

Domestic Natural Gas Supply in Nigeria: A Critical Review of Policy, Infrastructure, and System-Level Constraints

Tolulope Elekula*, Boniface A. Oriji, Emeka Okafor

Emerald Energy Institute, University of Port Harcourt, Port Harcourt, Nigeria

*Corresponding Author

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ABSTRACT

Nigeria is home to one of the world's largest natural gas reserve base, however despite this natural abundance, the country struggles to deliver reliable gas supply for local consumption to power generation plants and feedstock to domestic gas based industries, this failure persists even after repeated attempts by the Government through domestic gas policy formation and reforms, regulatory interventions and infrastructure drives aimed at positioning natural gas as Nigeria's energy security foundation. This review takes a close look at some existing literature on the topic of Nigeria's domestic gas supply and attempts to explain the structural drivers of this system failure. Studies published in peer-reviewed journals, conference proceedings and authoritative institutional sources were analysed to evaluate how policy design, regulatory framework, enforcement, development of infrastructure and market dynamics all work together to shape domestic gas supply outcomes. The approach applied is integrative, where regulatory, value-chain and infrastructure dimensions are considered in the postulation of the domestic gas sufficiency issue. This review is aimed at the identification of key gaps in existing literature on the topic of domestic gas sufficiency in Nigeria including the approach of fragmented analysis of the value chain, weak enforcement of Nigerian domestic gas supply obligation, insufficient infrastructure assessments, ignored demand side risk and scarce empirical evaluations of the cluster based gas development methods or approach. This paper makes an effort to consolidate dispersed evidence and showcase the constraints, thereby presents a clear analytical foundation for future research in this area and subsequent policy design, it emphasizes the need for a system-level execution oriented framework that considers infrastructure spread, regulatory mechanisms and financially credible demand, especially within the power sector, all with the aim of achieving sustainable domestic gas supply in Nigeria.

Keywords: Domestic gas supply, Energy infrastructure, Gas-to-power, Natural gas policy, Nigeria

INTRODUCTION

Natural gas is often regarded as the bridge towards cleaner systems, a transition fuel that is key in supporting emission reduction while providing energy security and industrial expansion especially in developing economies like Nigeria with growing power and industrial needs. Considering Nigeria's substantial gas resources and the country's ambition to pivot from an oil based economy to a gas based energy economy, the country is well positioned to harness the power of this transition fuel. Nigeria is reported to hold over 200 Trillion cubic feet of proven natural gas reserves, which is about the largest gas deposit in Africa and ranks among the top, globally, despite this abundance, Nigeria struggles with domestic gas supply which has remained inadequate compared to demand and potential requirements. [1], [2].

In the last two decades, The Nigerian Government has instituted several policies and policy reforms to address this problem, notable among them are: The Nigerian gas master plan, National gas policy, and the more recent "Decade of Gas Initiative", these policies are targeted at the prioritisation of domestic use of gas through infrastructure expansion, regulatory reforms and enforcement of Nigerian domestic gas supply obligation (DGSO) [1], [3]. These policies and frameworks were designed to underscore gas to power development, industrial utilization and reduction in routine gas flaring which should ultimately form the central pillars of

economic development and transformation. However available literature and reports provides evidence that the policy intent has not sufficiently translated into reliable domestic gas delivery, [4], [2].

An evident pattern in reviewed academic literature is the disconnect between the availability of gas and sufficient domestic utilization, studies that examine gas production and utilization patterns indicate that a significant portion of produced gas is channelled towards export markets, gas reinjection, or flaring, while domestic supply continuously underperform when compared to allocated volumes [1]. Analysing the demand side shows that rapid growth in electricity and industrial gas demands has overtaken the capacity of available domestic supply systems, this has widened the supply gap and increased system fragility [2].

The Domestic Gas Supply Obligation (DGSO) was instituted as a central policy intended to correct the imbalance of domestic gas supply in Nigeria, however multiple studies opine that the effectiveness of the DGSO policy has been impaired by unfavourable pricing frameworks, weak payment discipline especially in the gas to power sector and the commercial risk borne by gas producers and suppliers that serve the domestic market [2], [5], in depth analysis of gas to power sector has continuously demonstrated that liquidity shortfalls weaken the reliability of gas supply, this creates a feedback loop that further discourages investments in the upstream and midstream [6].

