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RESEARCH

The Role of Renewable Energy in Sudan's Reconstruction: The Path to Sustainable Development

Dr Hisham Salaheldin Shazali
Institute of Environmental Studies, University of Khartoum, Sudan
Email: drshazali@gmail.com
ORCID: 0009-0004-0329-8890

Dr Izzet A. Almubarak
Faculty of Engineering, University of Khartoum, Sudan
Email: izzetdotcom1@gmail.com
ORCID: 0009-0000-4204-3322

Dr Nadir M. Hassanein Yousif
Managing Director, University of Khartoum Consulting Corporations (UKCC)
Civil Engineering Department, University of Khartoum, Sudan
Email: gm@ukcc.com
ORCID: 0009-0001-1200-1532

ABSTRACT

PURPOSE: This article explores the role of renewable energy, particularly solar power, in addressing Sudan's energy crisis in the context of post-war reconstruction and long-term sustainable development.

DESIGN/METHODOLOGY/APPROACH: A qualitative approach will be used, analysing policy frameworks, technological advancements, and case studies in the fields of solar, wind, hydropower, and biomass energy. The research also evaluates the challenges and opportunities associated with integrating renewable energy into Sudan's energy infrastructure during the reconstruction phase.

FINDINGS: Solar energy is a fast, cost-effective solution for Sudan's immediate post-conflict energy needs. To ensure energy security, economic stability, and environmental sustainability, a diversified renewable energy mix, including solar, wind, and other sources, is crucial. However, challenges such as financial limitations, regulatory gaps, and infrastructure deficits need to be overcome.

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ORIGINALITY/VALUE: A distinct perspective is provided on how renewable energy can drive Sudan's recovery and long-term development, with practical pathways and policy recommendations for integrating renewables into the national rebuilding process. Valuable insights are offered into the transformative potential of solar and other renewable energy sources in reshaping Sudan's energy landscape.ergy sources in reshaping Sudan's energy landscape.

RESEARCH LIMITATIONS/IMPLICATIONS: The research is primarily qualitative and may be limited by the availability of data on Sudan's energy infrastructure post-conflict. The study also focuses more on policy and technological aspects rather than empirical data from specific case studies, which may influence the generalisability of the findings.

PRACTICAL IMPLICATIONS: The findings provide practical guidance for policy-makers, government entities, and development stakeholders in Sudan. By prioritising renewable energy solutions, particularly solar power, the country can address urgent energy needs while also fostering long-term economic and environmental benefits.

KEYWORDS: *Renewable Energy; Solar Power; Post-War Reconstruction; Energy Security; Sudan; Sustainable Development; Energy Infrastructure; Policy Frameworks*

INTRODUCTION

The extended war in Sudan has adversely affected major infrastructure, particularly the energy sector, and left millions with no access to a secure source of electricity. Energy insecurity has increased humanitarian crises, inhibited socio-economic progress, disrupted public utilities, and led to environmental degradation (IRENA, 2021a; UNDP, 2022). Sustainable recovery and stability post-conflict hinge on rehabilitating the energy sector (World Bank, 2021a, b).

As Sudan embarks on post-war recovery and reconstruction, there is an opportunity to shift towards a low-carbon, inclusive, and sustainable energy path. Solar, wind, hydro, and bioenergy are renewable energy (RE) technologies that are clean, scalable, and green alternatives to fossil fuel reliance (IRENA, 2023). With these resources, economic growth can be fuelled, basic service delivery improved, and climate adaptation and mitigation can be facilitated (AfDB, 2022).

The paper explores the strategic significance of RE to restore Sudan's energy industry and support long-term development. The paper applies qualitative policy regime analysis, relevant case studies, and the technical potential of renewable sources. The paper aims to:

- identify the benefit of RE after conflict;
- assess Sudan's potential for RE and lead technologies;
- identify key obstacles to the deployment of RE;
- provide strategic policy actions to guide sustainable energy development.

Through promoting renewables, Sudan can enhance resilience, regain basic services, and build foundations for a greener, more inclusive, and prosperous future (UNDP, 2022; IRENA, 2021b).

THE ROLE OF RENEWABLE ENERGY IN POST-WAR RECONSTRUCTION

Post-conflict reconstruction in Sudan offers the country an opportunity not only to restore infrastructure but to redirect its path of development towards sustainability, equity, and climate resilience. While traditional energy infrastructure has been destroyed at a time when it is most needed, RE offers a solution to address both short-term recovery and long-term development goals (IRENA, 2023; UNDP, 2022).

