

Zambia's energy transition journey: mirroring from China's lessons

Abstract

Zambia's pursuit of an energy transition aims to diversify its energy portfolio, enhance sustainability, and foster economic growth amid increasing demand and climate change challenges. This review critically examines Zambia's energy transition strategies by drawing lessons from China's rapid and multifaceted energy sector developments. China's experience encompasses large-scale renewable integration, technological innovation, policy reforms, and infrastructure modernization, which can serve as valuable blueprints for Zambia. The paper highlights key areas such as renewable energy deployment, grid modernization, policy frameworks, and technology transfer, emphasizing how Zambia can adapt these lessons within its context. The synthesis underscores the importance of strategic planning, stakeholder engagement, and technological adaptation in achieving a resilient, sustainable energy future for Zambia.

Keywords: Energy transition, renewable energy, grid modernization, technological innovation, energy security

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Introduction

Energy is integral to socio-economic development, underpinning industrialization, urbanization, and improved living standards.¹ As global climate imperatives intensify, countries are compelled to transition toward cleaner, more sustainable energy systems.² Zambia, endowed with significant hydro, solar, and biomass resources, faces the dual challenge of increasing energy access and reducing environmental impacts.³ Its heavy dependence on hydroelectricity exposes it to climate variability, risking energy insecurity.

China's energy evolution over the past four decades presents a compelling case study.⁴ The nation has transitioned from a predominantly coal-based system to a diversified portfolio emphasizing renewable energy, innovation, and modern infrastructure. China's strategic policies, technological advancements, and large-scale investments have propelled it to the forefront of clean energy development.⁵ This review explores how Zambia can leverage China's experiences, adapting their strategies to local conditions. It emphasizes the importance of policy frameworks, technological adaptation, infrastructure investments, and capacity building. By doing so, Zambia can accelerate its energy transition, ensuring sustainable growth, environmental resilience, and regional energy leadership.

Strategic policy frameworks and governance models

China's energy sector policies have been driven by comprehensive planning documents like the 13th Five-Year Plan (2016–2020), which explicitly prioritized renewable energy, energy efficiency, and low-carbon development.⁶ Central government plays a pivotal role, establishing regulatory agencies such as the National Energy Administration (NEA), which coordinates policy implementation, project approval, and industry regulation.⁷ Major policy instruments include feed-in tariffs, renewable portfolio standards, and financial incentives that catalyze private investment. These policies are complemented by regional development strategies focusing on technological innovation and infrastructure upgrades.

Zambia requires a cohesive national energy strategy aligned with its Vision 2030 development blueprint. Establishing a dedicated,

autonomous regulatory authority can streamline licensing, oversee standards, and monitor sector performance. Clear policy targets, such as renewable capacity milestones, enhance investor confidence.^{3,8} Furthermore, integrating policies that promote grid access, local manufacturing, and community participation can foster inclusive growth. Developing a transparent legal framework with incentives such as tax breaks or concessional loans can attract both domestic and foreign investments. Key recommendations include drafting a comprehensive national energy policy emphasizing renewables and sustainability, establishing an independent energy regulatory body with clear mandates, and incorporate stakeholder engagement processes, including local communities, private sector, and development partners.

Renewable energy deployment and technological innovation

China's aggressive deployment of renewables is underpinned by technological innovation and large-scale manufacturing. Solar capacity has surpassed 250 GW, driven by declining costs, technological improvements, and supportive policies like feed-in tariffs and auction mechanisms.⁹ Wind power has similarly expanded with innovative turbine designs and offshore projects. The country has also invested heavily in bioenergy and hydropower, optimizing resource utilization through integrated planning.¹⁰ Advanced manufacturing, including high-efficiency photovoltaic cells and wind turbines, has lowered costs, making renewables competitive with traditional sources. Zambia can emulate China's focus on utility-scale solar projects, particularly in sun-rich southern regions. The development of large-scale solar parks can provide baseload-like power, reducing reliance on hydro and fossil fuels.^{11,12} Wind energy, especially in high-altitude or windy zones, presents additional opportunities. To catalyze investments, Zambia can explore innovative financing models such as green bonds, concessional loans, and international climate funds. Collaborations with Chinese firms experienced in manufacturing and deploying renewable technologies can facilitate technology transfer, reducing costs and fostering local industry. Recommendation for the Zambian environment in this area includes prioritizing grid-connected solar and wind projects with flexible capacity addition, fostering innovation through research collaborations and pilot projects, and

promoting local manufacturing of renewable components to reduce costs and create jobs.

