BUSINESS RESCUE

Business-Continuity-Informed Program Analytics for Scalable Energy-Access and Development Initiatives: A Continuity-Priority Framework for Electricity Access, Clean Cooking, and Analytics-Led Programme Governance

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Abstract

This paper develops a business-continuity-informed analytics framework for scalable energy-access and development initiatives, with particular attention to electricity access and clean cooking transitions in Sub-Saharan Africa and other high-deficit settings. Although energy-access literature has expanded rapidly, much of the implementation debate still privileges deployment volumes over continuity of service, beneficiary retention, operational resilience and data-governed scale-up. To address that gap, the study combines secondary-data synthesis, continuity-risk scoring and programme-analytics design. Publicly accessible datasets and dashboards were screened, including Kaggle mirrors during the scoping phase, but the analytical base retained the harmonised indicators published by the World Bank-led Tracking SDG 7 platform and the International Energy Agency because those sources offered clearer metadata, comparable regional definitions and up-to-date 2023 and 2030 series. The empirical synthesis shows that the global electricity gap stood at 666 million people in 2023 and is still projected at 645 million in 2030 under current trajectories. In Sub-Saharan Africa, the electricity gap fell only marginally from 565 million in 2023 to a projected 545 million in 2030. Clean cooking displays an even more persistent implementation challenge: more than 2 billion people lacked access in 2023, with around 960 million of them in Sub-Saharan Africa, and the region is projected to remain near 940 million in 2030. Heat maps and continuity-priority scoring indicate that clean-cooking programmes in Sub-Saharan Africa face the highest combined pressure from burden persistence, weak reduction trajectories, affordability stress, supply-chain fragility and frontline-delivery constraints. The paper concludes that scalable energy-access programmes require a shift from connection-counting to continuity-centred programme management built on interoperable data systems, adaptive KPI dashboards, reliability engineering, workforce support and stage-gate scaling discipline.

Keywords: energy access; clean cooking; programme analytics; business continuity; Sub-Saharan Africa; decentralised renewable energy; operational resilience

1 Introduction

Universal access to affordable, reliable and modern energy remains one of the defining implementation challenges of the current development decade. According to the World Bank-led Energy Progress Report 2025, global access to electricity rose to 92% in 2023, yet 666 million people still lacked

access and progress remains too slow to achieve universal access by 2030 (World Bank, 2025). The burden is increasingly concentrated in Sub-Saharan Africa, which accounted for 85% of the global population without electricity in 2023. In the same year, 35 million people in the region obtained electricity, but rapid population growth meant that the net reduction in the access gap was only 5 million, leaving 565 million people still unserved (World Bank, 2025).

Clean cooking presents an even more stubborn deficit. The International Energy Agency reports that more than 2 billion people did not have access to clean cooking in 2023, with around 960 million of them in Sub-Saharan Africa and roughly 1.1 billion in developing Asia (IEA, 2024a). Under current policy trajectories, around 1.7 billion people are still expected to remain without clean cooking in 2030, including about 940 million in Sub-Saharan Africa (IEA, 2024a). These figures indicate that the energy-access problem is no longer only a question of technology deployment or capital mobilisation. It is equally a question of programme continuity: whether energy initiatives remain operational, trusted, affordable, repairable, monitored and scalable after the first phase of implementation.

That distinction matters because many programmes fail not at the moment of launch but at the level of sustained service. Mini-grids, solar home systems, clean-stove initiatives and productive-use schemes are often designed around connection targets, procurement milestones and disbursement cycles. Far less attention is given to demand retention, spare-parts continuity, frontline workforce resilience, interoperability of data systems, beneficiary tracking and corrective feedback loops. As a result, programmes can display apparent early success while accumulating hidden fragilities that erode long-run impact.

This paper argues that programme analytics and business continuity should be treated as central design principles for energy-access interventions rather than as post hoc monitoring functions. The study therefore asks three linked questions. First, where do current electricity-access and clean-cooking deficits show the greatest persistence under 2030 projections? Second, which continuity risks are most likely to disrupt large-scale deployment, adoption and ongoing service delivery? Third, what analytics architecture can translate these risks into operational management routines and replicable scale-up decisions?

The paper makes four contributions. It synthesises current 2023 burden and 2030 persistence indicators across electricity and clean-cooking domains. It develops a continuity-priority index that highlights where slow progress and high residual burden intersect. It constructs a stage-specific continuity-risk heat map for scalable energy-access programmes. Finally, it proposes a practical KPI framework for programme managers, financiers and implementation partners seeking to improve delivery reliability, learning and scale discipline.