A second critical constraint that was identified is the lack of adequate infrastructure, literature documents under-developed and poorly synchronized midstream systems, these include: transmission pipelines, processing facilities and distribution networks, which together limits the ability to efficiently process and move produced gas to demand centers [1], [7]. Current studies on Nigerian domestic gas utilization reveals that infrastructure development and expansion in the mid and down streams have lagged behind upstream development, this has resulted in cases of stranded gas resources and the country's continued domestic dependence on liquid fuels and uncoordinated power generation systems [4].

Another level of constraint is non-physical, namely fragmentation, which is apparent in existing literature that tends to isolate upstream production economics, infrastructure planning and development, regulatory design and power sector performance from each other, the insufficient integration of these different dimensions into a unified domestic gas supply framework [3], [2] has resulted in policy prescriptions that address symptoms rather than root causes and neglect of the systematic interdependencies in the gas to value chains. This fragmented approach is of particular concern, especially as Nigeria begins to increasingly explore corridor and cluster based natural gas development models targeted at aggregating gas supply, optimising infrastructure and improving reliability. Recent studies have suggested that cluster-based approaches to gas development by linking multiple gas fields through shared processing and transmission facilities may present a more reliably scalable route to domestic gas supply sufficiency for power generation and industrial use [8], [6]. However, it is worthy of note that the existing literature lacks the consolidation of empirical findings, policy insights and infrastructure considerations into an integrated model that can support an execution based exercise.

In the light of the above this paper attempts to decisively synthesise peer-reviewed journals, conference proceedings and authoritative institutional studies that borders on Nigeria's domestic natural gas supply with the aim to (i) consolidate fragmented evidence along the lines of policy, infrastructure, and market dimensions; (ii) Identify re-occurring gaps that limit reliable domestic gas delivery and (iii) Establish a scalable analytical foundation that is reusable for future models and corridor based gas development approaches.

THEORETICAL ANALYSIS

The available literature on domestic natural gas supply and gas to power systems in Nigeria, shows that there is no singular theory that applies exclusively to domestic natural gas supply and gas to power systems in Nigeria, rather the ideas of this unique systems borrows from multiple analytical frameworks across different fields like energy economics, industrial organisation, regulatory governance and infrastructure systems. This section digests various theoretical perspectives as filtered from the reviewed studies, providing an informational structure for understanding domestic gas supply performance in Nigeria.

The Resource endowment and resource infrastructure paradox

A basic principle in energy economics is that resource availability under efficient institutional, fiscal and structural arrangements should translate into improved energy availability, access and ultimately positive economic outcomes, however the reality of the Nigerian gas sector challenges this basic principle. Despite abundant and extensive gas reserves, we find that domestic utilization has remained constrained, this situation illustrates what may be referred to as resource-infrastructure paradox or more broadly the resource curse [1], [2]. Within this theoretical context, the availability of Natural gas alone is not sufficient, there needs to be the presence and configuration of well timed enabling infrastructure to harness domestic economic advantages of the resource.

Scholars who adopt this view underscore that upstream production capacity, midstream transmission, and also the downstream demand must progress in coordination with each other, in situations where infrastructure developments is misaligned or lags behind demand centres Natural gas remains stranded, trapped or diverted to export markets irrespective of domestic need [4]. This approach analyses domestic gas supply as a systemic outcome, rather than silos of reserve availability or policy declarations.

Gas to Power Value chain Theory

Value chain analysis provides a second dominant framework, especially within the gas to power literature, this framework views domestic gas supply as multi stage chain spanning production, processing, transportation, power generation, transmission, distribution and finally consumption, it is noted that weakness at any node generates significant risk backward through the chain, discouraging upstream incentives and general system reliability [6], [5].

This framework views Nigeria's gas to power challenges as coordination and incentives failures across market segments that are interdependent and not as engineering failures alone, for example lack of payment discipline in the power sector increases counter party risks for the gas suppliers and hence discourages upstream investment and reduces system reliability even where physical infrastructure is available [2]. The literature proposes a value chain risk transmission model, where domestic gas sufficiency is dependent on the weakest commercial or institutional link.