Sudan's energy is derived primarily from crude oil, hydroelectricity, biomass, and RE sources such as wind, solar, and geothermal. Figure 1 indicates that the highest source is from biomass, at 52% of Sudan's total energy requirement. The second is oil at 38%, then hydroelectricity at 10%. The primary energy source used for electricity generation in Sudan is hydropower, providing approximately 54.6% of the output. Fossil fuels are the second largest contributor, making up 44.62%, while only 0.78% is generated from other RE sources (Eldowma *et al.*, 2023)

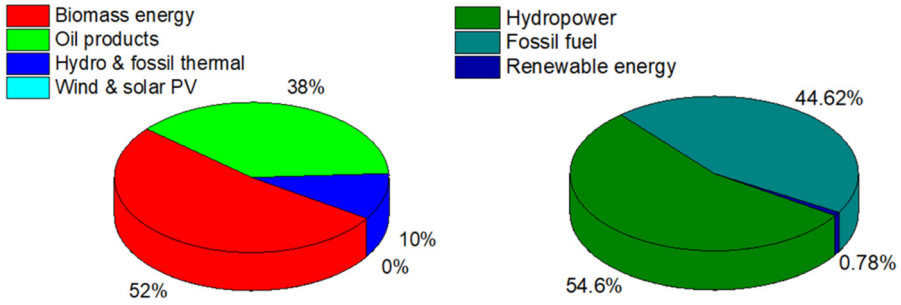

Figure 1: Total energy production in Sudan
Source: Eldowma *et al.*, 2023

Addressing Energy Insecurity and Humanitarian Needs

Energy is a basic requirement to regain essential services. Solar mini-grids and stand-alone systems can readily scale up to provide essential functions to off-grid or displaced populations, primarily in the settings of schools, healthcare facilities, and emergency camps (Table 1) (World Bank, 2021a, b; UNHCR, 2022). Figure 2 is a conceptual diagram showing solar panels powering a rural clinic, vaccine refrigeration, and lighting.

Table 1: RE Applications in Key Sectors of Sudan's Reconstruction

Sector	*RE Application*	*Impact*
Agriculture	Solar irrigation, water pumping	Increased yields, improved food security
Health	Solar clinics, cold chain systems	Reliable care and vaccine storage
Education	Lighting, digital access via solar	Longer study hours, e-learning access
Livelihoods	Solar dryers, refrigeration, welding	Micro-enterprise creation and rural job growth
Water & Sanitation	Solar desalination, water purification	Clean drinking water, improved sanitation

Source: Adapted by the author from IRENA, 2021c; UNDP, 2020a, b; SEforALL, 2020a, b, c; FAO, 2021a, b.

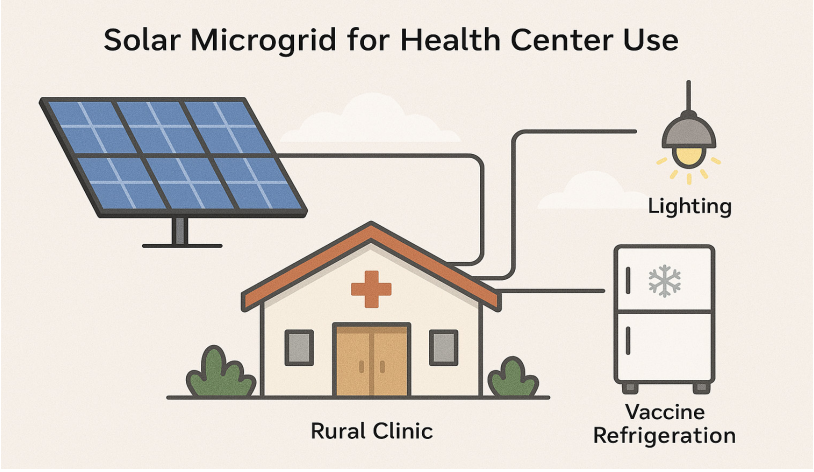

Figure 2: Solar Micro-Grid for Health Centre Use
Source: Constructed by authors

Supporting Economic Recovery and Livelihoods

Clean technology can be a source of income streams, especially from micro-enterprises and agriculture. Solar water pumps and schemes, for example, can translate into higher rural production, rendering food shortages and humanitarian dependence a thing of the past (AfDB, 2022; FAO, 2021a). Solar welding kits, dryers, and refrigeration also enable micro-enterprises and income.

Enhancing Climate Resilience and Environmental Sustainability

Sudan is highly vulnerable to climate stresses such as droughts and floods. Transition to small-scale hydro, solar, and wind avoids greenhouse gas emissions and maintains ecosystems in their natural state. Transition is consistent with global agendas such as the Paris Agreement and SDG 13 on climate action (UNEP, 2020; IRENA, 2023). Figure 3 compares the emissions of diesel generators to solar photovoltaic (PV), wind, and hydro.