2 Literature review and conceptual foundation

Energy-access scholarship has established that electricity and clean cooking generate broad welfare gains, but the size of those gains depends heavily on the continuity and quality of service. Lee et al. (2020) show that the economics of rural electrification cannot be reduced to binary connection status alone; costs, demand, reliability and actual usage matter for the welfare case. More recent field evidence from Kenya and Nigeria indicates that solar mini-grids can improve productivity, gender outcomes, safety and income where service is sustained and valued by users (Carabajal et al., 2024). Yet long-term usage data from off-grid solar home systems also show declining energy consumption over time in many households, indicating that initial access does not guarantee durable service value or productive-use deepening (Perriment et al., 2025).

Clean-cooking research similarly demonstrates that adoption is not a one-step transition from traditional to modern energy. Affordability, fuel supply reliability, behavioural preferences, stove compatibility and repair constraints all shape whether households sustain the transition or revert to biomass and kerosene. Gill-Wiehl, Ray and Kammen (2021) review the affordability challenge in clean cooking, while Onakomaiya et al. (2019) underline that implementation design and sustained use matter for health outcomes. Amegah and Jaakkola (2016) situate household air pollution within the Sustainable Development Goals more broadly, reinforcing that clean cooking has direct implications for health, gender equity, environmental stewardship and poverty reduction. The IEA (2024a) further notes that around 29 countries in Sub-Saharan Africa remain below 20% access to clean cooking, indicating a structurally persistent gap rather than a temporary policy lag.

A second body of literature concerns resilience and operational continuity. Mishra et al. (2019) argue that resilient microgrids require systematic threat assessment, vulnerability identification and mitigation design. Sodomaco et al. (2025) extend this logic to remote off-grid contexts by showing that long-term system availability depends on embedding operation and maintenance considerations from the outset rather than treating them as downstream technical issues. Likewise, survey and choice-experiment evidence from Nigeria suggests that households and SMEs value not only connections but also service timing, capacity, affordability and reliability, all of which are continuity-sensitive programme attributes (Pelz et al., 2023; Janghorban et al., 2024).

A third and increasingly important strand is analytics-led system management. Pirie et al. (2024) review AI-powered mini-grid approaches and conclude that forecasting, optimisation and adaptive control can improve operational decisions where data pipelines are sufficiently strong. Recent applied work has also begun to connect resilience, predictive maintenance and hybrid-system optimisation more directly to energy infrastructure. Kabera et al. (2026a) show how digital-twin and predictive-maintenance logic can improve solar PV and battery-storage operations, while Kabera et al. (2026b) develop a machine-learning-augmented framework for PV-grid-battery hybrid microgrids that targets full reliability at lower levelised cost of energy. These studies imply that continuity is analytically tractable when asset states, failures and utilisation patterns are measured systematically.

Data governance is equally important. Hagan et al. (2026a) argue that climate-sensitive systems need auditable, governance-oriented data structures rather than fragmented reporting architectures. In a related contribution, Hagan et al. (2026b) show how predictive analytics, anomaly detection and risk scoring can make complex, climate-exposed systems more resilient. Although those papers are not centred on household energy access, their core insight transfers directly: programmes scale more reliably when data lineage, risk signals and response thresholds are built into operational governance. The human side of continuity should not be ignored either. Mawora et al. (2025) demonstrate in a community-based organisational setting that frontline delivery quality depends in part on support bundles, supervision and protection against burnout and operational strain. Energy-access programmes that depend on field technicians, community mobilisers and local entrepreneurs face analogous continuity risks.

Despite these advances, an important gap remains. Much of the energy-access literature analyses technology choice, willingness to pay, socioeconomic impacts or emissions implications in isolation. Comparatively less work integrates burden persistence, continuity risks, data governance and stage-gate management into one programme-analytics framework. This paper addresses that gap by joining current SDG7 burden indicators with a structured continuity lens designed for implementation management and scale-up.

3 Methodology

The study adopts a mixed-method secondary-data design combining descriptive indicator synthesis, derived continuity scoring and programme-management interpretation. The empirical base was assembled from publicly accessible SDG7 repositories and analytical reports. During scoping, publicly shared datasets and mirrors, including Kaggle-hosted materials, were reviewed for relevance to electricity access, clean cooking and programme implementation. However, the final analytical base retained the World Bank-led Tracking SDG 7 and IEA SDG7 indicator series because these sources provided harmonised definitions, transparent metadata and the most current 2023 and 2030 figures suitable for a policy-quality synthesis.

Two analytical layers were then constructed. The first layer is a burden-and-outlook dataset covering five domains: global electricity access, Sub-Saharan Africa electricity access, global clean cooking, developing Asia clean cooking and Sub-Saharan Africa clean cooking. For each domain, the study compiled 2023 deficit levels, 2030 projected deficits, absolute reductions and percentage reductions to 2030. Where the IEA reported a lower-bound figure rather than an exact point estimate (most notably, that more than 2 billion people lacked clean cooking in 2023), the visualization used a conservative floor of 2.0 billion and flagged this explicitly in notes and captions.

