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Governing Artificial Intelligence in the Energy Sector of Resource-Rich Developing Economies: A Review of Legal, Institutional, and Policy Designs in Ghana

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Abstract
Artificial intelligence (AI) is transforming energy systems globally, yet governance frameworks in resource-rich developing economies remain structurally inadequate. This paper presents a qualitative review of the legal, institutional, and policy frameworks governing AI in the energy sector, with Ghana as an illustrative case. Employing a systematic literature review, doctrinal legal analysis, and thematic synthesis incorporating open coding, axial grouping, and cross-source integration, the paper identifies regulatory fragmentation, temporal misalignment between legal instruments and AI deployment realities, and institutional coordination failures that constitute a governance gap of structural character. The central analytical contribution is a six-step governance framework encompassing: (1) building on existing institutions and legislation; (2) risk-based calibration; (3) accountability mechanisms; (4) data protection integration; (5) sustainability standards; and (6) non-discrimination and energy justice principles. This framework offers a graduated pathway for regulators in resource-rich developing economies to construct effective AI governance without requiring new primary legislation. Drawing on a comparative analysis of international governance initiatives, African regulatory frameworks, and national AI strategy documents, the paper proposes an integrated governance architecture that encompasses AI-embedded energy regulation, inter-institutional coordination mechanisms, ethical AI standards for energy systems, and contextually calibrated regulatory capacity development. The findings advance scholarship in technology governance, energy policy, and development law by demonstrating the inadequacy of governance frameworks transplanted from high-income regulatory contexts.

Keywords
algorithmic accountability; artificial intelligence governance; energy justice; energy sector regulation; regulatory fragmentation; resource-rich developing economies; Global South

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1. Introduction

The integration of artificial intelligence (AI) into the global energy sector represents one of the most consequential technological shifts of the twenty-first century. AI-enabled applications encompassing smart grid optimisation, predictive maintenance, upstream exploration analytics, energy demand forecasting, and climate-responsive energy transition planning are fundamentally reconfiguring the operational, commercial, and governance architectures of energy systems worldwide (IEA, 2025; Sovacool et al., 2020). These developments are not confined to advanced industrialised economies; they are increasingly manifest in resource-rich developing economies, where energy infrastructure deficits, hydrocarbon dependency, and the imperatives of climate-aligned transition intersect with nascent digital governance environments (Okolo et al., 2023). Countries such as Ghana, Nigeria, Angola, and Mozambique are navigating concurrent pressures: the imperative to attract investment in digital energy infrastructure, the necessity to manage AI-related risks, and the obligation to advance energy justice in contexts marked by persistent inequality and uneven access (Dubber et al., 2020; Acheampong et al., 2021). Ghana's chronic electricity supply unreliability, popularly known as 'dumsor', exemplifies the demand for AI-enabled solutions to grid instability and load forecasting, while simultaneously highlighting the governance vacuum in which such technologies would be deployed (Ghana Energy Commission, 2022).

The deployment of AI in energy systems is not axiomatically beneficial. Without robust governance frameworks, AI introduces a constellation of risks acutely relevant to the Global South: algorithmic opacity and accountability deficits, data exploitation by extractive digital platforms, discriminatory energy access outcomes, cybersecurity vulnerabilities in critical infrastructure, and environmental externalities associated with AI's substantial computational energy demands (Coeckelbergh, 2020; Raji et al., 2020; Zuboff, 2019). These governance concerns are compounded in resource-rich developing economies by institutional fragmentation, regulatory capacity constraints, and the political economy dynamics characteristic of resource-dependent states (Hickey & Izama, 2017; Soderholm & Svahn, 2015).

A dimension of the governance challenge that has received insufficient analytical attention is the geopolitical character of AI deployment in Global South energy systems. The concept of AI 'extractivism', whereby foreign technology firms extract data, commercial value, and strategic intelligence from AI systems deployed in African energy infrastructure whilst contributing minimally to domestic governance or capacity development, represents a structural governance risk extending beyond conventional regulatory compliance frameworks (Kwet, 2019; Mohamed et al., 2020). Digital colonialism, as theorised by Couldry and Mejias (2019), describes the asymmetric power relations through which data-intensive platforms extract value from peripheral economies, reproducing colonial-era extraction dynamics in digital form. These dynamics are directly manifest in the energy sector, where multinational AI providers engage with national energy companies under contractual arrangements that constrain domestic regulators' access to algorithmic systems, training data, and decision logic (Ndemo & Weiss, 2017; Birhane et al., 2022). The result is a form of AI-mediated erosion of energy sovereignty: governance authority over critical infrastructure decisions is effectively ceded to entities whose accountability to domestic law is structurally limited. The international financial architecture further mediates the influence of foreign AI firms on energy governance in sub-Saharan Africa. Development finance institutions, including the World Bank and the African Development Bank, have increasingly conditioned energy sector investment on digital transformation programmes that, in practice, privilege AI systems developed by Global North technology providers (Mazzoni, 2019; Neto, 2025). Whilst such programmes carry genuine potential to improve energy system efficiency and transition planning, they also introduce governance dependencies that domestic regulatory frameworks are ill-equipped to manage. The political economy of AI-enabled energy development thus replicates, in a novel form, the structural asymmetries that resource dependency scholarship has long identified in extractive-sector governance (Ovadia, 2016; Hickey & Izama, 2017).

Despite the salience of these challenges, scholarly analysis of the legal, institutional, and policy frameworks governing AI within energy systems in resource-rich developing economies remains limited. Existing literature tends either to address AI governance in abstract terms or predominantly in European and North American contexts (Cihon, 2019; Dafoe, 2018) or to examine energy governance in developing economies without systematically attending to the AI dimension (Edomah, 2019; Bugaje, 2006). This paper addresses that gap through a comprehensive qualitative review of legal, regulatory, institutional, and policy frameworks governing AI in energy systems, with Ghana as an illustrative case. Three research questions inform the paper: (i) What legal and regulatory frameworks currently govern the deployment of AI in energy systems, and how adequate are they for resource-rich developing economies? (ii) What institutional and policy designs have been adopted to manage AI governance in the energy sector of developing economies? (iii) What governance gaps persist, and what reforms would constitute an effective AI governance architecture for the energy sector?