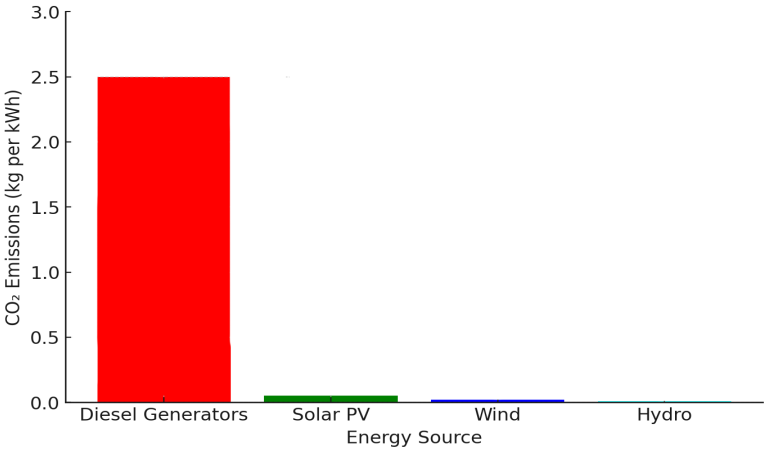

Figure 3: Comparative CO_2 Emissions by Energy Source

Source: Adapted and compiled by the authors. Data referenced from IRENA, 2020; Edenhofer *et al.*, 2014; IEA, 2021

Building Inclusive and Decentralised Energy Systems

RE allows decentralised power generation, ensuring energy management is in the control of local communities. This is particularly critical for conflict and rural areas that historically have been lacking infrastructure. Decentralised systems encourage local governance, increase resilience, and provide employment at the grassroots level (SEforALL, 2022; GIZ, 2021, 2023). Figure 4, a systems diagram, shows community-level generation, local job creation, improved service delivery, and inclusive governance in energy planning.

RE can help Sudan build a more equitable, more robust, and climate-resilient future. The technologies not only provide electrical power, they also generate hope, dignity, and set the path towards sustainable peace (UNDP, 2022; IRENA, 2021b).

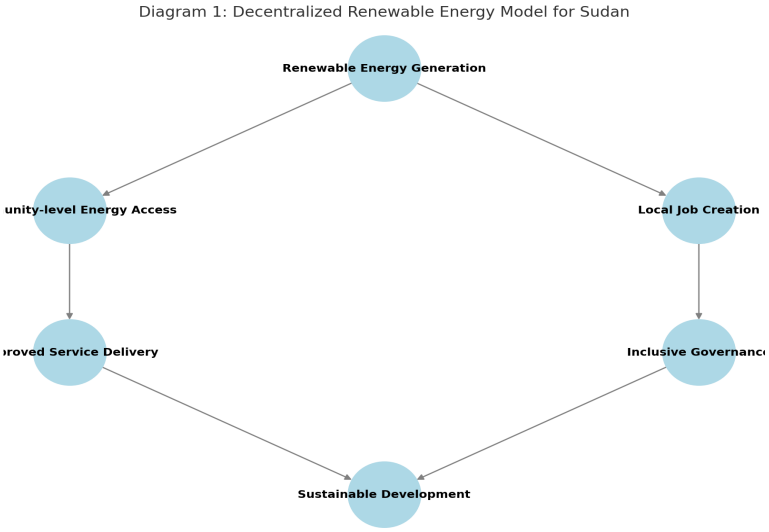

Figure 4: Decentralised RE Model for Sudan
Source: SEforALL, 2022

RE as a Catalyst for Post-Conflict Recovery

RE is a key, but frequently overlooked, component in conflict and post-conflict reconstruction, as well as for short-term stabilisation and long-term resilience. Global examples in the Democratic Republic of the Congo (DRC), Gaza, Ukraine, Yemen, and South Sudan demonstrate that decentralised renewable systems such as hydropower, rooftop photovoltaic solar, and wind power can sustain communities even amidst war. Hydroelectric initiatives in eastern DRC have supplied over 140,000 people with power despite continuing instability. Gaza's rooftop solar project, in one of the world's most urbanised cities supplies energy to nearly one-third of the population, a lifeline where traditional infrastructure has collapsed (CYS, 2021). Ukraine's RE transition, accelerated by the conflict, aims for 50% RE by 2035, demonstrating how crises can be the catalyst for transitions in sustainable energy. Faced with a war-damaged grid network, Yemen's post-conflict plan now focuses on an increase in renewables to 15-20% by 2025. It includes decentralised solar PV to off-grid villages and substantial solar, wind, and geothermal source investments to resume energy supply (Sufian, 2019). Even in South Sudan, the most un-electrified country, the yet-to-be-harnessed potential of the renewables provides a path towards equitable, sustainable growth.