The second layer is a continuity-risk matrix covering six programme stages: design, financing, deployment, adoption, operations and scale-up. Nine recurrent risk factors were scored on a five-point severity scale, where 1 indicates low risk pressure and 5 indicates critical pressure. Scores were assigned through structured synthesis of the official SDG7 reports and peer-reviewed or scholarly studies on mini-grid resilience, off-grid availability, clean-cooking adoption, field operations and analytics-enabled infrastructure management. The scoring is not presented as causal estimation; it is presented as a transparent synthesis tool for managerial prioritisation.

A continuity-priority index was calculated to identify domains where the combination of large current burden, high 2030 persistence and slow progress is most acute. The index combines standardised values of the 2023 deficit, the 2030 projected deficit and an inverse standardisation of the percentage reduction to 2030. Higher scores therefore indicate a stronger case for continuity-led analytics intervention. The weighting scheme places 25% on current burden, 25% on projected persistence and 50% on slow progress, thereby giving greater emphasis to domains where projected change is especially weak relative to the starting deficit.

The methodological intent is practical rather than purely econometric. Programme managers frequently need structured decision support even when harmonised microdata remain incomplete or dispersed across donors, ministries, utilities and private operators. A disciplined synthesis of official indicator series, explicit scoring rules and operational KPI design can therefore add value by improving programme governance, even where fine-grained causal modelling remains a future research task. The resulting burden-and-outlook dataset is given in Table 1 and Figure 1.

Table 1. Burden and outlook dataset for the continuity-priority analysis.

Domain	2023 deficit (millions)	2030 projected deficit (millions)	Absolute reduction (millions)	Reduction to 2030 (%)
Global electricity access gap	666	645	21	3.15
Sub-Saharan Africa electricity access gap	565	545	20	3.54

Domain	2023 deficit (millions)	2030 projected deficit (millions)	Absolute reduction (millions)	Reduction to 2030 (%)
Global clean cooking gap	2,000	1,700	300	15.00
Developing Asia clean cooking gap	1,100	760	340	30.91
Sub-Saharan Africa clean cooking gap	960	940	20	2.08

Note: The 2023 global clean-cooking figure is plotted conservatively at 2.0 billion because the IEA reports the value as "more than 2 billion".

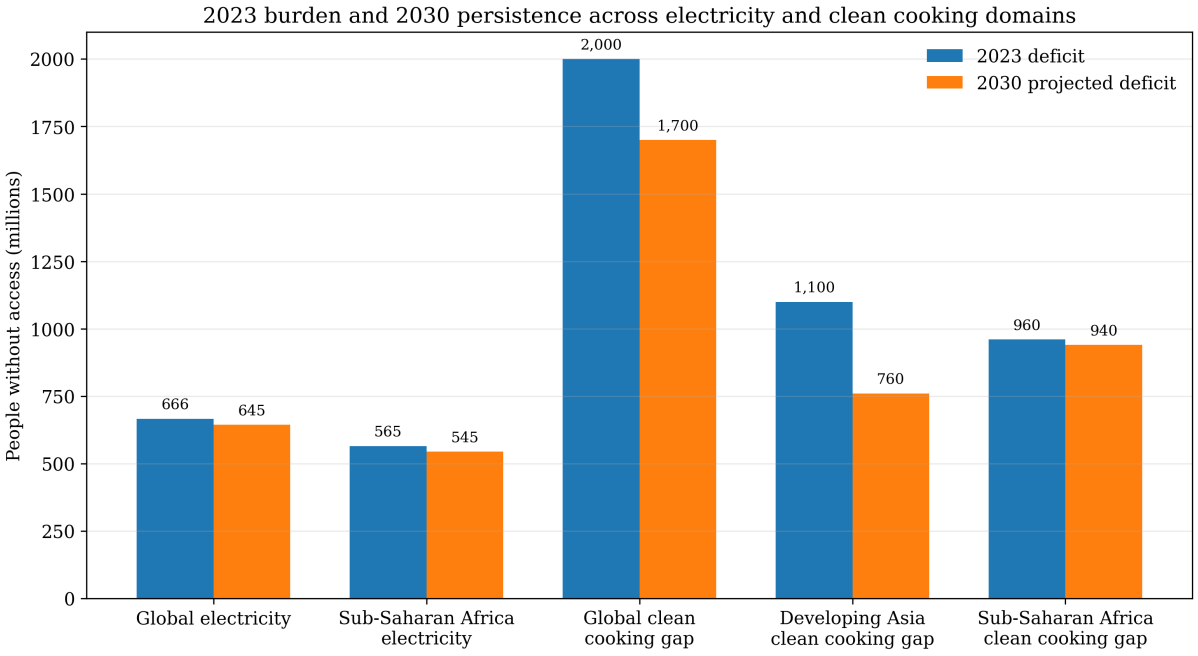


Figure 1. 2023 burden and 2030 persistence across electricity and clean cooking domains. Source: Author synthesis from World Bank (2025) and IEA (2024a; 2024b).