The paper contributes to scholarship at the intersection of energy governance, AI regulation, and development law by providing the first systematic doctrinal and comparative analysis of governance frameworks relevant to resource-rich developing economies, and by elaborating a six-step governance framework calibrated to the institutional conditions of the Global South. It advances theoretical understanding of technology governance under conditions of regulatory underdevelopment and institutional fragmentation, enriching debates in sustainability transitions, urban political ecology, and Global South governance studies (Burch et al., 2019; Lawhon & Murphy, 2012). Section 1.2 elaborates the research design; Section 2 reviews AI technologies, applications, and governance risks; Section 3 analyses legal and regulatory frameworks; Section 4 examines institutional and policy designs, including the six-step framework; and Section 5 synthesises findings and offers recommendations.

1.1 Research Design and Analytical Framework

This paper employs a qualitative research design that integrates a systematic literature review, doctrinal legal analysis, and thematic synthesis. This design is appropriate to the paper's ambition of producing a cross-jurisdictional, interdisciplinary account of AI governance in the energy sector, where the evidence base comprises heterogeneous sources, statutory instruments, international governance documents, policy frameworks, and scholarly literature demanding interpretive rather than purely quantitative treatment (Snyder, 2019; Fink, 2019).

A systematic literature review was conducted of peer-reviewed scholarship, grey literature, policy reports, and governance frameworks published between 2010 and 2024. Databases searched included Scopus, Web of Science, Google Scholar, and institutional repositories of the IEA, IRENA, the World Bank, UNEP, and the African Union. Search terms combined iterations of 'artificial intelligence', 'energy governance', 'regulatory frameworks', 'resource-rich economies', 'developing countries', 'Ghana', and 'AI regulation'. Doctrinal legal research was employed to examine the normative content and structural coherence of legal instruments, including statutes, regulations, and international norms bearing on AI in the energy sector (McKerchar, 2008). Instruments were analysed for their express provisions, regulatory gaps, and interpretive possibilities regarding AI deployment. Thematic synthesis was applied to identify recurrent governance patterns, institutional logics, and policy orientations across jurisdictions and source types (Braun & Clarke, 2006).

The thematic synthesis proceeded through three analytically distinct coding stages. In open coding, all sources, including statutory texts, policy documents, international instruments, and academic literature, were read iteratively and assigned descriptive codes that captured substantive content, such as 'algorithmic transparency obligation', 'energy sector licensing gap', and 'institutional coordination failure'. This produced a granular code inventory of over ninety distinct codes. In axial and theme grouping, related codes were clustered into six recurring governance themes: regulatory architecture, institutional design, accountability mechanisms, data governance, sustainability standards, and equity and justice. In cross-source integration, legal documentary sources were systematically compared with scholarly literature to identify points of alignment, tension, and mutual illumination. Data sources were drawn from four principal categories: international governance instruments, including UNESCO's Recommendation on the Ethics of AI (2021) and the OECD AI Principles (2019); national laws and policy frameworks, including Ghana's Data Protection Act (2012), the Petroleum Commission Act (2011), and the draft National AI Strategy; institutional mandates of regulators such as Ghana's Energy Commission, PURC, NCA, and regional bodies including AUDA-NEPAD; and comparative regulatory analysis drawing on the EU AI Act (2024) and analogous instruments. The analytical framework integrates three theoretical registers: governance of emerging technologies (Jasanoff, 2004; Stirling, 2008); AI regulatory models, including risk-based, sector-specific, and technology-neutral approaches (Calo, 2017); and energy governance in developing economies (Edomah, 2019; Ahlborg & Sjostedt, 2015). Limitations include the uneven availability of primary legal materials across jurisdictions, the nascent character of AI regulation in many developing economies, and reliance on grey literature where peer-reviewed sources are absent.

2. Artificial Intelligence in the Energy Sector: Technologies, Applications, and Governance Risks

Artificial intelligence constitutes a family of computational techniques, including machine learning (ML), deep learning, natural language processing (NLP), computer vision, and generative AI, that enable systems to perform tasks conventionally requiring human cognition, including pattern recognition, predictive modelling, decision optimisation, and autonomous action (Russell & Norvig, 2021). In the energy sector, these technologies are deployed across the entire value chain, from upstream resource extraction to final energy consumption, with transformative implications for operational efficiency, system reliability, and the political economy of energy governance (IEA, 2025; IRENA, 2023).

In upstream hydrocarbon exploration, ML algorithms are applied to seismic data interpretation, reservoir modelling, and drilling optimisation, substantially reducing exploration costs and improving success rates (Koroteev & Tekic, 2021). For resource-rich developing economies dependent on extractive revenues, including Ghana, where offshore oil production constitutes a pivotal component of national fiscal strategy, AI-assisted exploration represents both an economic opportunity and a governance challenge, as algorithmic outputs informing investment decisions remain largely inaccessible to domestic regulators (Acheampong et al., 2021; Ovadia, 2016). In power generation, AI applications encompass predictive maintenance of thermal and renewable generation assets, autonomous control of generation dispatch, and solar and wind resource assessment using satellite imagery and NLP-processed meteorological data (Rolnick et al., 2022).

Grid management and smart energy systems represent the most extensively developed domain of AI applications in energy. Smart grids integrate sensors, data networks, and AI-driven analytics to optimise electricity flows, detect faults, manage distributed energy resources, and coordinate demand response (Tuballa & Abundo, 2016). In Ghana's context, where erratic supply has historically undermined industrial productivity and household welfare, AI-enabled grid management offers the prospect of enhanced operational reliability, more precise load forecasting, and optimised dispatch of diversified generation assets. Energy demand forecasting through ML models enables system operators and commercial suppliers to anticipate load patterns with greater accuracy than conventional statistical methods, supporting improved procurement, tariff design, and infrastructure planning (Fabbri et al., 2015).

