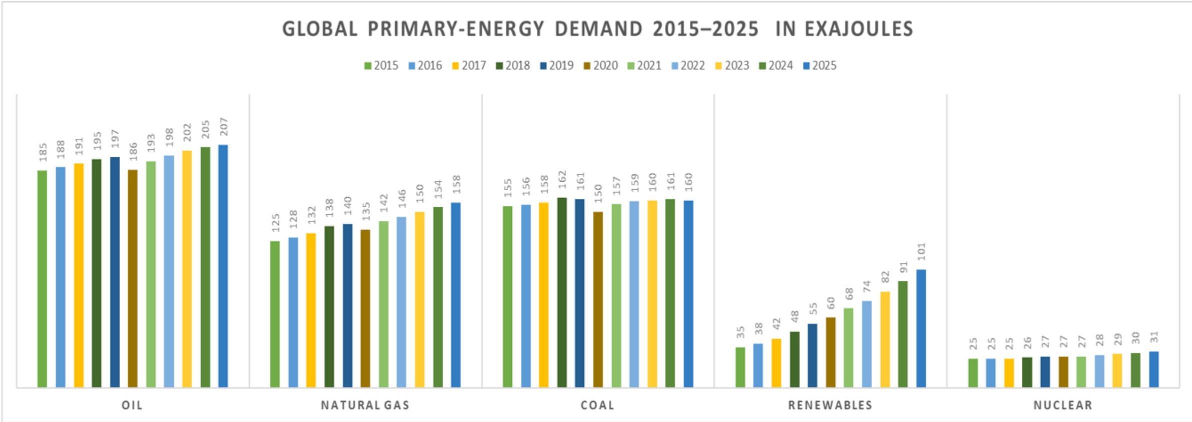
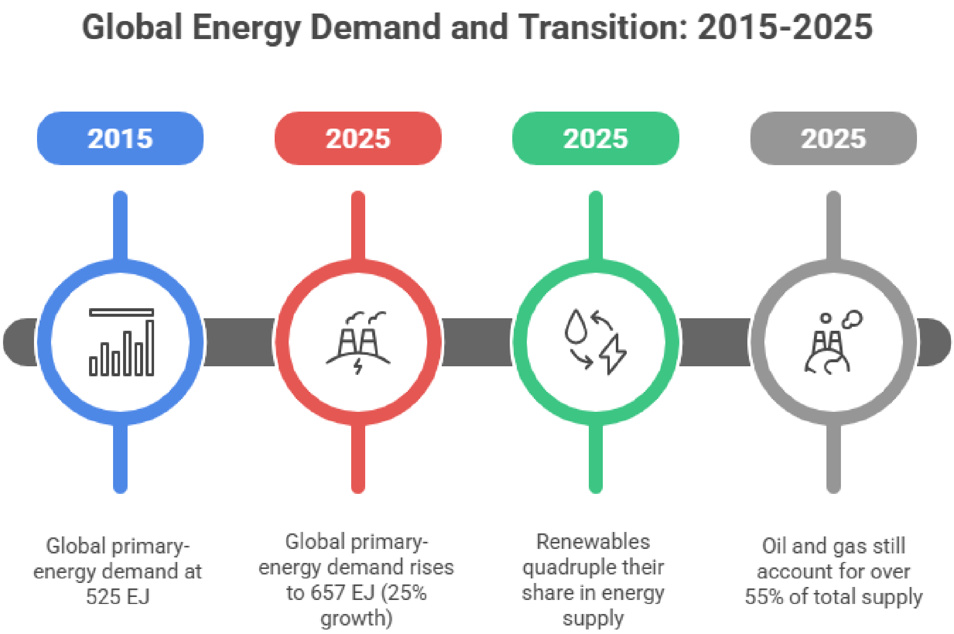


Figure 1: Global Primary-Energy Demand 2015–2025 (approximate values based on IEA 2024 and BP Statistical Review 2024)

Source: Compiled from International Energy Agency (2024) World Energy Outlook 2024 and BP Statistical Review of World Energy (2024)