Regulatory and Institutional Economics

Regulatory economics forms a third theoretical perspective provided by many studies reviewed, domestic gas market outcomes are largely shaped by the host country's regulatory design, it's enforcement capability and institutional coherence. The Nigerian Domestic Gas Supply Obligation (DGSO) regulation reflects an attempt to correct market failure through mandating supply of gas to key domestic sectors, however experience has proven that obligation based frameworks perform poorly when the regulated prices diverge or is less than commercial realities and enforcement mechanisms are weak. [1], [2]. Fragmented regulatory oversight also exists across upstream, midstream and power sector institutions which further weakens system wide coordination [3], from this viewpoint, Nigeria's domestic gas challenges are linked more to institutional misalignment than policy absence, this is evident as multiple regulatory mandates operate without an integral common execution framework.

Infrastructure Network and Spatial Economics Perspective

Infrastructure network theory and spatial economics provides an additional analytical perspective, given that gas transmission systems are spatial networks and their efficiency depends on topology, nodal balance, redundancy and proximity to demand centres. Studies that focus on pipeline development and gas transportation adopt this view while underscoring that linear field to market planning is insufficient in geographically dispersed systems [7].

Recent studies and analysis continually point towards "cluster based or corridor based gas development as a means for addressing spatial and scale inefficiencies, by the aggregation of multiple gas fields and utilizing

shared infrastructure such models reduce per unit processing and transportation cost of gas, improve load factors and enhance gas supply reliability to industrial and power hubs [8], [6].

Synthesis: Towards an Integrated Domestic Gas Supply Framework

An overall look at all reviewed literature suggests lack of an integrated analytical approach where domestic gas supply is the product of several interacting factors such as the resource availability, infrastructure, regulatory and market systems. No single approach or framework completely explains Nigeria's outcomes around domestic gas supply, rather it's performance results from the interaction of value chain risks, regulatory incentives, infrastructure topology and institutional capacity, this synthesis provides basis for a subsequent gap analysis, particularly it shows that while individual literature are well developed, what is lacking is an integration across these theoretical lenses to produce execution focused models like corridor based gas development and system level optimization for domestic gas delivery sufficiency in Nigeria.

GAP ANALYSIS

Though research and body of scholarship on Nigeria's natural gas sector has grown, key analytical gaps remains, and this limits the usefulness of research for execution focused domestic gas supply planning, these gaps cuts across policy analysis, infrastructure, gas to power economics and emerging system level-approaches, these collectively explain why domestic gas supply performance remains inadequate even in the face of policy formulation, enforcement and sustained efforts.

Fragmentation across the gas to power value chain

An observed continued fragmentation of analysis along value chain boundaries is a primary gap observed in literature, the approach here examines upstream gas production, midstream infrastructure or gas to power sector outcomes in isolation, without sufficient integration of these components to form a unified analytical framework. An example is where gas production and utilization focused studies document low domestic gas uptake and underperformance of domestic gas supply obligations (DGSO), but treats gas processing and transportation infrastructure constraints and lack of liquidity in the power sector as external conditions rather than integral drivers of gas supply outcomes [1], [2].

Gas to power economic analyses emphasize the negative effects of payment arrears, persistent backlogs and pricing distortions on domestic gas supply reliability, but does not go the next step of embedding these risks in a system wide domestic supply optimization framework [5], [6], this fragmentation in literature has led to the lack of integrated models capable of capturing how risks propagate across the Nigerian gas to power value chain, from the field development decisions to the final point of electricity delivery.

Limited Implementation of Domestic Gas Supply Obligation

The Domestic Gas Supply Obligation (DGSO) is frequently mentioned in policy and academic discussions; however, this literature remains largely prescriptive. Weak enforcement, misaligned pricing and institutional capacity constraints are some of the reasons for the underperformance of the DGSO [3], conversely only few contributions move beyond diagnosis to develop empirical model based approaches for improving the effectiveness of the DGSO especially under realistic commercial conditions. Some models exist, but focus only on allocation ratios and quota mechanisms and fall short of fully integrating demand side risk, availability of infrastructure and trade-offs between export and domestic markets [9]. Illustrated in Table 1, is an example of such allocation frameworks that distribute DGSO quotas to upstream operators in proportion to their reserves, production and importantly flaring contributions; however such frameworks remains volumetric and does not account for the infrastructure, pricing and demand side conditions, all of which determines if the allocated volumes can be reliably and efficiently delivered.