Energy transition planning is an emerging frontier of AI applications for developing economies seeking to reconcile resource dependence with decarbonisation commitments. AI tools support scenario modelling, least-cost planning, carbon accounting, and the identification of optimal sites for renewable energy deployment, functions of direct relevance to national energy planners and multilateral development finance institutions (Rolnick et al., 2022; Neto, 2025). Ghana's ambitions under its Nationally Determined Contributions and Renewable Energy Master Plan indicate substantial potential demand for AI-supported transition planning, provided that governance structures ensure the integrity and accountability of AI-generated recommendations (Environmental Protection Agency, Ghana, 2021).

Notwithstanding these transformative applications, AI deployment in energy systems poses a distinctive set of governance risks that warrant analytical attention. Algorithmic accountability is a foundational concern where AI systems inform critical decisions regarding grid access, tariff setting, or investment allocation. The opacity of algorithmic processes, the so-called 'black box' problem, undermines the capacity of regulators, affected communities, and civil society to scrutinise and contest those decisions (Pasquale, 2015; Diakopoulos, 2016). This accountability deficit is particularly acute in developing-economy contexts where institutional oversight mechanisms are already strained.

Data governance and cybersecurity risks are equally significant. AI systems consume vast quantities of sensitive data, consumer behaviour profiles, infrastructure operational data, and geospatial resource intelligence, all of which carry commercial and security sensitivities (Zuboff, 2019; IRENA, 2020). In contexts characterised by weak data protection regimes and limited cybersecurity infrastructure, the risks of data exploitation by foreign technology providers and state-sponsored cyberattacks on critical infrastructure are materially elevated (Carmody, 2013; Ndemo & Weiss, 2017). Environmental and climate risks associated with AI are increasingly recognised: the substantial energy demands of large-scale AI training and inference introduce carbon footprints that may contradict climate commitments (Strubell et al., 2019). Labour displacement from AI-driven automation in upstream extraction and grid operations further threatens employment in sectors that resource-rich developing economies rely upon for revenue and social stability (Cazzaniga et al., 2018).

Energy justice, understood as the equitable distribution of energy access, the fair allocation of costs and benefits, and the meaningful participation of communities in energy governance, is threatened where AI applications reproduce existing patterns of spatial inequality or exclude marginalised groups from the benefits of digitalised energy systems (Sovacool & Dworkin, 2015; Heffron & McCauley, 2017). These considerations are particularly salient for Ghana, where energy poverty remains geographically concentrated and gender-differentiated access to energy resources persists (Mensah et al., 2021; Ansu Mensah et al., 2021).

A critical but underexplored dimension of these risks is their intersection. Cybersecurity vulnerabilities and energy justice concerns are not merely co-occurring risks; they interact in ways that systematically amplify harm for already-marginalised communities. A cyber-attack on an AI-managed electricity distribution grid, an increasingly plausible threat given the expanding attack surface created by networked smart grid infrastructure (IRENA, 2020), can compromise the algorithms that determine which network segments receive priority restoration service. In contexts such as Ghana's, where peri-urban and rural electricity networks are characterised by lower infrastructure investment, weaker redundancy, and longer baseline restoration times, algorithmic prioritisation under attack conditions is likely to replicate and intensify existing spatial inequalities in energy access. The governance implication is clear: effective AI risk management in the energy sector cannot treat cybersecurity and energy justice as discrete compliance domains. Regulators must evaluate AI systems for distributional failure modes and establish equity-sensitive standards for the prioritisation of restoration and investment in community resilience.

3. Legal and Regulatory Frameworks for Governing AI in Energy Systems

The international governance landscape for AI has evolved rapidly, though it remains characterised by normative fragmentation and institutional multiplicity. The OECD's AI Principles (2019), endorsed by over 50 countries, establish a foundational normative architecture emphasising trustworthiness, transparency, accountability, and inclusive growth (OECD, 2019). UNESCO's Recommendation on the Ethics of Artificial Intelligence (2021) provides the first comprehensive global normative instrument on AI ethics, with explicit attention to environmental sustainability, gender equality, and the needs of developing countries (UNESCO, 2021). The Council of Europe's Framework Convention on Artificial Intelligence (2024) further elaborates international expectations, though its binding force and applicability in developing-economy contexts remain contested. The European Union's AI Act (2024) represents the most institutionally elaborate mandatory AI regulatory framework yet enacted, establishing a risk-based classification system imposing graduated obligations on developers and deployers. The most stringent requirements apply to high-risk applications, a category that explicitly includes AI systems affecting critical infrastructure, such as energy (European Parliament, 2024). Whilst directly applicable only within EU jurisdiction, the AI Act's extraterritorial reach through market access conditions and its standard-setting influence, the 'Brussels Effect', make it analytically significant for developing economies whose technology suppliers are subject to EU regulation (Bradford, 2020). The practical consequence for resource-rich developing economies is a form of regulatory dependency: governance standards are imported through contractual compliance clauses in technology procurement agreements without domestic regulatory deliberation or adaptation to local institutional conditions. The African Union's continental AI governance agenda has developed significantly. The AU Data Policy Framework (2022) establishes cross-cutting data governance principles applicable to AI systems and provides a basis for continental coordination of AI governance among member states (African Union, 2022). The AU's subsequent discussions on continental AI strategy, reflected in documents from the AU Commission's Digital Economy Directorate and the AUDA-NEPAD Digital Transformation Strategy, elaborate on governance expectations for member states, though binding continental AI instruments remain under development (Aklilu & Woldemariam, 2020; Ndung'u, 2019). At the level of individual African states, AI governance frameworks remain heterogeneous and unevenly developed. Rwanda's National AI Policy, Kenya's draft AI Policy, and Egypt's National AI Strategy represent relatively advanced instruments, whilst most sub-Saharan African states, including Ghana, are at earlier stages of developing national AI strategies (Ndung'u, 2019; Government of Ghana, 2023).