CHALLENGES AND OPPORTUNITIES FOR RE DEPLOYMENT IN SUDAN

Clean energy use in post-conflict Sudan is an essential challenge and an historic opportunity. Existing challenges are assessed, while tracing the path towards energy transition to clean energy to facilitate reconstruction efforts as well as the entire Agenda 2030 for Sustainable Development (UNDP, 2023a, b; IRENA, 2021a).

Infrastructure Deficits and Energy Access Gaps

The ongoing conflict has severely damaged Sudan's national electricity grid, leaving vast rural and conflict-affected areas entirely disconnected or with limited access to power. Transmission and distribution infrastructure have been destroyed, resulting in widespread dependence on inefficient, high-emission diesel generators and unsustainable natural biomass sources (Figure 5) (World Bank, 2022a, b; IRENA, 2024). Given that rebuilding a centralised grid may take decades, decentralised RE solutions, particularly solar-powered systems and micro-grids, present a viable and immediate alternative for meeting urgent energy needs in the short to medium term (SEforALL, 2020a, b, c; UNDP, 2024).

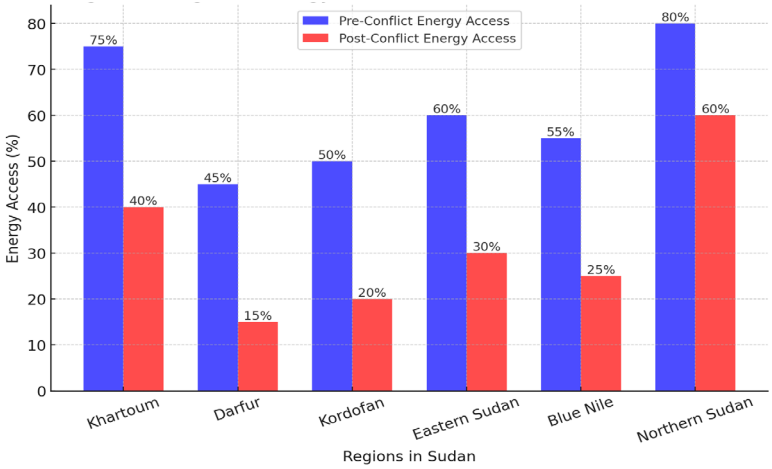

Figure 5: Regional Energy Access in Sudan (Pre- and Post-Conflict)

Source: Adapted and compiled by the authors. Data drawn from World Bank, 2022a, b, UNDP, 2023a, b and Sudan Household Energy Surveys (pre- and post-conflict assessments)

Financial Constraints and Investment Barriers

Sudan faces acute macro-economic instability, making foreign investment in RE risk-prone. High capital costs, especially for solar storage, hinder scalability (AfDB, 2020). Additionally, limited access to green finance, lack of sovereign guarantees, and under-developed public-private partnership (PPP) frameworks reduce investor confidence (Table 2) (GCF, 2023).

Table 2: Financial Barriers to RE in Sudan

Barrier	*Impact*	*Suggested Solution*
Lack of concessional loans	Limits large-scale projects	Leverage international climate funds
High import tariffs on solar products	Increases installation costs	Advocate for tariff exemptions
Absence of green finance institutions	No local lending options	Establish national green finance entities

Source: Adapted and compiled by the authors. Based on data and insights from AfDB, 2020; GCF, 2021; and World Bank, 2022a, b

Regulatory and Institutional Gaps

There is no harmonised national RE policy or legislation that is attractive to domestic and external investment (IRENA, 2021a). The current institutions of energy governance are fragmented by overlapping mandates for ministries, creating inefficiencies during planning and implementation. They lack adequate regulatory technical capacity to monitor and enforce RE policies and standards (UNEP, 2022). Box 1 captures the most important omission in Sudanese energy policy and sets out steps towards creating a post-conflict sustainable energy future.

The absence of a national RE policy in Sudan leads to scattered and disorganised energy projects.

- Unclear policies fail to attract investment in RE projects.
- RE is excluded from the national recovery because of low institutional arrangements.

Strategic Recommendations:

1. Create a **National RE Strategy**: Frame clear-cut policies to steer investments in clean energy.
2. **Encourage private sector investment** through tax breaks and subsidies to RE projects.
3. Improve **Institutional Capacity and Governance**: Establish a separate co-ordinating agency for RE.
4. **Connect Energy Planning with Reconstruction:** Ensure infrastructure reconstruction incorporates the utilisation of RE sources.