Table 1. Operator-level domestic gas supply obligation (DGSO) allocation framework

Operator	Reserves (TCF)	Utilised (TCF/yr)	Flared (TCF/yr)	DGSO Req. (TCF/yr)
SPDC	89.773	0.107	2.167	0.4986
MPNU	26.024	0.0019	0.0032	0.0855
CNL	25.721	0.174	0.604	0.1645
NAOC	14.29	0.452	0.585	0.1703
Total/ELF	8.788	0.5452	0.4175	0.1527
ADDAX	1.607	0.0077	0.2187	0.0255
NPDC/AENR	1.377	0.0006	0.0447	0.0085
SNEPCO	5.406	0.1267	0.0142	0.0392
Others	9.15	0.072	0	0.0414
Total	184	1.4917	4.135	1.2

Source: Adapted from Nduka et al. [9]. Values reflect illustrative allocation outputs of the DGSO model and are presented to indicate framework structure rather than current operational quotas

Infrastructure analysis without spatial or network integration

Infrastructure deficits has always been identified as a core constraint on the sufficiency of domestic gas supply in Nigeria, studies document inadequate pipeline networks or coverage, processing facility bottlenecks and extended delays in gas related project executions as hindrances to optimal domestic gas delivery [7], [4].

In Table 2 we see a summary of the principal high pressure gas transmission pipelines in operation within Nigeria, also considering the infrastructure inventories compiled in reviewed literature [13], it is evident that the limited number of trunk lines, couple with their concentration around the Niger-delta and the south western corridor and the absence of redundant routing is a classical illustration of the spatial sparsity of the domestic gas transmission network, this observed sparsity underlines why any incremental upstream supply of gas will not automatically mean improvement to consumption centres. It also helps us to see why a minor supply disruption on a single corridor can have a system-wide effect.

Little to no availability of spatial and network based analysis presents a critical gap, there are few studies that clearly assess the effects of pipeline topology, nodal balance, redundancy and proximity to demand centres on domestic gas supply efficiency, this results in infrastructure planning recommendations that stress general expansion but rather should consider optimized corridor or hub development to align with demand aggregation strategies [10]

Table 2. Major gas transmission pipelines within Nigeria

Pipeline	Start	End	Dia. (in)	Length (km)
Trans-Niger Pipeline System	Bomu/Bonga Field	Bonny Terminal	32	268
Escravos–Lagos Pipeline System (ELPS)	Escravos	Lagos	36	340
Aladja System Pipeline	Oben	Ajaokuta	24	294
Greater Ughelli System	Ughelli	Warri	n.r.	90.3

Source: Adapted from Adamu [13]. Dimensions are nominal and reflect headline trunk-line specifications reported in the literature. Diameter for the Greater Ughelli System is not reported (n.r.) in the source inventory.

Insufficient integration of demand side risk and market dynamics

A good number of studies notes the role of demand side risk of the domestic gas supply business in Nigeria, especially the lack of payment discipline in the gas to power sector, however this perspective is often not incorporated into formal supply models, a demand management analyses highlights the disparity between gas supply and end user demand, but treats demand as an external factor or policy driven rather than linked to pricing, liquidity and infrastructure constraints [11].

This also contributes to the limitations of literature in supporting practical decision making in the facet of sufficient and reliable domestic gas supply, as sufficiency depends on credible offtake arrangements and financially able demand.

Emerging cluster based approaches remains underdeveloped

Industry professionals and scholars have introduced cluster-based or corridor based approaches to gas development in Nigeria, a promising method for improving domestic gas supply reliability and efficiency, this method proposes aggregating multiple gas fields through shared infrastructure which can reduce costs, improve load factors and mitigate supply risk to power and industrial hubs [8], [12]. Cluster level analysis report aggregate generation potential of several hundred megawatts of additional gas, however this idea remains at developmental stages as there is limited validation of cluster performance in the Nigerian situation and no integration of regulatory, pricing and demand side considerations with cluster based models.