A comparative analysis of AI regulatory models reveals three principal archetypes with differential relevance for energy sector governance. Risk-based AI regulation, exemplified by the EU AI Act, calibrates regulatory requirements to the severity of potential harms, requiring conformity assessments, transparency obligations, and human oversight for high-risk applications (Floridi et al., 2020). This model has conceptual appeal for energy sector governance given its proportionality, though its implementation demands substantial regulatory capacity and data infrastructure that many developing economies currently lack. Sector-specific governance embeds AI oversight within existing energy regulatory frameworks, leveraging the technical expertise of specialised regulators (Calo, 2017). Technology-neutral regulatory approaches apply existing legal principles, including data protection, consumer rights, and environmental law, to AI without creating dedicated AI-specific instruments (Shadikhodjaev, 2021).

The analysis of legal instruments relevant to AI in the energy sector reveals a multi-layered but fragmented normative landscape. Ghana's Data Protection Act (Act 843, 2012) establishes core principles of lawfulness, purpose limitation, and data subject rights, but was enacted prior to the emergence of AI as an operational reality in Ghanaian energy systems and consequently lacks provisions addressing algorithmic processing, automated decision-making, or cross-border data flows associated with AI systems managed by foreign technology firms (Data Protection Commission Ghana, 2022). Nigeria's Data Protection Act (2023) represents a more contemporary and comprehensive instrument, yet significant implementation challenges persist, including inadequate regulatory capacity at the Nigeria Data Protection Commission and limited enforcement experience with complex digital systems (Makulilo, 2024; Aloamaka, 2025).

In energy regulation, Ghana's Energy Commission Act (Act 541, 1997) and the Public Utilities Regulatory Commission Act (Act 538, 1997) establish the principal regulatory architecture for the electricity sector but contain no provisions addressing AI or algorithmic systems, a lacuna replicated across most sub-Saharan African energy regulatory frameworks (Edomah, 2019). Environmental law instruments, including Ghana's Environmental Assessment Regulations (LI 1652, 1999) and the National Climate Change Policy (2013), establish procedural requirements for impact assessment and climate mitigation planning but are not applied to AI systems despite the material environmental externalities of large-scale AI deployment. Corporate accountability frameworks, including the Companies Act (Act 992, 2019) and sectoral licensing regimes, impose disclosure and due diligence obligations on energy operators but do not extend to algorithmic transparency or AI risk management. The cumulative result is regulatory fragmentation and temporal misalignment: legal instruments designed for pre-AI governance contexts are applied to AI-mediated energy systems for which they are structurally inadequate. Key regulatory gaps include the absence of mandatory algorithmic impact assessment requirements, the lack of provisions governing AI-generated recommendations in regulatory decision-making, inadequate frameworks for cross-border data governance, and the absence of liability rules for AI-caused harm in critical energy infrastructure. These gaps reflect deeper structural conditions, including the political marginalisation of AI governance in development policy agendas, the concentration of AI standard-setting authority in the Global North, and institutional capacity constraints that limit the autonomous development of domestic regulatory frameworks (Birhane et al., 2022; Mohamed et al., 2020).

4. Institutional and Policy Designs for AI Governance in Resource-Rich Developing Economies

The institutional architecture for AI governance in resource-rich developing economies is characterised by multiplicity, fragmentation, and emergent innovation. Multiple categories of institutions, energy regulators, digital technology authorities, environmental agencies, and bodies tasked with implementing national AI strategies claim partial jurisdiction over dimensions of AI governance in the energy sector, yet effective coordination mechanisms remain underdeveloped (Dosi et al., 2018; Birhane et al., 2022). In Ghana, this institutional landscape includes the Energy Commission, the Public Utilities Regulatory Commission, the National Communications Authority, the Data Protection Commission, and the Environmental Protection Agency, each with sector-specific mandates that intersect with, but do not comprehensively address, AI governance in energy systems.

National AI strategies constitute an increasingly prominent instrument through which developing economies signal their governance intentions. Ghana's draft National AI Policy for Inclusive Growth and its associated Artificial Intelligence Practitioners Guide constitute the most substantive national framework currently under development in West Africa, articulating commitments to ethical AI deployment, data protection, and inclusive innovation (Government of Ghana, 2023). However, the policy's applications in the energy sector are not systematically elaborated, and its implementation is contingent on institutional capacities and inter-agency coordination mechanisms that have yet to be established. Rwanda's National AI Policy and Kenya's draft AI Policy similarly reflect the growing recognition among African governments that AI governance requires dedicated strategic frameworks. However, comparable gaps in energy sector specification are evident (Ndung'u, 2019).

Policy approaches adopted by developing economies to govern digital technologies in the energy sector have tended to cluster around three orientations: facilitating technology adoption, mitigating risk through adaptive regulation, and adopting multilateral norms. The technology adoption orientation, exemplified by Ghana's energy sector digitalisation initiatives and Nigeria's Digital Economy Policy, prioritises removing barriers to AI deployment with limited attention to governance safeguards (Ministry of Communications and Digital Economy, Nigeria, 2020; Acheampong et al., 2021). Adaptive regulatory approaches, drawing on 'sandbox' and 'regulatory experimentation' models advanced by the World Bank and the African Development Bank, seek to accommodate innovation while progressively constructing oversight mechanisms (Neto, 2025; Mazzoni, 2019). Multilateral norm adoption reflects the influence of international standard-setting bodies on national policy design, though this influence risks producing governance frameworks calibrated to conditions prevailing in norm-exporting countries rather than the institutional realities of the Global South (Birhane et al., 2022; Mohamed et al., 2020).