4 Results

4.1 Burden persistence and outlook

The first result is the extent to which current policy trajectories still leave exceptionally large energy-access gaps in place by 2030. Figure 1 and Table 1 show that the global electricity deficit declines only from 666 million in 2023 to 645 million in 2030, while the Sub-Saharan African electricity deficit falls from 565 million to 545 million. These changes amount to reductions of only 3.15% and 3.54%, respectively. In practical terms, this means that the world, and especially Sub-Saharan Africa, is not facing a last-mile problem alone; it is facing a continuity and scale problem where current gains are repeatedly diluted by population growth, affordability constraints and uneven programme follow-through.

The burden is even more severe for clean cooking. The lower-bound global deficit falls from 2.0 billion in 2023 to 1.7 billion in 2030, while Sub-Saharan Africa shows only a marginal reduction from 960 million to 940 million. By contrast, developing Asia records a much stronger projected reduction from 1.1 billion to 760 million, equivalent to 30.91%. These differences imply that progress depends

not only on the existence of energy-access technologies, but also on the strength of programme architectures, policy coherence, affordability support and delivery continuity across regions.

The electricity-access benchmarks reinforce the scale of operational effort still required. The IEA estimates that around 135 million new electricity connections will be needed annually from 2024 to meet universal access, while the World Bank reports that decentralized renewable-energy solutions already benefited more than 561 million people worldwide in 2023 and delivered 55% of new electricity connections in Sub-Saharan Africa during 2020-2022 (IEA, 2024b; World Bank, 2025). These figures suggest that the challenge is not simply whether decentralised solutions work. Rather, the challenge is whether programme systems can sustain the financing, maintenance, customer support and data visibility needed for such solutions to remain available at scale.

Clean cooking benchmarks point in the same direction. The IEA estimates that nearly 300 million people would need to gain access each year to achieve universal clean cooking by 2030, with annual investment needs of around USD 8 billion. Yet in Sub-Saharan Africa the projected reduction to 2030 is negligible relative to the current burden, indicating that financial flows, fuel and appliance supply chains, behavioural transition support and affordability safeguards are not currently aligned at the required pace (IEA, 2024a). Table 2 summarises these empirical benchmarks.

Table 2. Empirical benchmarks relevant to continuity-sensitive programme design.

Benchmark area	Key empirical benchmark	Primary source
World electricity access	135 million new electricity connections per year required from 2024	IEA (2024b)
Sub-Saharan Africa electricity access	84% of those without electricity live in rural communities globally; 451 million rural residents in Sub-Saharan Africa remained without electricity in 2023	World Bank (2025)
Decentralized electricity access	DRE solutions benefited over 561 million people globally in 2023 and provided 55% of new connections in Sub-Saharan Africa during 2020-2022	World Bank (2025)
DRE investment benchmark	USD 95 billion funding need to expand off-grid and decentralized solutions	World Bank (2025)
Global clean cooking access	Nearly 300 million people need to gain access each year to achieve universal access by 2030	IEA (2024a)
Clean cooking investment benchmark	Around USD 8 billion annual investment needed for full clean cooking access by 2030	IEA (2024a)
Clean cooking mitigation benefit	Universal clean cooking access can save up to 1.5 Gt CO2-eq by 2030, including 900 Mt in Sub-Saharan Africa	IEA (2024a)

Note: These benchmarks are used in the discussion to link burden persistence to operational scale requirements.

4.2 Continuity-priority synthesis

Figure 2 translates the burden statistics into a continuity-priority heat map. Darker cells represent domains with high current burden, high residual burden in 2030 and weak expected reduction. The continuity-priority index (Figure 3) ranks the global clean-cooking gap first, followed by the Sub-Saharan African clean-cooking gap, global electricity access, Sub-Saharan African electricity access and, finally, developing-Asia clean cooking. The high ranking of clean cooking domains is not surprising: the burden is extremely large and the projected pace of change remains inadequate in the regions with the largest gap.

From a managerial perspective, the result implies that continuity-sensitive analytics are most urgently needed where programmes combine three traits: very large beneficiary backlogs, thin progress margins and recurrent post-deployment fragility. Clean cooking in Sub-Saharan Africa fits this profile strongly. The region's burden remains high, the 2030 projection remains close to the 2023 level, and the operating environment is characterised by affordability constraints, fuel stacking, logistics friction and cultural heterogeneity in cooking practices (Gill-Wiehl et al., 2021; IEA, 2024a).