Between 2015 and 2025, aggregate primary-energy demand increases from approximately 525 to 655 units, representing a sustained expansion in global consumption despite interim macroeconomic shocks. Renewable energy exhibits the most pronounced structural growth—nearly tripling over the decade—reflecting accelerated deployment of solar, wind, and other low-carbon technologies. Nonetheless, the overall system remains anchored by hydrocarbons: oil and natural gas collectively dominate the supply stack across all years,

underscoring the inertia of existing infrastructure and continued dependence on fossil-energy value chains. Coal output stabilizes after minor fluctuations, indicative of gradual phase-down pressures, while nuclear energy posts slow, incremental gain.
Taken together, the data illustrates an energy system undergoing transition but not yet transformation: low-carbon sources are scaling rapidly, yet their growth trajectory is insufficient to materially displace incumbent fossil sources by 2025, resulting in a mixed, path-dependent energy profile with rising total demand and only modest shifts in overall supply composition.

III. Constraints and the Changing Role of Fossil Fuels

Despite their resurgence, fossil fuels face structural and environmental headwinds.

3.1 Climate and Environmental Commitments
International agreements continue to tighten emission targets. Without large-scale carbon-capture deployment, fossil-fuel use risks undermining net-zero trajectories (ETC 2023).

3.2 Stranded-Asset and Financial Risks
Investments in new coal or oil capacity may become stranded as carbon pricing and renewable competitiveness rise. This poses balance-sheet and reputational risks for corporations and national economies.

3.3 Competitiveness of Renewables
The levelized cost of electricity from solar and wind has fallen by more than 80 % since 2010 (IEA 2024). When coupled with battery storage, renewables are now approaching cost parity with new gas generation in many markets.

3.4 Policy and Regulatory Headwinds
Carbon taxes, divestment campaigns, and green-finance regulations increase compliance costs for fossil-fuel enterprises. The political legitimacy of new fossil investment is also declining in many advanced economies.

3.5 Evolving Role: From Dominant Source to Transitional Asset
Rather than disappearing, fossil energy is repositioning as a complementary, transitional, and enabling asset. The future energy mix will rely on fossil fuels for stability and flexibility while renewables provide the growth margin.