Coordination challenges between institutions constitute one of the most significant structural impediments to effective AI governance in the energy sector. The co-evolution of AI, energy, data, and environmental governance domains generates complex jurisdictional overlaps and institutional boundary disputes that are difficult to resolve without clear statutory mandates and interoperability mechanisms. In Ghana, the absence of a whole-of-government AI governance coordinating body means that AI policies in the energy sector proceed without systematic integration of data protection, environmental, or competition law considerations, a coordination deficit that comparably afflicts Nigeria, Tanzania, and Zambia (Dubber et al., 2020). Governance capacity constraints present a further systemic challenge. Technical expertise in AI systems design, machine learning audit methodologies, and algorithmic impact assessment remains scarce across regulatory bodies in sub-Saharan Africa, limiting national regulators' capacity to evaluate the compliance of AI systems deployed by multinational energy companies and technology providers (Ndemo & Weiss, 2017). Regulatory resource constraints compound technical deficits, limiting the frequency and depth of regulatory engagement with AI-deploying actors in the energy sector.

4.1 The Six-Step Governance Framework: A Graduated Pathway for Resource-Rich Developing Economies

Against the structural constraints identified above, this paper advances a six-step governance framework as a core analytical contribution. The framework is designed to be implemented iteratively, building governance architecture from existing institutional foundations rather than requiring the construction of wholly new regulatory regimes, a practical imperative in contexts characterised by legislative capacity constraints and institutional resource limitations. The six steps and their governance logic are presented in Table 1.

The framework's sequential logic is significant. Steps 1 and 2 establish the regulatory and risk architecture; Steps 3 and 4 operationalise accountability and data governance within that architecture; Steps 5 and 6 embed the normative commitments, sustainability and non-discrimination that ensure governance serves energy justice imperatives as well as operational efficiency goals. Critically, the framework is designed for sequential but flexible implementation: resource-constrained regulators may advance Steps 1 and 2 immediately through amendments to existing licensing conditions, whilst Steps 3 through 6 are progressively elaborated as institutional capacity develops. Regional harmonisation initiatives under the African Union, including the AU Data Policy Framework (2022), provide a complementary mechanism for pooling regulatory capacity and establishing common standards applicable to cross-border AI deployments in shared energy infrastructure.

Table 1. The Six-Step AI Governance Framework for the Energy Sector in Resource-Rich Developing Economies

Step	Principle	Governance Logic	Application in Resource-Rich Developing Economies
Step 1	Build on Existing Institutions and Legislation	Rather than constructing a new regulatory architecture, governance should leverage and adapt existing statutory mandates, energy sector acts, data protection laws, and environmental regulations to accommodate AI-specific requirements. This reduces legislative lag and deploys already-legitimate institutional authority.	In Ghana, the Energy Commission Act (1997) and the Data Protection Act (2012) provide initial jurisdictional anchors. Energy sector licensing conditions can be amended to incorporate algorithmic transparency obligations without awaiting dedicated AI legislation.
Step 2	Risk-Based Calibration	Regulatory obligations should be proportionate to the severity of potential AI-related harms. High-risk applications, such as autonomous grid dispatch, AI-generated tariff recommendations, or seismic data interpretation informing investment decisions, face stringent requirements. Lower-risk applications face lighter-touch obligations.	Critical infrastructure AI in grid management warrants mandatory algorithmic impact assessments and human oversight mechanisms. Demand-forecasting tools used for internal planning may require transparency reporting but less intensive scrutiny.
Step 3	Accountability Mechanisms	Clear chains of responsibility must be established for AI-mediated decisions in the energy sector. This encompasses the designation of accountable persons within energy firms, mandatory incident reporting, and regulator access rights to audit algorithmic systems and their decision outputs.	Energy sector licensees should be required to designate an AI accountability officer, maintain algorithmic decision logs, and submit these to the Energy Commission or PURC upon request, modelled on data controller obligations under Ghana's Data Protection Act.
Step 4	Data Protection Integration	AI systems in the energy sector generate and consume sensitive data, including consumer behaviour profiles, operational infrastructure data, and geospatial resource intelligence, which requires robust data governance to prevent exploitation by foreign technology firms and to comply with applicable data protection law.	Cross-border data flow agreements, data localisation requirements for operationally sensitive energy infrastructure data, and algorithmic processing notices should be integrated into AI procurement standards for energy sector regulators and state-owned enterprises.
Step 5	Sustainability Standards	AI deployment in the energy sector should be evaluated against environmental sustainability criteria, including the computational energy demands of AI systems and their lifecycle environmental footprint. AI should demonstrably support, rather than contradict, national climate and energy transition commitments.	Environmental impact assessments for significant energy-sector AI deployments should be required under existing Environmental Assessment Regulations, with adaptations to address computational carbon footprints. AI-enabled transition planning tools should align with Ghana's NDC targets.
Step 6	Non-Discrimination and Energy Justice	AI systems governing energy access, tariff design, or infrastructure prioritisation must be designed and audited to prevent discriminatory outcomes. Community participation mechanisms should ensure that marginalised populations, including women, rural communities, and energy-poor households, can contest algorithmic decisions affecting their energy access.	Algorithmic equity audits should be embedded in the licensing conditions of AI-deploying energy distribution companies. Regulators should establish community grievance mechanisms that enable AI-mediated energy access decisions to be challenged without requiring technical expertise.

Source: Developed by the author, drawing on the EU AI Act (European Parliament, 2024), the AU Data Policy Framework (African Union, 2022), and the OECD AI Principles (OECD, 2019).

5. Discussion and Conclusion: Towards Effective AI Governance in the Energy Sector

The foregoing analysis establishes several cross-cutting findings. The deployment of AI in the energy sector of resource-rich developing economies is advancing substantially ahead of the governance frameworks designed to manage it. Legal instruments governing data protection, energy regulation, environmental compliance, and corporate accountability were enacted in pre-AI regulatory contexts and are structurally inadequate for the algorithmic dimensions of contemporary energy governance. Institutional architectures are fragmented, with jurisdictional overlaps among energy, digital, environmental, and AI governance bodies, leading to coordination failures that enable regulatory arbitrage by technologically sophisticated actors. National AI strategies remain nascent, under-resourced, and insufficiently integrated with energy sector governance frameworks. The influence of foreign AI providers, operating through dynamics of AI extractivism and digital colonialism, introduces a further structural dimension to the governance gap: authority over critical energy infrastructure decisions is effectively ceded to entities whose accountability to domestic law is structurally limited (Kwet, 2019; Couldry & Mejias, 2019; Mohamed et al., 2020). These findings collectively indicate a governance gap qualitatively distinct from, and more structurally embedded than, conventional regulatory lag.