Box 1: Policy Vacuum: The Need for a National RE Strategy

Socio-Political and Environmental Considerations

Lack of social trust resulting from decades of neglect, supplemented by conflict and weak environmental policy, can impede or even stop energy development (Mercy Corps, 2022). However, community control mechanisms and participatory systems of governance have enormous potential. Sudan's vast renewable endowment can be harnessed towards nature conservation without compromising livelihoods' potential (UNDP, 2023a, b).

Emerging Opportunities and Strategic Leverage Points

Despite these difficulties, Sudan holds an enormous capacity to leapfrog a carbon-fuelled past and into a clean energy future. Falling global prices of solar and wind technology, rising global climate finance, and regional cohesion, such as the African Union's Agenda 2063, offer historic levels of momentum (AU, 2020; Buchner *et al.*, 2023). Harmonising renewable investment with development priorities has the potential to drive lasting transformation.

CHALLENGES AND BARRIERS TO RENEWABLE ENERGY DEPLOYMENT IN POST-WAR SUDAN

Despite the extensive RE resource base in Sudan, numerous interlinked challenges continue to inhibit the large-scale deployment and adoption of cleaner energy technologies. These challenges transcend political, economic, technical, as well as institutional levels, particularly in the post-war situation (IRENA, 2017; UNDP, 2023a, b).

Political Instability and Weak Governance

The protracted conflict has led to institutional collapse in large parts of the country. Ineffective governance frameworks limit the capacity of the state to establish national energy policies, co-ordinate donor aid, and establish regulations necessary for the growth of the RE industry (Box 2) (Mercy Corps, 2022; UNEP, 2022)

- Lack of co-ordination among federal and local authorities in energy planning.
- Frequent leadership turnover disrupts continuity in energy programmes.
- Limited representation of community voices in energy decisions.

Sudan's post-conflict energy transition is faced with daunting governance challenges due to its fragmented political institutions and weak institutional co-ordination. Lack of one national energy plan and the presence of overlapping mandates among government institutions undermine decision-making coherence as well as policy implementation.

Key Issues:

- **Overlapping Jurisdictions:** The existence of numerous ministries, agencies, and regional state governments with competing mandates over energy governance delays project approvals and releases of funds.
- **Weak Decentralisation:** While the delivery of services is the role of local governments, they possess weak technical capacity and fiscal autonomy to initiate RE projects.
- **Regulatory Inconsistencies:** Inferred contradiction of energy policy between the federal and regional governments causes confusion among investors and development partners.

- **Lack of Proper Involvement of the Right Stakeholders:** Vulnerable groups and local co-operatives are not consulted in planning energy, thus decreasing peoples' trust in projects as well as the viability of the project.

Case Example:

A Blue Nile State rural electrification programme was put on hold for two years due to confusion regarding who among the federal Ministry of Energy and state governments would be responsible. Absence of a one-stop approval process discouraged private sector investment causing project failures.

Policy Recommendations:

- Establish a **National RE Authority** to unify policy direction and streamline approvals.
- Strengthen **local government capacity** to oversee decentralised energy projects.
- Develop a **transparent regulatory framework** that provides clear guidelines for PPPs in the energy sector.

Box 2: Political Fragmentation and Energy Governance

Financial Constraints and Investment Gaps

The war has devastated Sudan's economy, eroding fiscal capacity and reducing investor confidence.

- High capital costs for solar and wind systems remain a barrier.
- Absence of financial incentives such as feed-in tariffs or green bonds.
- Limited access to climate finance due to institutional inefficiencies (GCF, 2023; World Bank, 2022a, b).

Figure 6 visually compares the estimated investment needed for rural solar electrification (US$3 billion) with actual government and donor expenditures (US$500 million and US$750 million respectively).

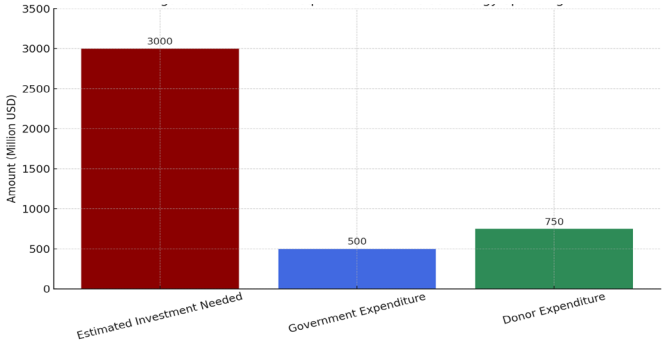

Figure 6: Investment Requirements vs Actual Energy Spending

Source: Adapted and compiled by the authors. Data referenced from World Bank, 2022a, b; UNDP, 2023a, b; and GCF, 2021

Infrastructure Deficits

Post-conflict destruction of infrastructure impedes RE delivery.