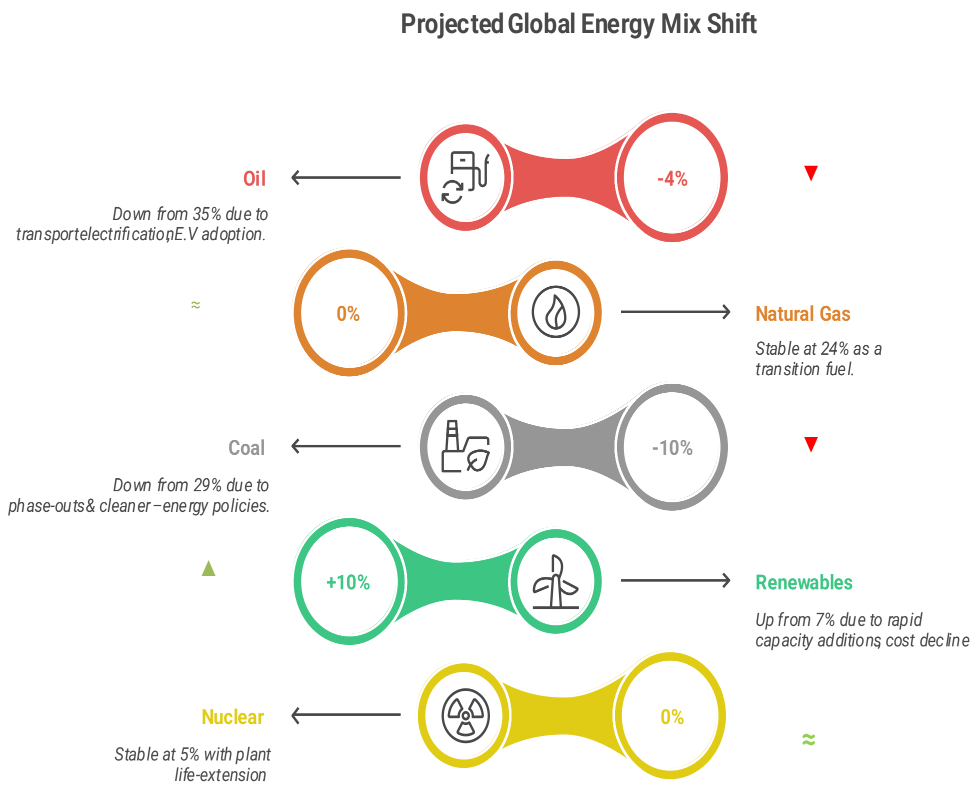


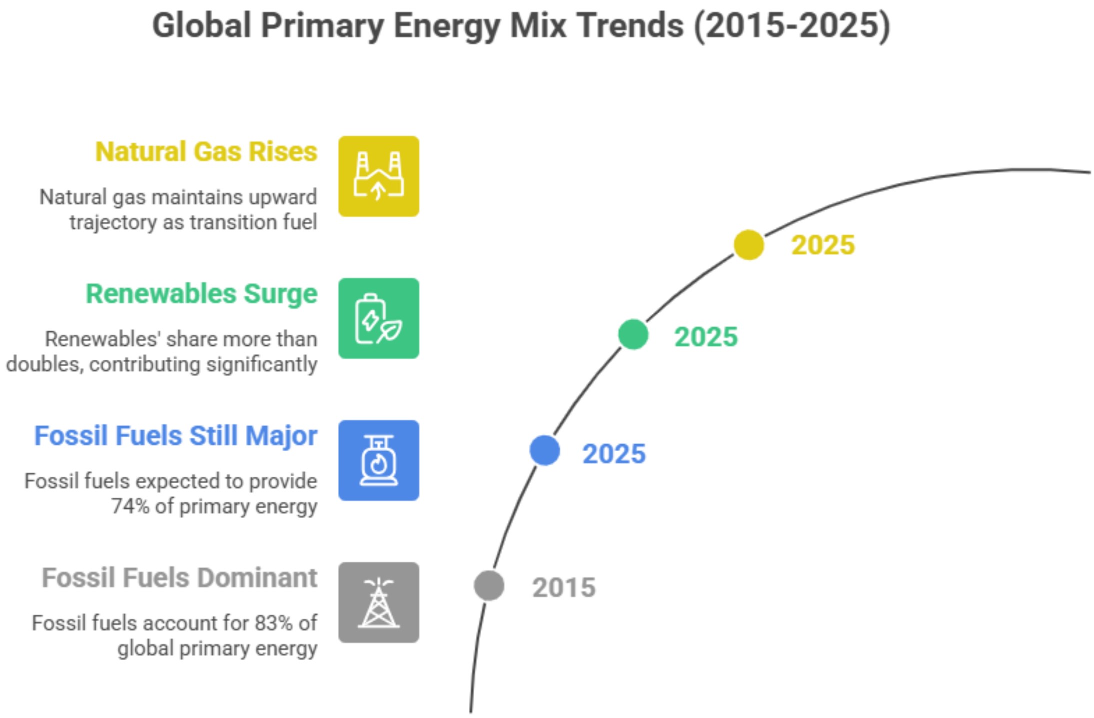
Figure 2: Projected Global Energy Mix, 2025 (Share of Total Primary Energy Consumption – approximate values)

***Source: Compiled from International Energy Agency (2024) World Energy Outlook 2024 and Energy Transitions Commission (2023) Fossil Fuels in Transition Report*.**

Between 2015 and 2025, the global energy mix shifts meaningfully but remains anchored on fossil fuels. Hydrocarbons fall from about 83% to 74% of primary supply, driven by sharp reductions in coal and gradual declines in oil, even as natural gas consolidates its role as the system's leading transition fuel. Coal's share drops from 29% to 19% under intensifying phase-out policies, while oil declines from 35% to 31% with accelerating transport electrification and EV adoption.

Renewables record the strongest structural gain, rising from 7% to 17%, supported by rapid capacity expansion and sustained cost declines across solar, wind, hydro, and bioenergy. Nuclear remains stable at around 5%, enabled by plant life-extension programmes and selective new builds.

Overall, the decade reflects a system undergoing measured transition rather than full transformation: low-carbon sources scale rapidly, but fossil fuels—particularly oil and natural gas—continue to underpin energy security, industrial reliability, and grid stability through the mid-2020s



IV. Strategic Implications for Knowledge-Driven Companies

4.1 Treating Fossil Operations as Knowledge Assets
Knowledge driven companies such as engineering and energy service, and oil and gas companies should endeavour to capture and centralize operational intelligence, process data, lessons learned etc, as strategic knowledge resources while also maintaining a robust and dynamic repository of knowledge assets and resources. These constitute intellectual capital that enhances resilience and innovation.