Electricity access in Sub-Saharan Africa also presents a high-continuity challenge, but with a somewhat different risk signature. The region's rural deficit remains enormous, and DRE systems are central to the access strategy. That makes asset uptime, spare-part continuity, field repair capability, tariff recovery and productive-use growth particularly important. Survey evidence from Nigeria suggests that households and SMEs differentiate sharply between connection attributes such as timing, capacity and source, underscoring the need for analytics that go beyond binary connection counts (Pelz et al., 2023; Janghorban et al., 2024).

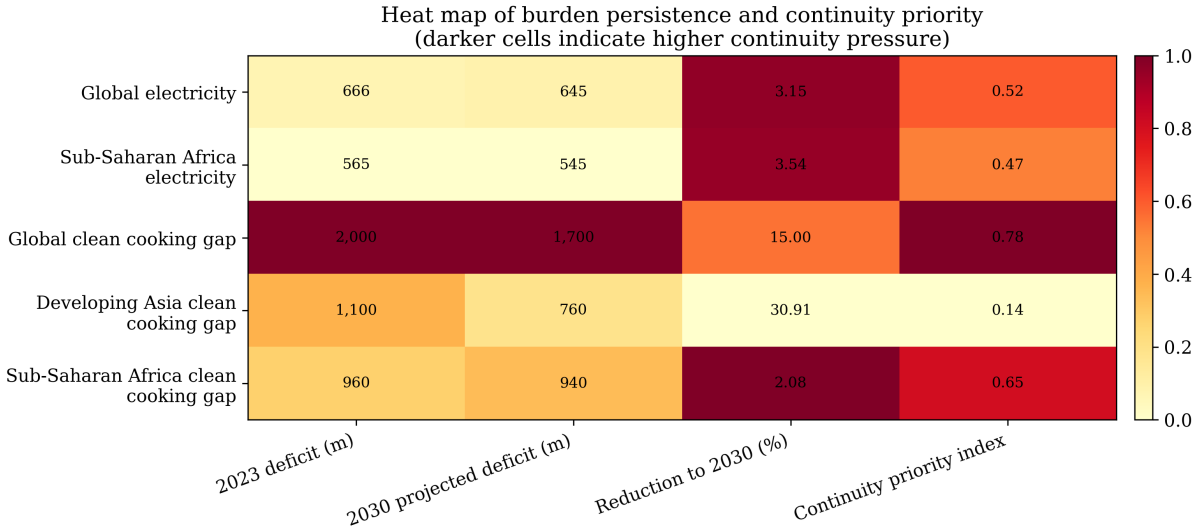


Figure 2. Heat map of burden persistence and continuity priority. Source: Author calculations based on World Bank (2025) and IEA (2024a; 2024b). Darker cells indicate greater continuity pressure; the reduction column is colour-inverted so weaker progress appears darker.

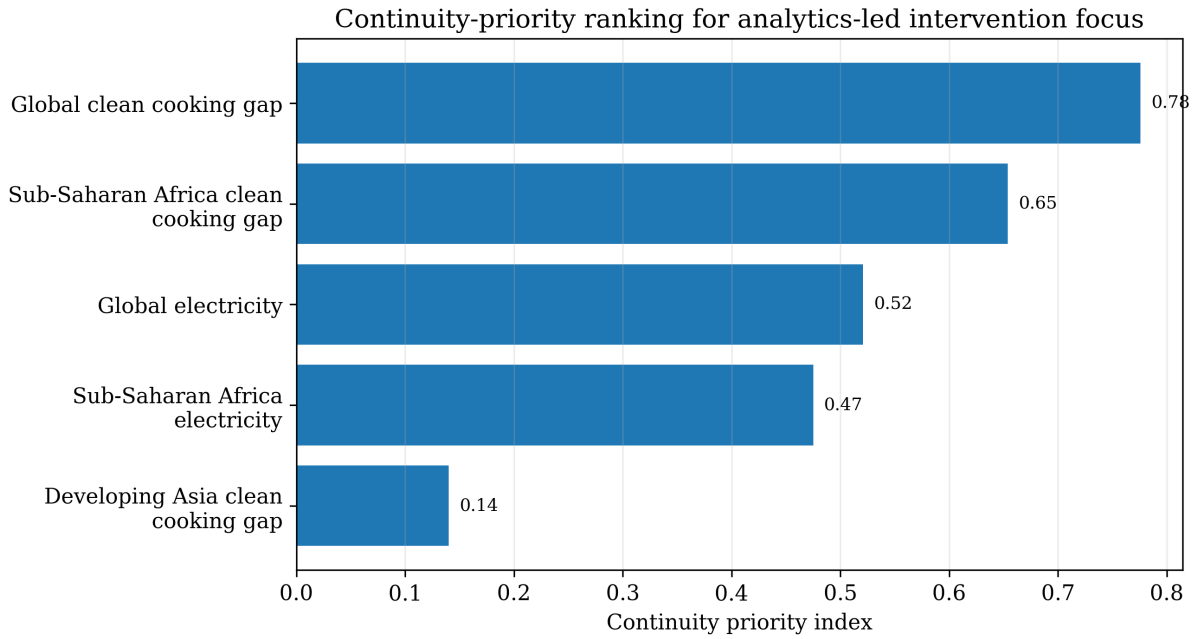


Figure 3. Continuity-priority ranking for analytics-led intervention focus. Source: Author calculations. Higher values indicate domains where large burden, high 2030 persistence and weak reduction coincide.