- Roads, substations, and transmission lines are damaged or non-existent in many regions.
- Off-grid areas face high deployment costs.
- Lack of storage and grid technologies reduces solar and wind reliability (SEforALL, 2020a, b, c; IRENA, 2017).

Technical and Human Capacity Limitations (Box 3)

Sudan lacks skilled energy technicians.

- Limited local manufacturing results in dependency on imports.
- Weak data systems impair energy planning (UNEP, 2022).

Sudan's transition to a new generation of RE requires specialised personnel for the installation, design, and maintenance of clean energy. Universities and Technical and Vocational Education and Training (TVET) institutions have the responsibility to bridge the gap through in-service and specialised training.

Promising Initiatives:

- **University of Khartoum RE Center** – Offers specialised courses on solar and wind technologies, fostering research in sustainable energy solutions.
- **Gedaref Polytechnic Solar Technician Program** – A pilot initiative training technicians in off-grid solar system installation and maintenance for rural communities.
- **Sudanese-German TVET Partnership** – Partnership to develop RE learning curricula as a step before preparing young people for employment readiness.
- **Darfur Energy-Based Training at the Community Level** – Collaborating with local institutions for training young people and women to assemble and fix solar home systems.

By building on such programmes, Sudan can create a workforce that will be in a position to support a sustainable, decentralised RE sector with long-term prospects and grass-roots employment opportunities.

Box 3: The Role of Universities and TVET Institutions in Closing the Skills Gap, Highlighting Promising Pilot Initiatives by Sudanese Institutions

Policy and Regulatory Barriers

- Lack of a unified legal framework for renewable integration.
- Inconsistent import duties and licensing procedures.
- Limited transparency in procurement processes (IRENA, 2017; UNDP, 2023a, b).

What Sudan Can Learn from Kenya's Energy Sector Reform

Kenya's Energy Act (2006) and robust regulatory institutions (EPRA, REREC) fostered a thriving RE sector (Table 3) (IEA, 2019). Key lessons include:

- establishing independent regulatory bodies;
- prioritising off-grid solar micro-grids in rural areas;
- promoting PPPs with risk-sharing mechanisms;
- encouraging local manufacturing and job training

Table 3: Comparative Insights – Kenya vs Sudan Energy Sector Reform

Aspect	*Kenya*	*Lesson for Sudan*
Legal & Regulatory Framework	Energy Act 2006; Independent regulator (EPRA)	Enact a national RE law and establish an autonomous regulatory body
Institutional Co-ordination	REREC for rural electrification; structured roles for agencies	Clarify mandates between ministries; create a unified RE authority
Decentralised Energy Access	National strategy for off-grid electrification via solar micro-grids	Prioritise solar and hybrid systems for rural and conflict-affected communities
PPPs	PPPs in geothermal, solar; risk-sharing policies	Develop frameworks to attract private investment in renewables
Financing and Subsidies	Donor-backed programmes; subsidies for rural solar kits	Design blended finance models and targeted subsidies for rural electrification
Local Industry & Jobs	Local solar kit assembly; training programmes for technicians	Promote local manufacturing and integrate RE into vocational training
Community Participation	Stakeholder engagement in project planning and monitoring	Ensure inclusive governance in energy planning and local ownership

Source: Adapted and compiled by the authors. Informed by data from IEA, 2022; World Bank, 2020a, b; and Eberhard *et al.*, 2017

Social Acceptance and Community Participation

Many communities mistrust energy interventions due to historical neglect.

- Gender disparities in access and decision-making persist.
- Public awareness of benefits and maintenance remains low (Mercy Corps, 2022; UNDP, 2023a, b).

Figure 7 illustrates key community concerns regarding household solar adoption in Kassala and South Kordofan. It highlights major barriers such as affordability, maintenance, access to credit, technical knowledge, and availability.