Case illustration: gas-based industrial clustering in Trinidad and Tobago

Trinidad and Tobago offers an instructive empirical reference for cluster-based gas development in a comparable resource setting. The Point Lisas Industrial Estate, covering approximately 870 hectares and representing investment exceeding US\$2 billion, hosts seventy-nine companies, with ammonia, urea, methanol, petrochemical and steel producers drawn principally by assured access to competitively priced gas [14]. The determining factor was institutional rather than geological. The National Gas Company of Trinidad and Tobago was mandated as prime mover in gas-based development, operating as an aggregator that purchases gas from upstream producers and contracts its onward sale to industrial users, thereby interposing a creditworthy intermediary and absorbing the counterparty risk that otherwise deters upstream commitment to domestic supply [15]. Aggregated and bankable demand justified transmission investment at a scale isolated projects could not support: system capacity was expanded from 780 MMscf/d to 1.4 Bcf/d through construction of 42 miles of 36-inch transmission line, while gas sales rose from 513 MMscf/d in 1992 to an average of 717 MMscf/d by 1997 [15]. Sectoral analysis confirms the durability of the resulting demand structure, with natural gas now utilised across ten distinct sectors of the Trinidadian economy, sustained over three decades after the estate's establishment [16]. Subject to differences in market scale and governance, the case demonstrates that co-locating anchor demand, commercial aggregation and dedicated infrastructure can convert resource abundance into sustained domestic utilisation — a sequencing that Nigeria has largely pursued as separate and uncoordinated interventions.

Lack of an Execution focused system level framework

When considered together, the above highlighted gaps point to a single greater deficiency: the lack of an execution focused system level framework for domestic gas supply sufficiency in Nigeria. We see that while literature is quite rich in diagnostics, it offers a limited consolidated solution capable of advising a coordinated infrastructure drive, regulatory calibration and market outlooks.

This gap is significant especially in the context of Nigeria's current reform strides, where emphasis is shifting from policy delivery to actual implementation, there is a risk that these new Nigerian initiatives might replicate historical fragmentation, rather than address structural causes.

Figure 1 illustrates the structure of such a framework, showing how the principal constraints identified in this

review map onto corresponding execution levers, and how the coordinated application of those levers gives rise to an integrated system capable of delivering sufficient and reliable domestic gas supply.