4.3 Stage-specific continuity risks

Figure 4 and Table 3 present the stage-specific continuity-risk heat map and scores. Governance and partner coordination are scored as critical at the design and scale-up stages because fragmented mandates, donor conditionalities, weak data-sharing agreements and unclear accountability frequently undermine programme coherence before technical systems fail. Financing continuity is scored as critical at financing and scale-up because many programmes can secure capital for initial deployment but struggle to preserve working capital for maintenance, customer support, spares and replacement cycles.

Operations-stage risks are dominated by affordability and demand retention, supply-chain continuity, workforce capacity, O&M management and security or climate disruption. This profile is consistent with the wider literature. Off-grid systems may be technically viable yet still lose service value when maintenance pathways are weak or when households reduce or abandon use due to payment stress, seasonal income volatility or unreliable after-sales support (Sodomaco et al., 2025; Perriment et al., 2025). Clean-cooking transitions are especially sensitive to these risks because fuel stacking and reversion can occur even after apparently successful adoption campaigns (Gill-Wiehl et al., 2021).

The results also highlight the importance of data visibility. Data visibility and beneficiary tracking are scored highly throughout the programme cycle and critically at scale-up. Without interoperable records of assets, households, enterprises, outages, payments, repairs and user behaviour, programme managers cannot distinguish between delayed adoption, partial use, dormant connections, failing assets or frontline bottlenecks. In this regard, the data-governance arguments advanced by Hagan et al. (2026a) are directly applicable to energy-access systems: scaling without traceable, auditable and decision-ready data structures compounds governance risk.

Figure 3 consolidates the burden results into a continuity-priority ranking. The ranking should not be interpreted as a statement that one domain matters and others do not. It should be read as a decision aid that helps implementation agencies determine where continuity-sensitive analytics can deliver

the largest marginal governance value. On the present evidence base, clean-cooking systems, especially in Sub-Saharan Africa, warrant the most urgent strengthening of analytics, frontline support and operational-continuity design.

Table 3. Stage-specific continuity-risk scoring matrix.

Risk factor	Design	Financing	Deployment	Adoption	Operations	Scale-up
Financing continuity	3	5	4	3	4	5
Affordability and demand retention	2	3	3	5	5	4
Supply-chain and spare-parts logistics	2	3	5	3	5	4
Field workforce capability and wellbeing	3	3	4	4	5	4
Data visibility and beneficiary tracking	4	3	4	4	4	5
Governance and partner coordination	5	4	4	4	4	5
O&M and asset uptime management	3	3	4	4	5	5
Security, conflict and climate disruption	3	4	4	4	5	5
Technology interoperability and standards	4	3	4	3	4	5

Note: Scoring rubric: 1 = low pressure, 2 = moderate-low, 3 = moderate, 4 = high, 5 = critical. Scores were derived through structured literature synthesis and are intended for managerial prioritisation rather than causal inference.