4.2 Integrating AI for Efficiency and Decarbonisation
Artificial-intelligence tools can optimise fuel efficiency, predictive maintenance, and emissions monitoring. AI-driven analytics extend asset life and reduce operational costs, thereby aligning profitability with sustainability.

4.3 Transition-Risk Governance
Companies must institutionalise transition-risk assessments, scenario planning, and knowledge-capture processes. Knowledge-management systems enable learning from pilot projects and policy shifts.

4.4 Leveraging Fossil Assets for New Business Models
Existing infrastructure can be repurposed for hydrogen production, carbon-capture utilisation and storage (CCUS), or hybrid fossil-renewable microgrids—turning potential liabilities into opportunities.

4.5 Building a Learning and Knowledge Culture
Organisational learning mechanisms—after-action reviews, digital knowledge repositories, and communities of practice—should be embedded within corporate culture. Leadership commitment to knowledge sharing determines long-term adaptability.

Energy Category 2020 Baseline (TWh) Vs 2025 Projection (TWh)

2020 Baseline vs. 2025 Projections

Energy Category	2020 Baseline (TWh)	2025 Projections (TWh)	Change (%)	Key Notes
Natural Gas-to-Power	58	82	+41	Gas remains main power backbone
Oil (Diesel/Fuel)	22	18	-18	Slight decline as industries convert
Coal	4	2	-50	Marginal decline; limited utilisation
Hydro Power	10	14	+40	Moderate growth through small projects
Solar & Wind	3	10	+233	Rapid acceleration driven by solar
Total Electricity Supply	97	126	+30	Energy demand outpaces population growth

Figure 4: Nigeria – Projected Gas Demand and Renewable Integration, 2025 (Approximate estimates based on IEA Africa Energy Outlook 2024, NNPC & ECOWAS energy statistics)

Source: International Energy Agency (2024) Africa Energy Outlook; Nigerian National Petroleum Company (NNPC) 2024 data; ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE).

Between 2020 and 2025, Nigeria's electricity landscape shows strong growth driven by natural gas and accelerating renewables. Total power generation increases from 97 TWh to 126 TWh—a 30% rise—reflecting expanding demand from industry, households, and commercial sectors. Natural gas remains the system's backbone, growing from 58 to 82 TWh (+41%) and supplying nearly two-thirds of national output by 2025. Oil-based generation declines by 18% as industries shift toward gas and more efficient energy mixes, while coal's already limited utilisation halves from 4 to 2 TWh. Hydropower posts steady gains (+40%) through incremental development of small and medium plants, strengthening regional supply diversity.

Solar and wind deliver the most significant proportional expansion, rising from 3 to 10 TWh (+233%) through decentralised solar systems, hybrid mini-grids, and private-sector investments that broaden access and reduce reliance on diesel. Although renewables triple their contribution, Nigeria's power system remains anchored by natural gas, which continues to provide critical grid stability and baseload reliability. Altogether, the trends point to an energy system undergoing measured transition—with fossil fuels acting as near-term transition enablers—supported increasingly by knowledge-driven operations, digital optimisation, and AI-enhanced monitoring to improve efficiency, reliability, and emission performance

V. The AI–KM Framework for Fossil-Energy Transition

The intersection of artificial intelligence and knowledge management (KM) offers a pathway for intelligent transition management. The proposed framework integrates four interdependent pillars:

