Who Decides Africa's Net Zero Pathways?

FIVE WAYS TO FIX HOW WE MODEL AFRICAN ENERGY TRANSITIONS AND WHY IT MATTERS FOR CLIMATE AND DEVELOPMENT

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Summary

To achieve an equitable global net zero future, lower-income and under-electrified countries must play a much bigger role in deciding how we get there. Africa will be home to roughly a quarter of the world's total population by 2050 and is a vital source of resources critical to the energy transition. Mapping viable global pathways to a net zero emissions energy system cannot happen without African leadership, analysis, and data. Energy systems modeling is central to exploring transition scenarios and helping decision-makers weigh timelines, technology options, and infrastructure investments.

But today, the vast majority of analyses addressing the African energy transition are deeply flawed. Global or regional modeling efforts often apply very little (sometimes zero) analytic rigor to African economies. They often rely on data and trends from other regions that do not reflect local markets, and make limited assumptions about future growth. And models are most often conducted by non-African institutions and analysts. Because these analyses are already playing a significant role in shaping policies and climate negotiations, these gaps may have enormous consequences for Africa's future.

A global energy transition relying on modeling approaches that assume Africa will remain poor, sideline development priorities, and prioritize the perspectives of wealthy economies is destined to fail.

This report details what's wrong with the current approach, explains why better modeling matters to climate and development goals, and lays out five priorities to better model inclusive and prosperous transitions to net zero energy systems in Africa:

1. Place sustainable development at the center of energy transition modeling.
2. Expand access to (and integration of) critical Africa-specific data.
3. Strengthen long-term demand forecasting in African markets.
4. Improve communication around the content and purpose of energy transition models.
5. Build and strengthen the African institutions and analysts doing this work.

Energy systems modeling is not an end in itself. But it is a crucial tool in improving our collective understanding of what's needed to get to net zero – and to ensure that when we do, the world is more prosperous and more equitable.

Context: What energy system modeling is and why it matters

The goal of achieving 'net zero' carbon emissions has become a central paradigm in global climate policy, and increasingly drives both analysis and action.[2] But in order to achieve a global net zero future that is also equitable and prosperous, we need lower-income and under-electrified countries – including those in Africa – to play a much bigger role in deciding how we get there.

In the energy sector, getting to net zero will depend in large part on energy systems modeling. The scenarios produced in such models (along with the insights they provide) are crucial to decarbonization because they identify viable transition pathways and enable decision-makers to assess relevant risks, opportunities, and trade-offs. They can be designed and applied in many different ways to enable various kinds of analyses. For instance, they can explore different strategies to meet future energy demands and environmental targets; illustrate the particular role of specific energy technologies within a larger system; or optimize energy systems across specific criteria and under different assumptions (e.g. output, efficiency, carbon emissions, energy prices, etc.) They can be used to explore scenarios for energy transition at very broad scales – for example, the International Energy Agency's Net Zero by 2050 report presented a global pathway. They can also be applied at smaller, more targeted scales for individual countries, regions, economic sectors, or utilities.

Energy systems modeling does not predict the future, nor does it lay out perfect pathways to achieve any single goal. But it does drive action by establishing a vision of the future, and by helping key actors (such as utilities and policymakers) better understand their options and prioritize the various investments and policy choices available.[3] As the world's commitment to advancing a global 'energy transition' has grown, energy system modeling has become more important – and is increasingly referenced and relied upon by audiences outside of traditional niche academic and utility planning circles.

Why mapping pathways to net zero African energy systems is crucial

Dramatic emissions reductions are most urgent and most globally impactful in wealthy, high-emitting economies.[4] Many components of global climate policy reflect this: the Paris Agreement notes that emissions will take longer to peak in developing countries, and the IPCC's latest assessment report on Climate Change Mitigation acknowledges that near-term development in low-income countries will not jeopardize global climate goals.[5] Accordingly, some argue that focusing attention on (or pushing for) a transition to net zero emissions in low- and lower-middle income economies is both inappropriate and unjust – that the

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[2] In order to achieve the Paris Agreement's goal of limiting global average temperature change to less than 1.5 degrees C, the Intergovernmental Panel on Climate Change (IPCC)'s flagship *Special Report on Global Warming of 1.5 degrees C* states that global human-caused CO_2 emissions will need to reach 'net zero' by about mid-century. To date, 128 countries and almost 700 companies have put forward their own targets for achieving net zero carbon emissions, with the majority focusing on a deadline on or about 2050.
[3] Such models include IAMs, energy system models, power system models, economic models, etc.) (e.g. GCAM, REMIND, MAgPIE, MARKAL/TIMES, OSeMOSYS, PLEXOS, etc.)
[4] Lei Duan et al (2020), "Balancing Climate and Development Goals", Environ. Res. Lett. 15 124057.
[5] IPCC, *Climate Change 2022: Mitigation of Climate Change (Summary for Policymakers)*, Working Group III contribution to the Sixth Assessment Report of the IPCC.

timelines should be very different, and that emissions concerns should be secondary to eradicating energy poverty and enabling economic prosperity.[6] However, even so, modeling viable pathways to net zero emissions in lower-income economies remains crucially important.

