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Sub-Sahara Africa's Transition to Net-Zero: Electricity Sector Investment Insights and Opportunities

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Summary

Decarbonization of the sub-Saharan African (SSA) electricity sector will play an important role in achieving a net-zero energy transition by 2050. Using the Global Change Analysis Model, this study provides first-order estimates of capital investment and stranded assets over multiple technology scenarios. The investment for decarbonizing the electricity sector in a net-zero future ranges between USD 0.8–1.8 trillion. Compared to the baseline capital investment, these estimates are substantial, representing a 124–376 % increase. Achieving this transition causes minimal stranded assets, estimated at ~0.15–0.38 times more than the baseline capital investments. Acquiring investment funds, technology transfers and leveraging local technological capabilities will play a central role in the net-zero energy transition in SSA.

Key Policy Recommendations

- Demand and supply-side electricity sector decarbonization strategies can play a key role in achieving a cost-effective transition to a net-zero carbon pathway by 2050 in sub-Saharan Africa.
- The investment requirement for the electricity sector is substantial relative to the baseline and varies significantly (i.e., 124–376%) depending on the technology pathway.
- Stranding of capital due to this transition is minor, representing ~0.15–0.38 times the baseline investment.
- The ability to secure investments, technology transfer and leverage local technological capabilities will play a critical role in the region's net-zero energy transition.
- Net-zero policies should consider issues of scalability, uncertainty and externalities associated with novel electricity sector technologies

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Introduction

A transition to a low-carbon electricity sector in sub-Sahara Africa (SSA) is an important lever to achieve sustainable development in this sub-region [1]. Besides contributing to climate mitigation, decarbonizing the electricity sector can provide synergistic opportunities such as access to clean and reliable energy, job creation, improved productivity, and reduced energy-related health outcomes [2]. Most SSA countries have a unique opportunity to pre-empt a carbon-intensive electricity sector development due to their vast renewable energy endowment. Nevertheless, decarbonizing SSA's electricity sector while satisfying the expected growth in energy demand will require substantial investment, that exceeds the current investment rates. The expected premature retirement or stranding of carbon-intensive electricity plants before the end of their planned lifetime can also pose a hindrance to decarbonizing the electricity sector.

The briefing provides a first order-estimate[1] of the investment requirement and stranded capital associated with decarbonizing SSA's electricity sector for a net-zero energy system target. We model a net-zero targets to demonstrate the importance of decarbonizing the electricity sector. Using an open-source integrated energy–economy–climate modelling tool called the Global Change Analysis Model (GCAM), this brief presents evidence of the economic opportunities and challenges of decarbonizing the electricity sector in SSA. The goal of the brief is to provide instructive policy insights about the feasibility of decarbonizing the electricity sector.

Methodology

GCAM simulates the dynamics of five major systems – energy, water, land, climate, and the economy – at global and regional levels [3]. GCAM is a technology-rich model with detailed technological representations of energy activities from production to end-use in the SSA region. We explored six technology scenarios to investigate the range of sensitivity associated with net-zero energy system transition in the region (2021–2050). These scenarios vary across a range of technology levers which include the availability of mature and non-mature supply-side solutions coupled with demand-side energy saving strategies (**Table 1**). A baseline scenario is simulated for comparison with the net-zero scenarios. The underlying socioeconomic drivers of the model are calibrated to the Shared Socioeconomic Pathway 2 (SSP2) projections created by the integrated assessment modelling community[2]. SSP2 is characterized by trends where social, economic, and technological trajectories do not shift markedly from historical patterns [4].

Scenario	Policy Lever/Policy Barrier
Baseline	No climate mitigation
Central	Moderate deployment of supply & demand-side electrification technologies.
LimCCS	Deployment of carbon capture & storage (CCS) is stifled by high cost and geological storage limits.
NoCDR	Carbon removal technologies are not deployed.
LED	Electricity demand is 10% less than Central due to conservation and technical efficiency improvements.
AdvEle	Increased clean electricity supply & demand from lower entry barriers.
FullTech	Full suite of supply & demand-side energy solutions deployed.

Table 1: Scenario descriptions

[1] The term first-order refers to the fact the estimates provided do not explicitly account for grid transmission and distribution investment costs.

[2] The SSPs are reference pathways that describe plausible alternative trajectories of societal and ecosystem changes over a century timescale, in the absence of climate change or climate policies [4].

Results & Discussion

STRUCTURAL SHIFTS

An overview of the 2050 emissions profile for the scenarios is shown in **Figure 1**. The baseline scenario emissions increase to 2.1 $GtCO_2$ by 2050 – which represents a 2.5-fold increase relative to levels in 2015.