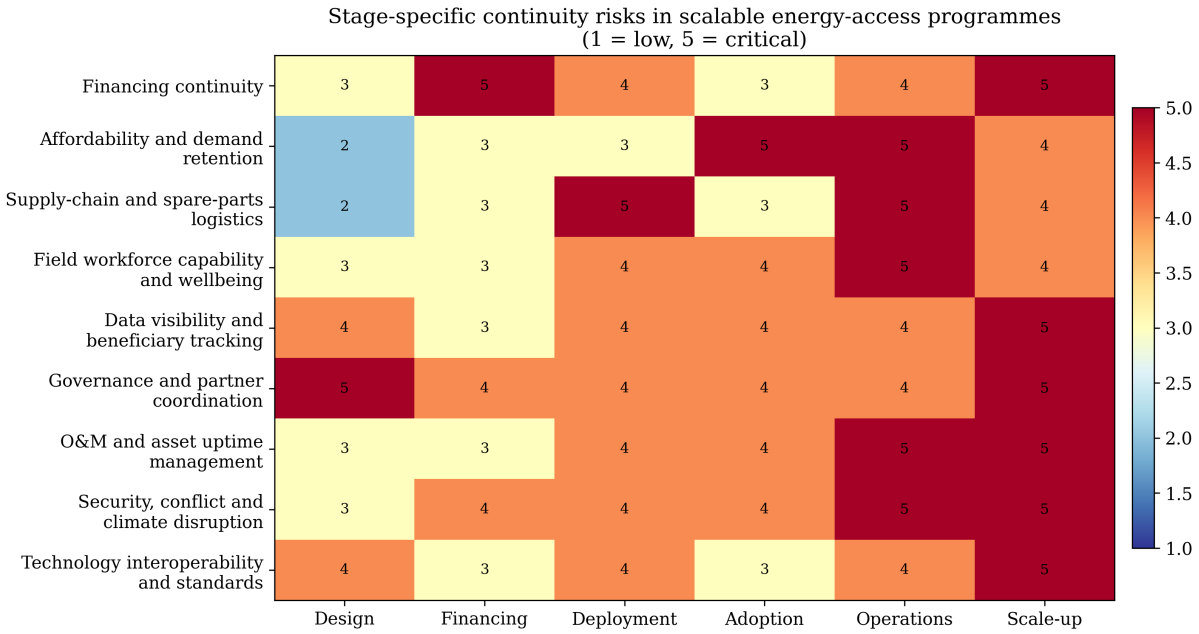


Figure 4. Stage-specific continuity risks in scalable energy-access programmes. Source: Author synthesis from the cited literature and official SDG7 reports.

5 Discussion

The results imply that energy-access programmes should be managed more like continuity-critical service systems than like one-off capital projects. A connection, stove or appliance distribution event is only the start of impact creation. Lasting outcomes depend on whether the service remains

affordable, usable, repairable, financed and visible to managers after commissioning. This is particularly important where progress is offset by rapid demographic growth or by households' reversion to traditional practices.

The continuity lens also helps reconcile a long-standing tension in energy-access policy between scale and quality. Programmes are often incentivised to maximise installations within funding windows, but that incentive can generate fragile portfolios if installation growth exceeds maintenance depth, customer support capacity or data quality. The evidence on long-term off-grid use and the importance of reliability for willingness to pay suggests that weak continuity can silently erode both developmental outcomes and commercial viability (Pelz et al., 2023; Janghorban et al., 2024; Perriment et al., 2025).

A second implication concerns productive use. Electricity access contributes more to enterprise development and welfare when users can rely on the service for income-generating activities and when programme managers can observe demand evolution, segment users and adjust the operating model accordingly. DRE growth in Sub-Saharan Africa therefore creates an opportunity not only for more connections but also for analytics-enabled portfolio management. Productive-use demand, tariff collection, outage frequency, repair lags and appliance take-up should all be treated as core portfolio variables, not as peripheral monitoring indicators.

A third implication concerns organisational resilience. Energy-access programmes depend on field technicians, community mobilisers, distributors, local government liaisons, women's groups, micro-entrepreneurs and financing partners. The frontline support argument made by Mawora et al. (2025) in community-based organisations is relevant here: where frontline systems are exposed to stress without adequate supervision, replenishment or escalation pathways, continuity degrades. Large-scale programmes therefore need human-support protocols alongside technical maintenance plans.

Finally, the paper suggests that analytics maturity and governance maturity are inseparable. Predictive maintenance, hybrid microgrid optimisation and risk scoring can improve performance only when data capture, lineage and accountability are robust. The applied studies by Kabera et al. (2026a; 2026b) and Hagan et al. (2026a; 2026b) collectively reinforce that resilience gains emerge when technical modelling is embedded in a governance structure rather than deployed as a stand-alone data exercise.

6 Policy and managerial implications

Based on the empirical synthesis and the continuity-risk assessment, five policy and managerial implications follow. First, programme appraisal should include a continuity budget, not only a capital budget. This means ring-fenced provisions for maintenance, spares, customer education, data systems, workforce support and replacement cycles.

Second, programme dashboards should shift from installation counts to continuity-sensitive KPIs. Table 4 proposes a KPI architecture spanning commissioning cycle time, activation rates, stacking persistence, asset uptime, mean time to repair, collection efficiency, data completeness and replication readiness. Together these indicators reveal whether programmes are scaling durable service or merely scaling hardware placement.

Third, scale-up should be stage-gated. Expansion into new geographies should be conditional on threshold performance in existing portfolios, especially around uptime, user retention, collections,

data quality and field response times. Such discipline can prevent the propagation of fragile operating models across wider territories.

Fourth, continuity design should explicitly account for rurality, remoteness and fragility. World Bank (2025) shows that 84% of those without electricity live in rural communities and that 451 million rural residents in Sub-Saharan Africa lacked electricity in 2023. In such settings, logistics, inventory buffers, local technician ecosystems and offline data capture become core programme design variables.

Fifth, clean-cooking scale-up requires differentiated transition strategies rather than uniform technology pushes. The IEA's technology mix for universal access—45% LPG, 32% improved biomass, 12% electricity and the remainder biogas or ethanol—shows that implementation pathways are heterogeneous (IEA, 2024a). Programme analytics therefore need to observe local cooking practices, affordability thresholds, refill distances, appliance repair patterns and stacking behaviour at segment level. Table 5 summarises the framework pillars and the corresponding managerial actions.