Achieving a net zero future remains the *only way* to stop a rise in global temperatures – and presents many opportunities for development, economic diversification, and growth. The question is how to do it equitably. Net zero is a global concept – it does not need to be achieved on a country-by-country basis, or everywhere on the same timeline. What's at issue is how to map and pursue transitions in lower-income economies that enhance broader development goals. What timeline is viable? What technology options are best? And based on those results, what types of infrastructure should be prioritized for funding, and which policies pursued? These are the values of better modeling.

Existing approaches to modeling African energy transitions are deeply flawed

Energy system modeling is not an end in itself. It inevitably produces stylized or simplified representations of both energy systems and broader socioeconomic realities, relying on averages, past trends, and assumptions. Therefore, the factors that shape model design, underlie analysis, and determine how models ultimately get used are informed by very human factors – including: who is doing the modeling, and for what purpose; who the intended audience is; how the modelers choose to approach the problem; and what assumptions they make.

The majority of energy transition analysis for lower-income economies – particularly in Africa – is extremely limited.

- **Models exploring decarbonization pathways at the global or regional level often apply very little (sometimes zero) analytic rigor to African economies,** either by ignoring the region altogether; relying too heavily on anomalous proxy economies, such as South Africa; or by aggregating large numbers of African countries or even neighboring regions despite vast socioeconomic and resource differences. This can skew model outputs and limit the usability of regional data.[7]

- **Models often make very limited assumptions about Africa's future energy needs and economic growth.** As of 2018, an estimated 789 million people — the vast majority in sub-Saharan Africa — lacked access to any modern electricity.[8] Even in that region's largest economies, average annual per capita electricity consumption is often under 200 kilowatt-hours (kWh) — less than what is needed to power a typical refrigerator.[9] An equitable and resilient net zero future is going to require *significant increases* in per capita electricity consumption by people in lower- and lower-middle-income

[6] For example: Sam Fankhauser et al., "The meaning of net zero and how to get it right", *Nature Climate Change* 12, 2022.
[7] For example: BP's Statistical Review of World Energy presents data for 'Africa' as a whole. And integrated assessment models (IAMs) often combine regions including 'Middle East and Africa'.
[8] IEA, IRENA, UNSD, World Bank and WHO (2020), *Tracking SDG7: The Energy Progress Report*.
[9] Todd Moss, "My fridge versus Power Africa," *Center for Global Development*, September 9, 2013.

economies. Yet many energy systems models exploring decarbonization pathways – even those claiming to integrate development priorities – assume minimal energy consumption increases in their assumptions and inputs, basing projections for future development largely on the past, and targets for achieving universal electricity access on international goals of just 50-100 kWh per person, far below what's needed to power opportunity.

- **The assumptions underlying existing models of African energy transitions often rely on data and trends that do not reflect local markets.** Assumptions regarding things like technology costs and learning curves are often based on data from richer economies, resulting in outputs that ignore or obscure key specificities in lower-income markets, where the pace and nature of technological roll-out will play out differently. For example, modelers trying to forecast the growth of air conditioners or electric vehicles in African markets often have to rely on historical data from other regions. The cost assumptions underlying African energy transitions also differ significantly from those in the US or Europe. The cost of capital (which has disproportionate impacts on renewable generation, because it is comparatively capital-intensive) differs dramatically in Africa – and between different African markets. Most mainstream decarbonization modeling efforts do not consider these specifics; instead, they apply a 'quasi-uniform cost of capital' that tends to underestimate the costs in African countries – and therefore the cost of the energy transition.[10] Accurately assessing these costs with much sharper geographic disaggregation will be crucial to mapping viable pathways forward, and identifying the best and most impactful role of various funding streams.

- **African energy transitions are most often modeled by non-African institutions and analysts.** The majority of energy systems modeling capacity, funding, and expertise sits in non-African institutions. When African countries seek to develop their own pathways to net zero, they often have no choice but to turn to international consulting firms or other external groups. Reliance on external analysts increases the risk that resulting model outputs omit key local data and priorities.