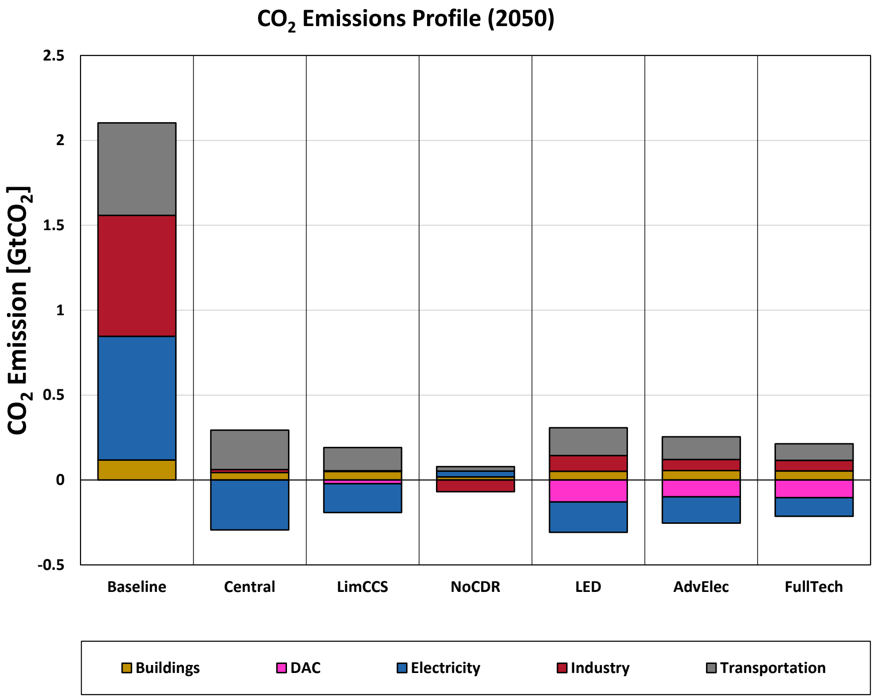


***Figure 1:** Snapshot of energy system CO_2 emissions profile for 2050.*

It is important note that the difference in residual emissions shown in **Figure 1** represent important technical and financial feasibility outcomes associated with decarbonizing SSA's energy sector. Notably, the results indicate that the electricity sector can play a pivotal decarbonization role in achieving net-zero energy systems. In fact, for most of the scenarios (except NoCDR), the emissions from the electricity sector become net negative to offset the residual emissions from other end-use by 2050.

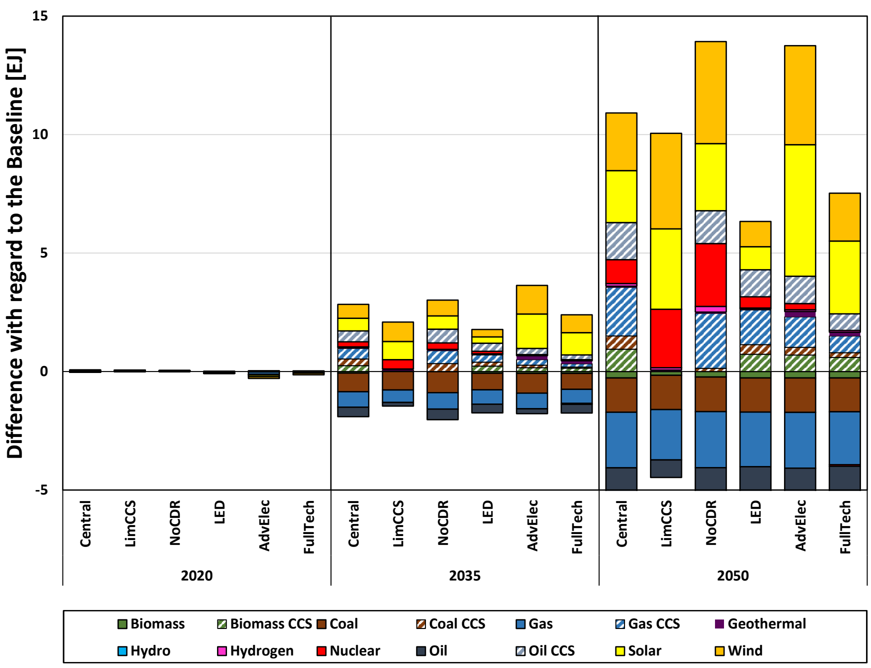


***Figure 2:** Structural shift in electricity generation*

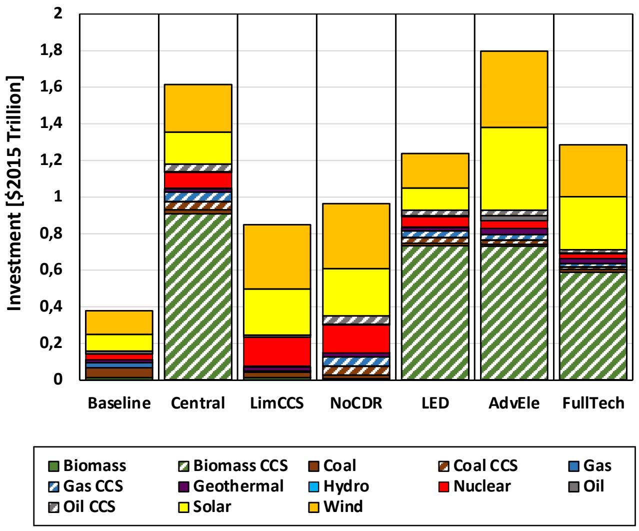
Figure 2 provides a detailed overview of the electricity sector's structural transformation in reference to the baseline scenario. A noticeable net increase in electricity demand is observed across the net-zero scenarios. The increase in electrification again highlights the flexible role the electricity sector can play in decarbonizing SSA's energy sector. The structural changes shown in **Figure 2** reveal that solar and wind will play a central role in decarbonizing SSA's electricity sector. The optimistic projection of solar and wind is due to the significant decline in capital costs following recent historical trends. Novel technologies that can capture and store CO_2 can also play a complementary role in decarbonizing SSA's electricity sector. Particularly, the deployment of oil, gas, and bioenergy power plants retrofitted with CCS can play a pivotal decarbonization role.