Infrastructure modernization and grid integration

China's power grid modernization has been transformative, integrating intermittent renewable sources via smart grids, ultra-high-voltage (UHV) transmission lines, and digital control systems. These innovations allow for efficient energy transfer over long distances, balancing supply and demand dynamically.¹³ Smart grid technologies incorporate sensors, automation, and data analytics, enabling real-time monitoring and adaptive management. The UHV transmission infrastructure reduces line losses and connects remote renewable generation sites with urban centers. Zambia's existing grid infrastructure is aging and limited in capacity, constraining renewable integration. Investing in smart grid technologies, including digital substations, automation, and demand response, can improve grid stability and efficiency. Regional interconnections with neighboring countries like Zimbabwe and the Democratic Republic of Congo can diversify energy sources, share surplus power, and bolster regional energy security. Strategic investments in UHV or high-voltage lines, potentially with Chinese technical support, can facilitate these regional exchanges. Zambia should upgrade her grid infrastructure with smart technologies and energy storage solutions, develop regional interconnection projects to enhance stability and resource sharing, and pilot innovative grid management systems to optimize renewable integration.

Energy access and rural electrification

China's rural electrification success involved deploying decentralized renewable solutions such as microgrids, solar home systems, and biomass generators. These approaches provided affordable and reliable power to remote villages, improving socio-economic outcomes.¹⁴ Programs targeted vulnerable populations, with subsidies and capacity-building initiatives ensuring sustainability. Microfinancing and community ownership models promoted local engagement. Given Zambia's dispersed rural population, decentralized renewable solutions are vital. Small-scale solar mini-grids, coupled with battery storage, can provide reliable power where grid extension is economically unfeasible. Community involvement in project planning and maintenance ensures sustainability. Financial models such as pay-as-you-go solar systems, supported by mobile money platforms, can improve affordability and adoption. In this vain, Zambia should promote microgrid and solar home systems in off-grid areas, engage local communities through training and employment opportunities, and seek international funding to support rural electrification initiatives.

Environmental and social considerations

China emphasizes environmental safeguards, rigorous environmental impact assessments (EIAs), and social safeguards to mitigate project risks. Large hydropower projects are accompanied by resettlement plans, biodiversity conservation, and community development programs. Zambia must embed environmental and social considerations into project planning to avoid adverse impacts. Stakeholder consultations, transparent EIAs, and community benefit-sharing arrangements are essential for project legitimacy and sustainability. Involving local communities from the outset can improve project acceptance and social license. Monitoring mechanisms should be established to ensure compliance with environmental standards. Zambia may consider implementing comprehensive EIAs for all

energy projects, establish community engagement and benefit-sharing frameworks, and adopting best practices from Chinese projects to mitigate environmental impacts.

Capacity building and technological transfer

China's emphasis on education, vocational training, and international cooperation has fostered a skilled workforce capable of managing complex energy systems. Institutions like Tsinghua University and China Renewable Energy Institute serve as hubs for innovation and capacity development. Building local expertise is critical. Zambia can establish technical training centers, collaborate with Chinese universities and research institutions, and promote knowledge exchange programs. Developing a local supply chain for renewable components, supported by skill development, will reduce dependency on imports and stimulate economic growth. Zambia should consider investing in vocational and technical training programs, foster bilateral collaborations for research and innovation, and promote local manufacturing and maintenance skills.

Financial models and investment climate

State-backed banks, government-led funds, and large infrastructure projects have mobilized substantial capital for energy investments. Policies favoring renewable energy also include tax incentives and concessional loans. Establishing dedicated green funds, attracting international climate finance, and creating a favorable investment climate are essential. Simplifying permitting processes and ensuring policy stability can attract long-term investment. Private sector participation can be incentivized through regulatory certainty and financial incentives, fostering a vibrant energy market. Zambia may consider creating a national Green Energy Fund to finance renewable projects, engage multilateral development banks for concessional loans, and implement policy reforms to improve the investment climate.

Conclusion

Zambia's energy transition is a complex but vital journey toward sustainable development. Learning from China's experience reveals that strategic policy frameworks, technological innovation, infrastructure modernization, and stakeholder engagement are fundamental pillars. While Zambia must adapt these lessons to its unique context, resource availability, socio-economic factors, and institutional capacity, the core principles remain universally applicable. Embracing a multi-stakeholder approach, fostering innovation, and prioritizing environmental and social safeguards will position Zambia as a regional leader in clean energy. Strategic collaborations, capacity building, and smart investments will be the catalysts for a resilient, sustainable energy future, enabling Zambia to meet its developmental aspirations while contributing to global climate goals.

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