Table 4. Continuity-oriented KPI architecture for scalable energy-access programmes.

Program layer	KPI	Operational definition	Reporting cadence
Design and targeting	Geospatial coverage integrity	Planned households or enterprises reached / target households or enterprises	Monthly during planning
Financing continuity	Committed-to-disbursed capital ratio	Funds disbursed / funds committed	Monthly
Deployment	Commissioning cycle time	Days from procurement approval to field commissioning	Monthly
Adoption and use	Activation rate	Active users after 90 days / installed users	Monthly
Adoption and clean transition	Fuel- or stove-stacking persistence	Households still using traditional fuels as primary or secondary option	Quarterly
Operations	Asset uptime	Hours system available / total service hours	Monthly
Operations	Mean time to repair	Average hours or days from fault report to restoration	Monthly
Portfolio quality	Collection efficiency / tariff recovery	Cash collected / billed or expected collections	Monthly
Data governance	Beneficiary-data completeness	Non-missing critical fields / total critical fields	Monthly
Inclusion	Women-led productive-use participation	Women-led enterprises using programme assets / total productive-use enterprises	Quarterly
Scale-up	Replication readiness score	Composite of governance, O&M, data, workforce and financing readiness	Semi-annually

Note: The proposed KPI structure is intended to complement conventional connection and disbursement reporting by adding adoption, reliability, data quality and replication metrics.

Table 5. Framework pillars for continuity-centred programme analytics.

Framework pillar	Managerial action	Why it matters for scale
Data backbone	Create interoperable registries for households, enterprises, assets, payments, outages and maintenance events.	Makes programmes auditable, reduces beneficiary duplication, and improves targeting and continuity decisions.
Continuity-aware capital planning	Ring-fence working capital for O&M, spare parts, warranty fulfilment and fuel or appliance distribution continuity.	Prevents deployment-heavy programmes from failing after commissioning.
Adaptive demand analytics	Track activation, load growth, stacking behaviour, affordability stress and productive-use uptake by segment.	Enables differentiated tariffs, financing support and customer engagement.
Frontline support systems	Provide supervision, training, staffing reserves and escalation protocols for field agents and technicians.	Stabilises delivery quality in high-friction environments.
Reliability engineering	Embed predictive maintenance, remote monitoring and failure-threshold alerts into routine operations.	Improves uptime and protects trust in clean energy systems.
Scaling governance	Use stage-gate expansion criteria linked to uptime, collections, data quality, user retention and partner performance.	Reduces the risk of scaling fragile programmes prematurely.

Note: These actions translate the empirical findings into a practical operating model for programme managers, donors, utilities and decentralised energy providers.

7 Limitations and future research

The study has three principal limitations. First, the empirical synthesis is based on secondary and mostly aggregated indicator series rather than on fully harmonised household- or project-level microdata. The resulting analysis is useful for strategic prioritisation but cannot identify causal programme effects.

Second, the continuity-risk matrix involves structured judgement. Although the scores are grounded in the cited literature and official reports, different expert panels could assign somewhat different stage severities. Future work could formalise this through Delphi methods, multi-criteria decision analysis or validation against project failure data.

Third, the burden-and-outlook analysis necessarily combines electricity and clean-cooking domains with different measurement traditions. Even where this limits direct comparability, the approach remains valuable because programme managers often need cross-domain prioritisation under imperfect data conditions.

Future research should therefore move in three directions: project-level longitudinal datasets linking deployment, payments, repairs and user behaviour; causal testing of continuity interventions such as spare-parts buffers, field support bundles and adaptive tariff design; and country-specific analytics that integrate geospatial, operational and climate-risk data for portfolio steering.

8 Conclusion

This paper set out to reframe scalable energy-access delivery as a continuity-sensitive programme-management problem. The evidence shows that both electricity access and clean cooking remain far

off-track in high-burden settings, but the continuity challenge is particularly acute where large beneficiary backlogs coexist with weak projected reduction, fragmented delivery systems and heavy dependence on frontline execution.

The analysis demonstrates that current SDG7 trajectories leave substantial residual deficits in 2030 and that the most pressing continuity pressures cluster around clean cooking in Sub-Saharan Africa, followed by electricity access in the same region. Financing continuity, governance coordination, data visibility, O&M capability, demand retention and frontline workforce resilience emerge as the most consequential risk domains across the programme life cycle.

The central managerial implication is clear: energy-access scale should be judged not only by the number of connections or appliances distributed, but by the continuity of service, behavioural retention and operational learning that follow. Analytics can support that shift, but only when embedded in interoperable data systems, explicit governance routines and stage-gated scaling decisions. Programmes that adopt this continuity-centred model are better positioned to convert deployment into durable development impact.

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