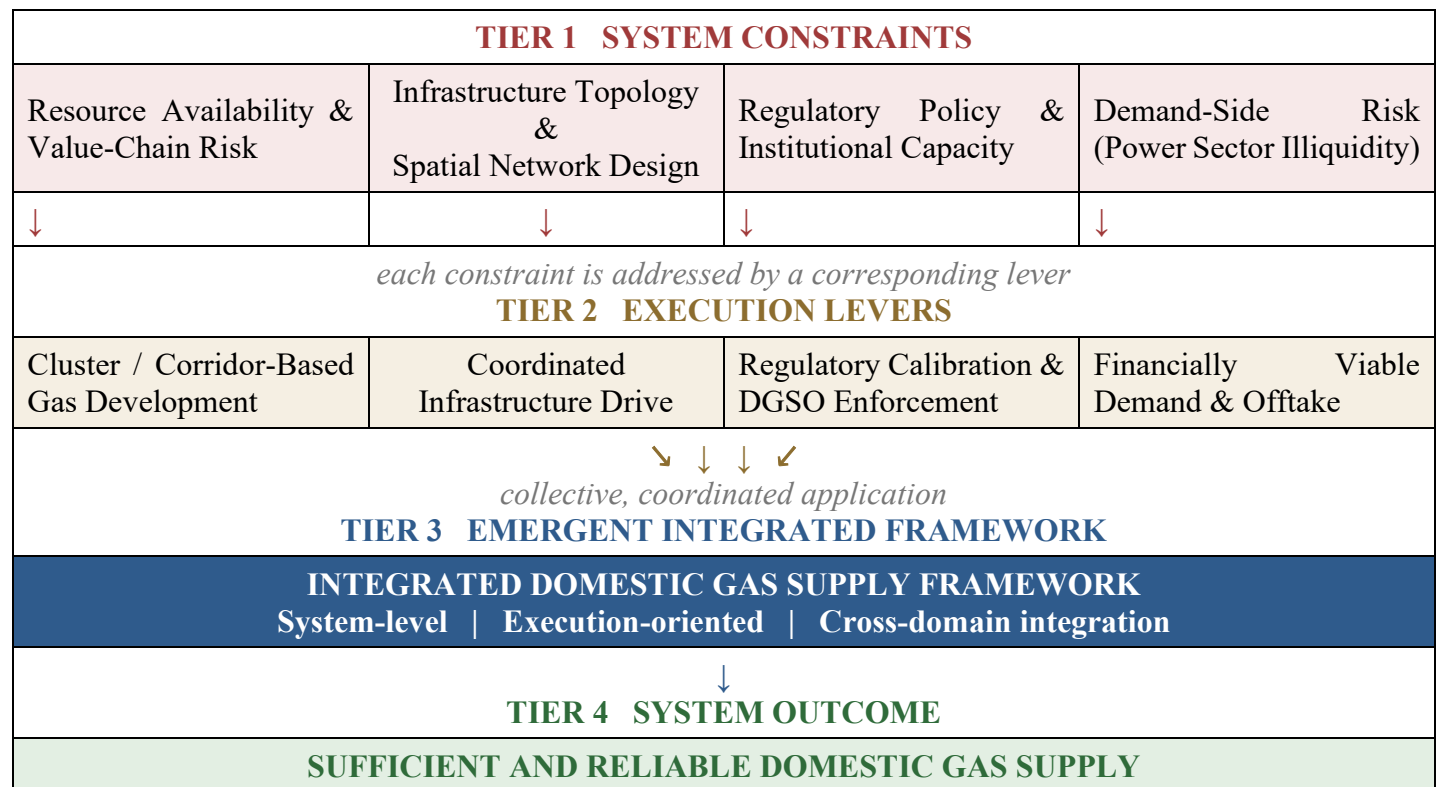


Figure 1. Proposed system-level execution-oriented framework for domestic gas supply sufficiency in Nigeria

Source: Authors' construction, derived from the synthesis of reviewed literature.

CONCLUSION

This review aims to examine existing literature on the topic of Nigeria's domestic natural gas supply, with some emphasis on the gas to power value chain, in the light of continual energy shortfalls despite extensive gas reserves and several iterations of policy reforms.

Drawing from peer-reviewed journals, conference proceedings and authoritative institutional studies, this review has shown that the issue of insufficient domestic gas supply in Nigeria is not the result of a single point of failure, but rather the combined outcome of the interaction between structural, institutional and even market-based constraints. All available literature on the subject agrees that the abundant availability of the natural gas resources in Nigeria has not translated into domestic sufficiency, as we go on to see that is occasioned by the fact that enabling systems have evolved unevenly. Published studies on the Nigerian gas production and utilization emphasize low domestic uptake when compared to reserves, weak performance of the domestic gas supply obligation and the deviation of produced gas towards export market, re-injection or flaring. Gas to power studies and analysis also show that payment indiscipline, price distortions and liquidity issues in the gas to power sector affect gas supply reliability and discourages upstream and midstream infrastructure investments [5], [6]. These findings support the view that sufficient domestic gas supply outcomes is a system level phenomena, that is dependent on value-chain risk transmission not an isolated technical or policy shortcoming.

This review also establishes that infrastructure shortages, especially in gas transmission, processing and transportation network is a major reason for the underperformance of domestic gas supply, this has led to many studies documenting the need for expansion of pipelines and processing capacity, but little attention has been

paid to the spatial optimization, network resilience and the sequencing of these infrastructure investments in relation to demand aggregation [7], [4], hence infrastructure recommendations most times lack the system level viewpoint that is essential for a broad focused planning.

This review has identified analytical fragmentation as a limiting factor in existing literature, majority of the available literature examines policy design, infrastructure development and market dynamics as stand alone, in isolation, this has reduced the ability of scholars to propose integrated domestic gas supply strategies. Although recent proposals have suggested that clustering approach to gas field development and shared infrastructure could improve domestic supply reliability and efficiency, these approaches are still relatively underdeveloped and not well integrated into the regulatory and market considerations [8], [12]

In the consolidation of all the above, this review reaffirms the need to recapture the domestic gas supply scenario in Nigeria as an integrated system that cuts across resource availability, infrastructure availability, infrastructure topology, regulatory policy, regulatory incentives and demand side credibility, this indicates that further policy reforms based only on obligation mandates, isolated infrastructure projects or price adjustments are unlikely to yield tangible or expected results except they are embedded in an integrated execution focused framework, that incorporates value-chain risk, spatial network design and the consideration of financially viable demand, with special emphasis on the power sector.

DECLARATIONS

Ethical Approval

This study is a review of previously published literature and did not involve human participants or animals; ethical approval was therefore not required.

Conflict of Interest

The authors declare that they have no conflict of interest.

Data Availability Statement

No new data were generated in this study. All data analysed are drawn from publicly available published sources cited within this article.

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