Three reasons why better modeling of African energy systems matters for climate and development

1. **Energy transitions in Africa must enable economic, urban, and demographic growth – not just decarbonization.** The African continent – home to the world's youngest population – is changing rapidly, and faces confluent challenges including population growth, urbanization, energy poverty, economic instability, and the intensifying effects of climate change. African energy transitions are not simply about replacing existing fossil-fueled assets with renewable energy. They must be about meeting immediate (and rapidly growing) needs as quickly and cleanly as possible; powering broad-based economic development and socioeconomic gains; and ensuring climate resilience and adaptation – all of which will necessitate significant

[10] Nadia Ameli et al., "Higher cost of finance exacerbates a climate investment trap in developing economies", *Nature Communications*, 2021.

increases in energy consumption. This must be reflected in analyses of energy transition pathways. Modeling approaches that sideline economic development priorities and increases in energy consumption often reflect unspoken assumptions that the continent will remain poor – and that energy poverty will remain a defining feature of its economic and social reality. A global energy transition resulting in that outcome will have failed.

2. **Net zero targets are meaningless without good data, a plan to get there, or ties to decision-making and economic development plans.** To date, several African countries, including Nigeria and South Africa, have put forward net zero pledges, and many others have discussed doing so.[11] At least twelve African countries (Djibouti, DRC, Gambia, Ghana, Kenya, Malawi, Morocco, Niger, Rwanda, Senegal, Sudan, and Tanzania) aim to achieve 100% renewable electricity generation on or before 2050.[12] But too few of these ambitious goals align with plans to get there. Often, this is because African governments and institutions lack the resources and data to model localized transition pathways that can shape credible plans. This puts long-term global climate goals at risk, since energy transition plans that do not reflect local contexts are inherently detached from political decision-making – and thus far less effective.[13] The absence of a credible data-driven plan also makes it more difficult for potential funders to understand what needs to be prioritized: the vast majority of African Nationally Determined Contributions (NDCs) make adaptation and mitigation targets contingent on receiving international aid, but only 14 countries specify precise emissions outcomes associated with that request – and African NDCs rarely specify specific projects that would need to be funded.[14] In addition, many African NDCs are donor-driven and largely divorced from existing economic development plans and strategies.[15] Better regional and country-specific modeling will empower African decision-makers to design and implement transition pathways with a higher likelihood of success, and help to align development partners and other financiers around African needs and priorities.

3. **These gaps skew conceptions of what the global energy transition will look like (along with policy discussions on how to achieve it) to the perspectives, needs, and priorities of wealthy economies.** Analysis aimed at tackling a global challenge cannot be successful if it does not adequately integrate the needs, ambitions, and unique opportunities and challenges of a continent that will represent one-quarter of humanity by 2050.

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[11] Net Zero Tracker
[12] REN21, *Renewables 2020 Global Status Report*, REN21 Secretariat.
[13] IPCC, *Climate Change 2022: Mitigation of Climate Change (Summary for Policymakers)*, Working Group III contribution to the Sixth Assessment Report of the IPCC. The IPCC noted that "mitigation action designed and conducted in the context of sustainable development, equity, and poverty eradication, and rooted in the development aspirations of the societies within which they take place, will be more acceptable, durable and effective."
[14] IEA, Africa Energy Outlook 2022.
[15] Chukwumerije Okereke, "Aligning Africa's Nationally Determined Contributions with their Long-Term National Development Plans", *Africa Policy Research Institute*, June 29, 2021.

What's Needed: Five priorities to enable better modeling of inclusive, prosperous, net zero energy transitions in Africa

Addressing these concerns will require action by African leaders, researchers, development partners, and philanthropy – and the following priorities include recommendations for each of those groups. This agenda focuses most specifically on energy systems modeling in the power sector, given that deep decarbonization in the electricity sector needs to happen before achieving net zero economy-wide. But the authors recognize that modeling for African energy transitions needs to be improved across all aspects of the energy sector – and that non-electricity sectors like clean cooking and industry will have pivotal roles in both managing emissions and achieving core development goals.

Priority #1: Put sustainable development at the center of energy transition modeling.

Modeling approaches that focus predominantly on, or are framed as mostly targeting, decarbonization omit many of the most important domestic priorities for emerging and frontier economies – including economic development and diversification, climate resilience, energy access and affordability, energy security, and energy independence. Integrating priorities like these at the heart of modeling efforts, and optimizing for them alongside carbon emissions, will produce transition pathways more relevant for African economies – and more likely to be implemented successfully.