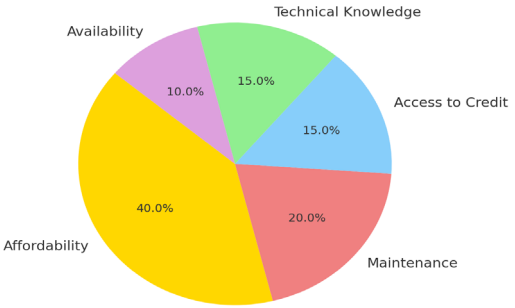

Figure 7: Barriers to Household Solar Adoption – Survey Insights from Kassala and South Kordofan

Source: Adapted and compiled by the author. Based on field insights from UNDP, 2022; Mercy Corps, 2022; and SEforALL, 2020a, b, c

Climate and Environmental Challenges

While renewables support climate resilience, climate change poses implementation risks:

- dust storms reduce solar efficiency;
- hydrological variability threatens hydropower (UNEP, 2022)

STRATEGIC PATHWAYS FOR INTEGRATING RENEWABLES INTO SUDAN'S RECONSTRUCTION

Sudan's reconstruction offers an opportunity to realign its energy development trajectory toward sustainability, inclusivity, and resilience. Strategic integration of RE systems can serve as a cornerstone of this transformation. This section outlines key pathways to achieve that goal.

Policy and Institutional Reforms

Building a coherent, open, and inclusive policy framework is critical in scaling up RE deployment in post-conflict Sudan. There needs to be a committed national RE authority established for organising energy planning, the execution of regulatory functions, and integrating fragmented mandates across ministries and local governments (IRENA, 2017).

Key policy priorities include:

- enacting a comprehensive **RE Act** with clear targets, procurement rules, and performance standards;
- developing a national **off-grid electrification strategy,** particularly for rural and conflict-affected zones;
- ensuring regulatory independence and transparency in licensing and tariff setting to build investor confidence (World Bank, 2020a, b).

These reforms should be grounded in participatory governance that actively involves communities, civil society, and local governments in the energy decision-making process (AfDB, 2021).

Financing Mechanisms and Investment Strategies

To overcome the investment gap, Sudan must diversify its financing sources and establish mechanisms to attract private capital, donor funding, and climate finance.

Key actions include:

- establishing an **RE Investment Fund** that pools public and donor resources to de-risk private investment;
- introducing **green bonds**, **feed-in tariffs**, and **results-based financing** to incentivise private developers (UNDP, 2020a, b);
- leveraging **blended finance models**, where grants and concessional loans support high-impact solar micro-grids and mini-hydro projects (GCF, 2021);
- strengthening institutional capacity to develop bankable RE proposals to access funds from entities such as the **Green Climate Fund** and **Climate Investment Funds** (CIF, 2022).

A robust investment strategy should also prioritise infrastructure rehabilitation, such as roads and substations, to lower deployment costs and enhance market access for energy companies.

Capacity Building and Technological Advancement

Human capital is a linchpin for Sudan's RE transition: bridging the skills gap through education, training, and innovation is vital.

Recommendations:

- Expand **TVET** in solar PV, wind, biomass, and energy storage systems, with gender-inclusive programmes.
- Support **university-based RE research centres** and innovation hubs to localise technologies and adapt them to Sudan's climatic and socio-economic context (IRENA, 2019).

- Promote **partnerships with international organisations and diaspora networks** for knowledge exchange and technical mentorship.
- Foster **local manufacturing of solar modules, batteries, and components** to create jobs and reduce reliance on imports (REN21, 2022).
- **Investment in digital tools such as GIS-based energy planning, smart grids,** and energy monitoring systems will also enhance system performance and transparency.

Community Engagement and PPPs

Social acceptance and local ownership are critical to the long-term success of RE initiatives. Programmes must be culturally sensitive, gender-inclusive, and community-driven.

Strategies include:

- institutionalising **Free, Prior and Informed Consent (FPIC)** in all energy projects;
- supporting **community energy co-operatives and women-led solar enterprises**, particularly in post-conflict areas (SEforALL, 2020a, b, c);
- establishing **PPP frameworks** that ensure equitable benefit-sharing between investors and communities;
- scaling up pilot models such as the **community solar training centres in Darfur** and **micro-grid co-ownership schemes** in Kassala and Blue Nile States.

Lessons from Kenya and other Sub-Saharan African countries show that local participation in planning, operations, and benefit distribution significantly improves project sustainability and impact (USAID, 2021).

POLICY RECOMMENDATIONS FOR A SUSTAINABLE ENERGY FUTURE

As Sudan rebuilds from conflict, its energy future must be based on sustainability, inclusivity, and resilience. This section presents actionable policy recommendations across governance, international co-operation, and social equity dimensions to ensure that RE becomes a catalyst for long-term peace and prosperity.