A piecemeal, instrument-specific approach to AI governance in the energy sector is unlikely to produce the coherent governance architecture that effective AI oversight requires. The structural character of the governance gap demands an integrated response attending simultaneously to the legal, institutional, policy, and capacity dimensions of the challenge. The six-step governance framework elaborated in Section 4.1 provides a practical instrument for this integrated response. As a graduated pathway, it does not demand the simultaneous achievement of full governance capacity; rather, it enables regulators to begin with immediately achievable interventions, amending energy sector licensing conditions to incorporate algorithmic transparency requirements and designating AI accountability officers, while progressively constructing the accountability, data governance, sustainability, and equity infrastructure that comprehensive AI governance requires.

Four principal policy recommendations follow from this analysis. First, integrated AI-energy regulatory frameworks should be developed that embed AI governance requirements, algorithmic transparency, impact assessment, and human oversight obligations within energy sector licensing conditions, regulatory reporting requirements, and investment approval processes. This responds directly to the finding of regulatory temporal misalignment: the absence of AI-specific provisions in energy sector legislation can be remedied incrementally through licensing conditions without awaiting primary legislation. Second, institutional coordination mechanisms, including interdepartmental AI-energy governance task forces, joint regulatory capacity-building programmes, and statutory information-sharing obligations, should be established to manage jurisdictional complexity across energy, data, environmental, and competition domains. Third, ethical AI standards for energy systems, encompassing non-discrimination in algorithmic access and tariff design, algorithmic transparency requirements, and community participation mechanisms, should be developed through participatory processes that centre the perspectives of marginalised and energy-poor communities, particularly women and rural populations. This responds to the intersectional cybersecurity-energy justice finding that governance standards must be evaluated for their distributional failure modes, not merely their compliance with formal transparency obligations. Fourth, regulatory capacity building, technical training in AI systems audit, algorithmic impact assessment, and digital infrastructure security should be prioritised and supported through multilateral development finance and South-South knowledge exchange, ensuring that capacity development is contextually calibrated rather than transplanted from Global North regulatory environments.

The theoretical implications of this analysis advance scholarship across several domains. This paper demonstrates that AI governance in resource-rich developing economies functions as a 'gatekeeper' in the sustainability transition from fossil-fuel dependency to digitised renewable energy systems, in the sense theorised by Sovacool et al. (2020) regarding incumbent-oriented transition intermediaries. Just as incumbent fossil fuel interests shape the terms on which low-carbon alternatives enter energy markets, incumbent AI governance structures, including foreign technology providers, international standard-setting bodies dominated by Global North actors, and multilateral development finance conditions, shape the terms on which AI is integrated into developing economy energy systems. Effective AI governance is not merely a compliance function; it is a structural determinant of whether AI-enabled energy transitions are socially just, democratically accountable, and genuinely aligned with the energy sovereignty of resource-rich developing economies. Governance frameworks that fail to interrogate these incumbent dynamics risk reproducing, in digital form, the structural asymmetries that resource dependency scholarship has long documented in the extractive sector (Ovadia, 2016; Hickey & Izama, 2017).

Several directions for future research follow from this analysis. Empirical studies examining the actual deployment of AI systems by energy sector actors in specific resource-rich developing economy contexts, including ethnographic and documentary analyses of regulatory encounters between AI-deploying firms and national authorities, would substantially enrich the evidence base for governance design. Comparative legal analysis of emerging AI governance frameworks across African states, attending to differential pathways of norm adoption, institutional innovation, and enforcement practices, would advance understanding of the conditions under which effective AI governance develops in resource-constrained settings. Pilot implementation studies examining the application of the six-step governance framework in specific national contexts, beginning with Ghana, given its advanced AI strategy development and documented energy sector challenges, would test the framework's practical utility and identify context-specific adaptations. Interdisciplinary research integrating energy justice theory, computational social science, and regulatory studies could advance understanding of how AI-mediated energy governance distributes benefits and burdens across socially differentiated populations.

References

[1] Acheampong, A. O., Ackah, I., & Opoku, F. (2021). Who bears the burden? Distributional effects of energy taxation in Ghana. Energy Research & Social Science, 71, 101810.

[2] African Union. (2022). African Union data policy framework. African Union Commission. https://au.int/sites/default/files/documents/42078-doc-DATA- POLICY-FRAMEWORKS-2024-ENG-V2.pdf

[3] Ahlborg, H., & Sjostedt, M. (2015). Small-scale hydropower in Africa: Socio-technical designs for renewable energy in Tanzanian villages. Energy

[4] Research & Social Science, 5, 20–33. https://doi.org/10.1016/j.erss.2014.12.017

[5] Aklilu, A., & Woldemariam, G. (2020). AI governance in Africa: Opportunities and challenges for the continent. African Journal of Science, Technology, Innovation and Development, 12(6), 735–748. https://doi.org/10.1080/20421338.2019.1695189

[6] Aloamaka, P. C. (2025). A critical analysis of the Nigeria Data Protection Act 2023: Elevating standards to global norms. UCC Law Journal, 4(2), 242–263. https://doi.org/10.47963/ucclj.v4i2.1724

[7] Ansu-Mensah, P. & Kwakwa, P. (2021). Modelling electricity consumption in Ghana: the role of financial development indicators. Green Finance. 4. 54–70. 10.3934/GF.2022003.

[8] Birhane, A., Cummins, R., & Mohamed, S. (2022). The values encoded in machine learning research. Patterns, 3(6), 100490. https://doi.org/10.1016/j.patter.2022.100490

[9] Bradford, A. (2020). The Brussels effect: How the European Union rules the world. Oxford University Press.