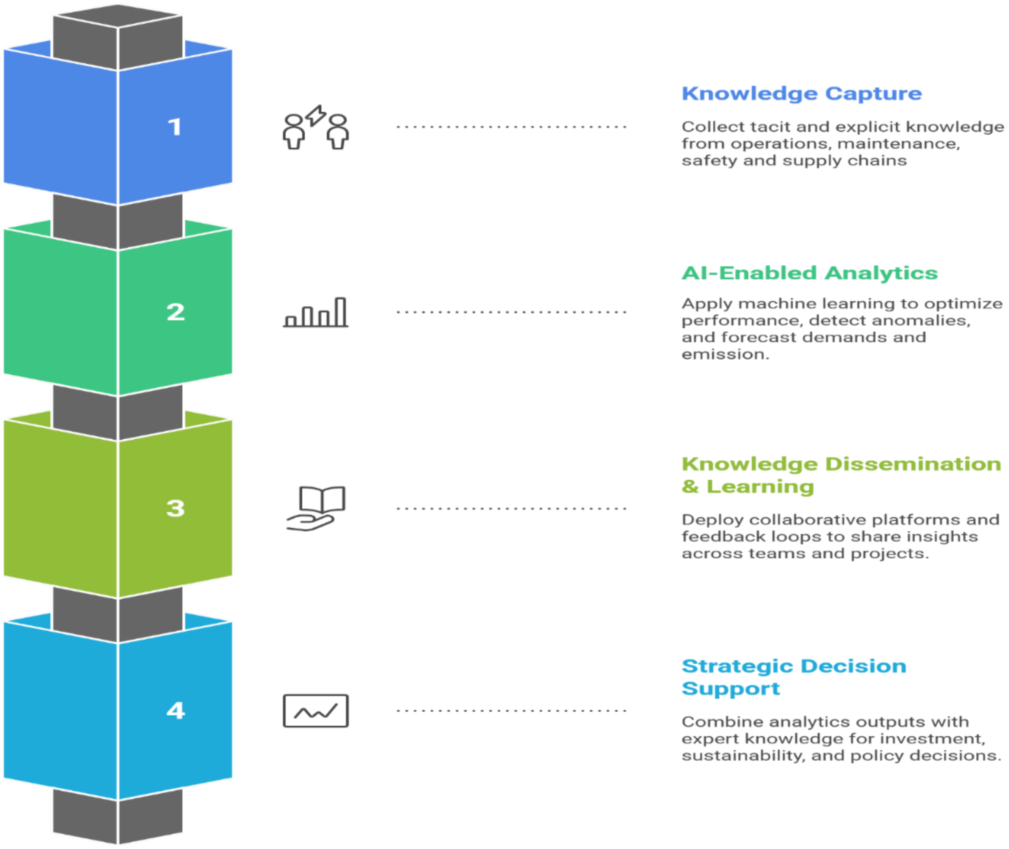


Figure 6: AI–KM Framework for Fossil-Energy Transition

VI. Regional Focus: Nigeria and Sub-Saharan Africa.

In sub-Saharan Africa, fossil energy underpins national development strategies. Nigeria's proven gas reserves (over 200 tcf) position it as a regional hub for gas-to-power and LNG exports. Yet infrastructure deficits, regulatory uncertainty, and carbon-transition pressures require knowledge-based governance.

Oil and gas companies, including engineering service companies and producers, must leverage digital technologies to improve asset performance and environmental compliance. AI-enabled pipeline monitoring, predictive maintenance, and workforce upskilling exemplify how knowledge systems can bridge the gap between fossil dependence and sustainable growth.

VII. Conclusion

Fossil energy remains indispensable to the current phase of global economic and digital expansion. However, its role is changing from primary engine of growth to strategic enabler of stability and transition. The challenge for governments and enterprises is not merely to phase out fossil fuels, but to manage them intelligently through knowledge, innovation, and technology.

For developing countries like Nigeria, fossil fuels can serve as the platform for leapfrogging into a knowledge economy. The future of energy therefore lies not in the binary of fossil versus renewable, but in the fusion of knowledge and intelligence that governs their integration.

References

[1]. Energy Transitions Commission (2023) Fossil Fuels in Transition: Main Report. London: ETC. Available at: https://www.energy-transitions.org (Accessed 10 November 2025).

[2]. International Energy Agency (2024) World Energy Outlook 2024. Paris: IEA.

[3]. International Monetary Fund (2023) 'Natural Gas as a Bridge Fuel: Macroeconomic Perspectives', IMF Energy Policy Paper, No. 23/4.

[4]. Kulagin, V.A., Grushevenko, E.V. and Melnikov, Y.V. (2020) 'Fossil Fuel Markets in the Energy Transition Era', Russian Journal of Economics, 6 (1), pp. 1–20.

[5]. Niang, S.A.A., Faye, A. and Mbengue, B. (2024) 'A Tale of Sustainable Energy Transition Under New Fossil Realities', Sustainability, 16 (23), 10633.

[6]. Organisation for Economic Co-operation and Development (2023) Leveraging Fossil Fuel Capabilities for Clean Energy Transitions. Paris: OECD Publishing.