Recommendations:

- **Integrate equity into energy modeling.** In energy-poor countries, equitable access to energy (and the economic and social benefits it provides) will be central to achieving just transitions. Modeling efforts can better integrate equity by looking at things like energy use patterns across income bands; the differential impacts of pricing pathways and regulatory approaches; and the impacts of other policies and assumptions on disadvantaged communities.

- **Be more geographically specific in costing transition pathways.** Cost assumptions in specific African economies will vary widely, depending on local economic conditions and sector risk. In low- and lower-middle income economies, producing realistic assessments of the comparative costs of various transition pathways matters significantly, not only because resources are limited – but because they influence climate finance discussions and negotiations. Modeling approaches should go beyond project financing costs to also consider developmental costs and benefits including health, job creation, etc.

- **Pursue more interdisciplinary modeling approaches.** One fundamental challenge is the large disconnect between energy, climate, and development analysts. Look for opportunities to bring together different types of models (e.g. sector-wide models, distributional analysis, distributional economic impacts) in integrated analyses, and combine modeling tools to leverage the respective strengths of various approaches (for example: linking a bottom-up technology-rich model with a top-down macro-economic model). This approach will produce innovative insights and raise new questions. This could also include efforts to improve models of development and incorporate carbon constraints in those models, rather than relying on energy systems models that were never designed to consider development issues.

Priority #2: Expand access to (and integration of) critical Africa-specific data.

There are two major issues here. First, availability: Robust models rely on energy statistics that can be difficult to obtain and utilize in African countries – either because institutions do not make them available, because they don't exist (sometimes because it is too expensive for relevant government entities to collect), or because they are not aggregated or available in a usable format.[16] In contrast to research in advanced energy markets, where most analysis can be done virtually, African energy data is often physically housed across multiple institutions that can be difficult to contact or obtain information from without visiting in person, and institutions are often not incentivized to share it. Second, African energy sectors differ significantly from those in other regions. For example, a significant portion of Africa's electricity supply comes from distributed, privately owned diesel generators, which are difficult to systematically track. Because the majority of widely used energy system models were developed in (and for) industrialized economies, it can be difficult to integrate data reflecting characteristics like these.[17]

Recommendations:

- **Make the data that exists free and broadly accessible.** Push the institutions with African data behind paywalls, as well as the data underlying major decarbonization reports and analyses, to make it openly available, especially to African researchers, institutions, and governments. (Ongoing efforts to push for this include the advocacy campaign, led by Our World in Data and others, to encourage the IEA to make its data sets freely available.)

- **Fund innovations in modeling that can account for limited data input.** This could include using emerging data sources (e.g. satellite imagery, internet scraping, and other big datasets) to counterbalance the dearth of more traditional data. It might also include using artificial intelligence and machine learning to 'create' new data sets in the absence of historical data and modeling experience, and adapt existing data to usable forms.

- **Integrate different data collection approaches.** A more comprehensive approach to modeling African energy transitions will require more diversified data collection efforts, including through stakeholder consultations and co-production of knowledge. This is particularly important in order to accurately model things like willingness to pay, energy consumption decision making, and technology uptake. This can also help ground truth collected data, which is necessary to validate and train machine learning models so that they are scalable.

[16] In the energy sector, key examples of such data include the availability of renewable resources, market share of technologies, and the value and usage of traditional solid biomass in African energy systems.
[17] Examples of specific key differences include: the convergence of on-grid and off-grid systems; the consumption of traditional biomass; the limitations of existing grid systems; low electrification rates and how that may impact demand, electricity usage, economic development, the energy ladder theory, etc.

- **Leverage bottom-up approaches.** A lot of interesting energy systems modeling in Africa is happening at the sub-national level – even within individual cities.[18] Many of these models use granular primary data collected on the ground. National, regional, and global analyses should make better use of these existing datasets to inform their analyses.

- **Make government data (e.g from African utilities and others) more transparent and available to academic and research communities.** There is an urgent need to strengthen institutional infrastructure for energy data management at national and regional levels, and to establish responsibilities for updating and curating key datasets and training those responsible for it.

Priority #3: Strengthen long-term demand forecasting in African markets.

Energy systems models do not predict the future, but they depend heavily on assumptions about what it will look like. Electricity demand forecasts are a prerequisite for power systems planning. In many emerging markets, they're also critical for crowding in capital, because outside investors require sound predictions of demand in order to invest in what they consider to be uncertain environments.[19] Long-term net zero transition pathways present a challenge because often, utilities only project demand out over the short-term (for example, five years). Net zero transition pathways require a much longer, multi-decadal timeline. This is particularly difficult because the energy transition will also encompass fundamental shifts in technology, consumption, economic trends, and climate risk – making historical trends less relevant. For example, many long-term planning exercises use demand projections based on an econometric relationship to income and population growth. This makes sense in advanced markets but is poorly suited to environments in which large portions of the population lack access to electricity or depend on non-commercial sources of energy.[20]

Recommendations:

- **Priority research agenda: Create new methodologies for forecasting demand.** New methodologies and approaches are needed to increase collaboration between energy and climate modelers, and produce new insights into how the future will evolve and how climate will impact energy systems specifically in low- and lower-middle income economies.