INVESTMENT AND STRANDED CAPITAL

The capital investment requirement varies across the net-zero scenarios due to the structural differences in the electricity generation mix. The cumulative investment for the net-zero scenarios (**Figure 3a**) ranges from USD 0.8 to 1.8 trillion, corresponding to a 124–376% increase relative to the baseline scenario. Although the deployment of Biomass with CCS (BECCS) technologies plays a minor role in the generation mix (see **Figure 2**), the high capital investment intensity of BECCS leads to a substantial increase in the total capital investment. BECCS technologies have a unique advantage because these technologies produce energy and negative emissions. The cost-effectiveness of BECCS is enhanced in a carbon price regime since the technologies receive a premium for generating negative emissions and subsidies for every kWh of electricity generated. The "AdvEle" scenario, which represents an optimistic future with advanced demand-side (e.g. electromobility) and supply-side electricity technologies has the highest cumulative investment. In contrast, the coupling of these advanced electrification assumptions with demand reduction (10% reduction) leads to a drastic decrease in cumulative capital investment. This result highlights that the availability of a full suite of the demand- and supply-side technologies can help improve the cost-effectiveness of decarbonizing SSA's electricity sector.

The scale of cumulative stranded capital is moderate compared to the total investment. The premature retirement of capital is ~0.15–0.38 times compared to the cumulative baseline capital investment[3] (**Figure 3b**). Fossil plants retrofitted with CCS, such as refined oil and natural gas plants will have the largest impact on cumulative stranded assets. Under a stringent net-zero targets, these capital-intensive fossil fuel assets are retired earlier to accommodate less capital-intensive zero-carbon options like wind and solar.

3a



3b

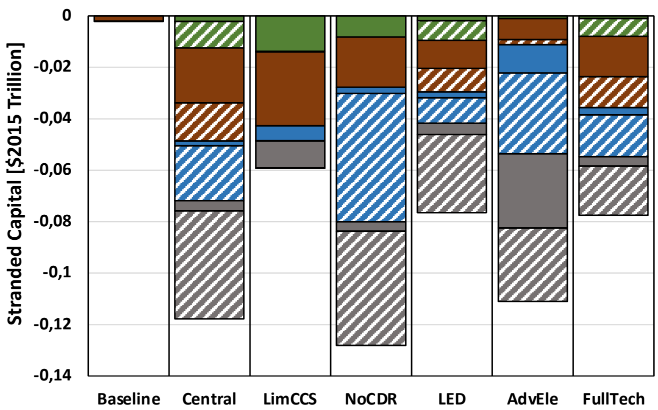


Figure 3: Cumulative Investment (a) and Stranded Capital (b)

[3] The stranded asset is computed by tracking the vintage of existing and future electricity technologies. The retirement of capital is calibrated and compared to the natural rate of depreciation to compute stranded assets

Policy Implications

This policy briefing highlights the important role the electricity sector can play in achieving a net-zero energy system target in sub-Saharan Africa (SSA). Decarbonizing the electricity sector is a capital-intensive endeavour, which most SSA countries cannot afford independently. Therefore, the ability to secure external financial assistance can help achieve this goal. **Assistance for regional development and multilateral institute and private investment can bridge this financial gap.** To help enhance the investment attractiveness of these projects, SSA stakeholders can create a favourable investment environment through stable macroeconomic and coherent electricity sector policies.

Considering the sub-region's limited ability to develop and deploy low-carbon technologies, it stands to reason that technology transfer from more developed regions will also play a pivotal role in decarbonizing SSA's electricity sector. **Nevertheless, leveraging existing local technological capabilities can help enhance the process of technology development and transfer.**

Achieving a transition to a net-zero target is fraught with many challenges and risks. For instance, the large-scale deployment of Biomass with carbon capture and storage (BECCS) has the potential to induce food insecurity, biodiversity loss, and water insecurity threats. The impact of threats can be mitigated with innovative sector-specific investment and policies. To achieve this, **policymakers must consider the externalities and co-benefits from a systems perspective to help identify trade-offs and address sub-optimal outcomes.** Other important issues related to the uncertainty, scalability, and feasibility of CCS technologies should also be considered in the formulation of policies.

Although, this policy brief treats SSA as a single economic unit, the countries in this region have diverse characteristics. **Hence, the formulation of country-level policies should consider local opportunities and address country-specific barriers.** Coordination and policy learning among countries in SSA can play a pivotal role.

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