[10] Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. Qualitative Research in Psychology, 3(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

[11] Bugaje, I. M. (2006). Renewable energy for sustainable development in Africa: A review. Renewable and Sustainable Energy Reviews, 10(6), 603–612. https://doi.org/10.1016/j.rser.2004.11.002

[12] Burch, S., Gupta, A., Iglecias, C., Kaur, A., Olsson, L., & VanDeveer, S. D. (2019). New directions in earth system governance research. Earth System Governance, 1, 100006. https://doi.org/10.1016/j.esg.2019.100006

[13] Calo, R. (2017). Artificial intelligence policy: A primer and roadmap. UC Davis Law Review, 51(2),399–435. https://lawreview.law.ucdavis.edu/sites/g/files/dgvnsk15026/files/media/documents/51-2_Calo.pdf

[14] Carmody, P. (2013). A knowledge economy or an information society in Africa? The integration and the mobile phone revolution. Information Technology for Development, 19(1), 24–39. https://doi.org/10.1080/02681102.2012.719859

[15] Cazzaniga, M., Jaumotte, F., Li, L., Melina, G., Panton, A., Pizzinelli, C., Rockall, E., & Tavares, M. (2018). The future of work in advanced economies (IMF Staff Discussion Note SDN/18/07). International Monetary Fund.

[16] Cihon, P. (2019). Standards for AI governance: International standards to enable global coordination in AI research and development. Centre for the Governance of AI, Future of Humanity Institute. https://cdn.governance.ai/Standards_-FHI-Technical-Report.pdf

[17] Coeckelbergh, M. (2020). AI ethics. MIT Press. https://www.researchgate.net/publication/339103412_AI_Ethics

[18] Council of Europe. (2024). Framework Convention on Artificial Intelligence and Human Rights, Democracy and the Rule of Law (CETS No. 225). Council of Europe.

[19] Couldry, N., & Mejias, U. A. (2019). The costs of connection: How data is colonising human life and appropriating it for capitalism. Stanford University Press.

[20] Dafoe, A. (2018). AI governance: A research agenda. Future of Humanity Institute, University of

Oxford. https://cdn.governance.ai/GovAI-Research-Agenda.pdf

[21] Data Protection Commission, Ghana. (2022). Annual report 2022. Data Protection Commission. https://www.dataprotection.org.gh

[22] Diakopoulos, N. (2016). Accountability in algorithmic decision making. Communications of the ACM, 59(2), 56–62. https://doi.org/10.1145/2844110

[23] Dosi, G., Pereira, M. C., Roventini, A., & Virgillito, M. E. (2018). Causes and consequences of hysteresis: Aggregate demand, productivity, and employment. Industrial and Corporate Change, 27(6), 1015–1044. https://doi.org/10.1093/icc/dty010

[24] Dubber, M., Pasquale, F., & Das, S. (Eds.). (2020). The Oxford handbook of ethics of AI. Oxford University Press.

[25] Edomah, N. (2019). Governing energy access and the role of governance beyond government: A case study of rural Nigeria. Sustainability, 11(18), 5033. Environmental Protection Agency, Ghana. (2021). Ghana's updated nationally determined contribution under the Paris Agreement, Ministry of Environment, Science & Technology. https://mesti.gov.gh/documents/ghanas-updated-nationally- determined-contribution-unfccc_2021/

[26] European Parliament. (2024). Regulation (EU) 2024/1689 of the European Parliament and of the Council on artificial intelligence (AI Act). Official Journal of the European Union, OJ L 2024/1689. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ:L_202401689

[27] González, P. A., & Zamarreño, J. M. (2005). Prediction of hourly energy consumption in buildings based on a feedback artificial neural network. Energy and Buildings, 37(6), 595–601. https://doi.org/10.1016/j.enbuild.2004.09.006

[28] Fink, A. (2019). Conducting research literature reviews: From the internet to paper (5th ed.). SAGE Publications.

[29] Floridi, L., Cowls, J., King, T. C., & Taddeo, M. (2020). How to design AI for social good: Seven essential factors. Science and Engineering Ethics, 26(3), 1771-1796. https://doi.org/10.1007/s11948-020-00213-5

[30] Ghana Energy Commission. (2022). National energy statistics 2022. Energy Commission of Ghana. https://www.energycom.gov.gh

[31] Government of Ghana. (2023). Ghana's national artificial intelligence strategy for inclusive growth. Ministry of Communications and Digitalisation. https://www.moc.gov.gh

[32] Heffron, R. J., & McCauley, D. (2017). The concept of energy justice across the disciplines. Energy Policy, 105, 658–667. https://doi.org/10.1016/j.enpol.2017.03.018

[33] Hickey, S., & Izama, A. (2017). The politics of governing oil in Uganda: Going against the grain? African Affairs, 116(463), 163–185. https://doi.org/10.1093/afraf/adw048

[34] IEA (2025), Energy and AI, IEA, Paris https://www.iea.org/reports/energy-and-ai, Licence: CC BY 4.0

[35] International Renewable Energy Agency. (2020). Innovation landscape for a renewable-powered future: Solutions to integrate variable renewables. IRENA. https://www.irena.org/publications/2019/Feb/Innovation-landscape-for-a-renewable-powered-future

[36] International Renewable Energy Agency. (2023). Renewable power generation costs in 2022. IRENA. https://www.irena.org/Publications/2023/Aug/Renewable-Power-Generation-Costs-in-2022

[37] Jasanoff, S. (2004). The idiom of co-production. In S. Jasanoff (Ed.), States of knowledge: The co-production of science and social order (pp. 1–12). Routledge.