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[18] Examples of pioneering initiatives include SAMSET (a database to help African municipalities plan energy transitions) and Cape Town's Energy Futures model.
[19] Nadia S. Ouedraogo, "Modeling sustainable long-term electricity supply-demand in Africa", *Applied Energy* 190(2017): 1047-1067.
[20] Morgan Bazilian et al., "Energy access scenarios to 2030 for the power sector in sub-Saharan Africa", *Utilities Policy 20(2012).*

Priority #4: Improve communication around the content and purpose of energy transition models.

Ultimately, the value of energy systems modeling depends on the degree to which it is understood and the ways in which it is used. As energy systems models for decarbonization become more mainstream, the risk of misinterpreting their results increases. Applying them successfully requires helping funders and policymakers understand how to recognize good models, and how to use them to make effective decisions.

Recommendations:

- **Engage early with the target policy audience:** The economic and development assumptions adopted in normative modeling exercises should reflect priorities on the ground, including alignment with broader policy priorities.
- **Be clearer and more explicit about the underlying assumptions.** The narratives accompanying energy systems models and reports should describe in detail the structure of models, particularly regarding socioeconomic development assumptions. For example, the modeling group at the University of Cape Town released the assumptions behind South Africa's TIMES model, which was then used to develop the country's NDC and Integrated Resource Plan.[21]
- **Open models up for broader scrutiny and critique.** In addition to clarifying assumptions, create and encourage fora where a broader peer community can engage with the data and analyses.[22]
- **Share best practices for communicating energy systems models.** Support training, workshops, and material on how to best communicate modeling approaches and findings to influence policy. Dissemination via academic journals does not often reach policy makers or shape specific energy transition plans, requiring a new approach.

Priority #5: Expand and strengthen the African institutions and analysts doing this work.

An increasing number of African institutions and researchers are engaged in modeling energy transitions. But the network is still far too small, and their resources far too limited. Prioritizing the increased involvement (and leadership) of African researchers and institutions is crucial because meaningful outputs depend on asking the right questions and on interpreting the results in a way that extracts meaning and reflects the local context. It's easier to train good modelers than it is to train people to understand locally-specific dynamics, and how they interact in specific settings.

[21] Merven, Bruno; Stone, Adrian; Hughes, Alison; McCall, Bryce; Ahjum, Fadiel; Senatla, Mamahloko; et al. (2019): Assumptions and Methodologies in the African TIMES (SATIM) Energy Model, University of Cape Town. Journal contribution.
[22] S. Pye et al., "Modelling net-zero emissions energy systems requires a change in approach", *Climate Policy*, October 2020.

Recommendations:

- **Explore new institutional structures to advance African-led energy transitions.** This could include expanded support for existing entities, and/or creation of a new institution advancing a combination of data analysis, energy systems modeling, and policy innovation. It should house an interdisciplinary cohort of energy, climate, economics, and policy experts and adopt an approach that links development and decarbonization. It should be well-funded over a sustained period to enable it to attract world-class analysts, and to ensure sufficient longevity to influence long-term policy.

- **Expand opportunities to bring modelers from across the continent together.** Establish a platform where African energy systems modelers, researchers, and analysts can share thoughts, best practices from various markets, and resolve questions over how to optimize data and reconcile conflicting datasets. This could include scaling up the Energy Modeling Platform for Africa.[23]

- **Invest in local expertise, and integrate it into policy decisions:** African governments should increase investment in energy transition analysis, supported by research budgets that include energy systems modeling. African academic institutions should consider bolstering data science programs and adding concentrations in energy data analytics and modeling using publicly available datasets and 'big' datasets. This will increase opportunities to draw on the research being generated by local and regional experts, rather than being forced to rely on external consultants. African policymakers and industry leaders should also bring actual case studies and challenges to students, and better integrate them into local real-life efforts.

- **Create scholar exchange programs:** Fund exchange initiatives to help African analysts gain experience at international institutions like IIASA, SEI, and other modeling-focused research labs.

[23] Examples exist of efforts to train African modelers by IRENA, UNECA, and the IEA, but they do not appear to be recurring.