[38] Koroteev, D., & Tekic, Z. (2021). Artificial intelligence in oil and gas upstream: Trends, challenges, and scenarios for the future. Energy and AI, 3, 100041. https://doi.org/10.1016/j.egyai.2020.100041

[39] Kwet, M. (2019). Digital colonialism: US empire and the new imperialism in the Global South. Race & Class, 60(4), 3–26. https://doi.org/10.1177/0306396818823172

[40] Lawhon, M., & Murphy, J. T. (2012). Socio-technical regimes and sustainability transitions: Insights from political ecology. Progress in Human Geography, 36(3), 354–378. https://doi.org/10.1177/0309132511427960

[41] Makulilo, A. B. (2024). Data privacy in Africa. In L.A. Abdulrauf & H.Dube (Ed.), Data privacy law in Africa: Emerging perspectives (pp. 41-73). Mazzoni, D. (2019). Digitalisation for energy access in sub-Saharan Africa: Challenges, opportunities and potential business models (Working Paper No. 002.2019). Fondazione Eni Enrico Mattei.

[42] McKerchar, M. (2008). Philosophical paradigms, inquiry strategies and knowledge claims: Applying the principles of research design and conduct to taxation. eJournal of Tax Research, 6(1), 5-22.

[43] Ministry of Communications and Digital Economy, Nigeria. (2020). National dig-

ital economy policy and strategy for a digital Nigeria. Federal Ministry of Communications and Digital Economy.https://nitda.gov.ng/wp-content/uploads/2020/06/National-Digital- Economy-Policy-and-Strategy.pdf

[44] Mohamed, S., Png, M.-T., & Isaac, W. (2020). Decolonial AI: Decolonial theory as sociotechnical foresight in artificial intelligence. Philosophy & Technology, 33(4), 659–684. https://doi.org/10.1007/s13347-020-00405-8

[45] Ndemo, B., & Weiss, T. (2017). Making sense of Africa's emerging digital transformation and its many futures. Africa Journal of Management, 3(3–4), 328–347. https://doi.org/10.1080/23322373.2017.1400260

[46] Ndung'u, N. (2019). Digital Technology and State Capacity in Kenya. https://www.cgdev.org/sites/default/files/digital-technology-and-state- capacity-kenya.pdf

[47] Neto, A. M. (2025). Digital Progress and Trends Report 2025: Harnessing AI for Efficiency- Transforming agriculture and energy sectors. World Bank Group. http://documents.worldbank.org/curated/en/09911252516051790

[48] OECD. (2019). Recommendation of the Council on Artificial Intelligence (OECD/LEGAL/0449). OECD.

[49] Okolo, C. T., Aruleba, K., & Obaido, G. (2023). Responsible AI in Africa: Challenges and opportunities. In D. O. Eke, K. Wakunuma, & S. Akintoye (Eds.), Responsible AI in Africa (pp. 35–64). Palgrave Macmillan. https://doi.org/10.1007/978-3-031-08215-3_3

[50] Ovadia, J. S. (2016). The petro-developmental state in Africa: Making oil work in Angola, Nigeria and the Gulf of Guinea. Hurst & Company.

[51] Pasquale, F. (2015). The black box society: The secret algorithms that control money and information. Harvard University Press.

[52] Raji, I. D., Smart, A., White, R. N., Mitchell, M., Gebru, T., Hutchinson, B., Smith-Loud, J., Theron, D., & Barnes, P. (2020). Closing the AI accountability gap: Defining an end-to-end framework for internal algorithmic auditing. Proceedings of the 2020 Conference on Fairness, Accountability, and Transparency (pp. 33–44). ACM. https://doi.org/10.48550/arXiv.2001.00973

[53] Rolnick, D., Donti, P. L., Kaack, L. H., Kochanski, K., Lacoste, A., Sankaran, K., Ross, A. S., Milojevic-Dupont, N., Jaques, N., Waldman-Brown, A., Luccioni, A., Maharaj, T., Sherwin, E. D., Kharecha, S., Bengio, G., Delgado Lopes, S. A., Bhatt, U., Strubell, E., & Bengio, Y. (2022). Tackling climate change with machine learning. ACM Computing Surveys, 55(2), 1–96. https://doi.org/10.1145/3485128

[54] Russell, S., & Norvig, P. (2021). Artificial intelligence: A modern approach (4th ed.). Pearson.

[55] Shadikhodjaev, S. (2021). Technological neutrality and regulation of digital trade: How far can we go? The European Journal of International Law, 32(4), 1221–1248. https://doi.org/10.1093/ejil/chab054

[56] Snyder, H. (2019). Literature review as a research methodology: An overview and guidelines. Journal of Business Research, 104, 333–339. https://doi.org/10.1016/j.jbusres.2019.07.039

[57] Soderholm, P., & Svahn, N. (2015). Mining, regional development and benefit-sharing in developed and developing countries. Resources Policy, 45, 78–91. https://doi.org/10.1016/j.resourpol.2015.03.003

[58] Sovacool, B. K., & Dworkin, M. H. (2015). Energy justice: Conceptual insights and practical applications. Applied Energy, 142, 435–444. https://doi.org/10.1016/j.apenergy.2015.01.002

[59] Sovacool, B. K., Turnheim, B., Martiskainen, M., Brown, D., & Kivimaa, P. (2020). Guides or gatekeepers? Incumbent-oriented transition intermediaries in the European low-carbon energy transition. Energy Research & Social Science, https://doi.org/10.1016/j.erss.2020.101490.

[60] Stirling, A. (2008). 'Opening up' and 'closing down': Power, participation, and pluralism in the social appraisal of technology. Science, Technology, & Human Values, 33(2), 262–294. https://doi.org/10.1177/0162243907311265

[61] Strubell, E., Ganesh, A., & McCallum, A. (2019). Energy and policy considerations for deep learning in NLP. Proceedings of the 57th Annual Meeting of the Association for Computational Linguistics (pp. 3645–3650). ACL.

[62] Tuballa, M. L., & Abundo, M. L. (2016). A review of the development of smart grid technologies. Renewable and Sustainable Energy Reviews, 59, 710–725. https://doi.org/10.1016/j.rser.2016.01.011

[63] UNESCO. (2022). Recommendation on the ethics of artificial intelligence. United Nations Educational, Scientific and Cultural Organisation.

[64] Zuboff, S. (2019). The age of surveillance capitalism: The fight for a human future at the new frontier of power. PublicAffairs.