Strengthening Governance and Regulatory Frameworks

A robust, transparent, and unified regulatory environment is essential for investor confidence and efficient project implementation. Sudan should prioritise:

- **enacting a comprehensive National RE Law** that sets clear national targets, defines licensing procedures, and embeds climate resilience;
- **establishing an independent regulatory authority** to oversee energy pricing, performance monitoring, and compliance enforcement (IRENA, 2017);

- **clarifying institutional mandates** between federal and state entities to prevent project delays and duplication;
- **developing an RE Planning and Information System (REPIS)** for data-driven decision-making, especially for off-grid electrification.

Figure 8 shows the proposed structure linking the Ministry of Energy, the proposed National RE Authority, local governments, private developers, and civil society.

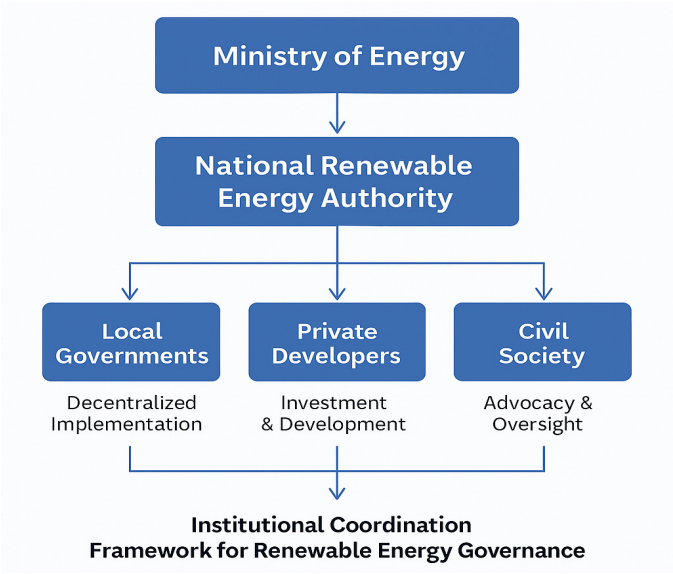

Figure 8: Institutional Co-ordination Framework for RE Governance
Source: IRENA 2021a

Case-in-Point: Enhancing Regulatory Power for Industry Transparency

Kenya's Energy and Petroleum Regulatory Authority (EPRA) is a model of how independent regulatory bodies can push transparency, accountability, and investor trust in the RE sector. Formed under the Energy Act of 2019, EPRA oversees tariff-setting, licensing, and enforcement of compliance, ensuring that reforms in the energy sector are implemented effectively and to a moderate degree with little political interference. Its success as a process-driven force has attracted investments and put Kenya on the map as regional clean energy use champion (World Bank, 2020a, b).

Box 4: Case-in-Point: Learning from Kenya's EPRA Model

Context: Post-reform Kenya, 2019

Institution: Energy and Petroleum Regulatory Authority (EPRA)

Impact: Increased transparency, boosted investment, and streamlined licensing

Lesson for Sudan:

- Create an independent energy regulatory body
- Enshrine autonomy in legal frameworks
- Ensure oversight of licensing, tariffs, and compliance

Source: World Bank, 2020a, b

Leveraging International Support and Collaboration

Sudan's energy shift needs co-ordinated global partnerships, technical support, and climate finance.

Key strategies:

- **engage with multilateral climate finance institutions** (e.g., GCF, CIF, AfDB) to fund large-scale solar, wind, and mini-grid projects (GCF, 2021);
- **participate in regional energy markets and power pools** (e.g., COMESA, Nile Basin Initiative) to import/export RE during surplus and shortage periods (AfDB, 2021);
- **sign bilateral energy co-operation agreements** to facilitate technology transfer, technical training, and joint research (Table 4).

Table 4: Key International Partners and Opportunities for RE Development in Sudan

Partner	*Area of Support*	*Notable Initiative*
Green Climate Fund (GCF)	Climate finance	Readiness programme for LDCs
AfDB	Infrastructure & policy support	Desert to Power Initiative
Germany's GIZ	Technical capacity building	Sudan-German TVET Partnership
UNDP	Local electrification projects	Access to Energy for Recovery

Source: Constructed by authors

Ensuring Inclusive and Equitable Energy Access

Energy justice is critical to post-war reconstruction and sustainable development. Sudan's energy policies must actively address disparities and empower marginalised groups.

RECOMMENDATIONS

- **Mandate gender-sensitive energy policies** that promote women's participation in energy decision-making, ownership, and employment.
- **Support community-owned energy co-operatives** and participatory project models to enhance local ownership and accountability (SEforALL, 2020a, b, c).
- **Implement targeted subsidies or voucher programmes** to improve affordability of solar systems for vulnerable households.

Figure 9 shows survey data from Darfur, Kassala, and South Kordofan indicating affordability, distance, and knowledge gaps as top challenges among women, youth, and internally displaced persons (IDPs).

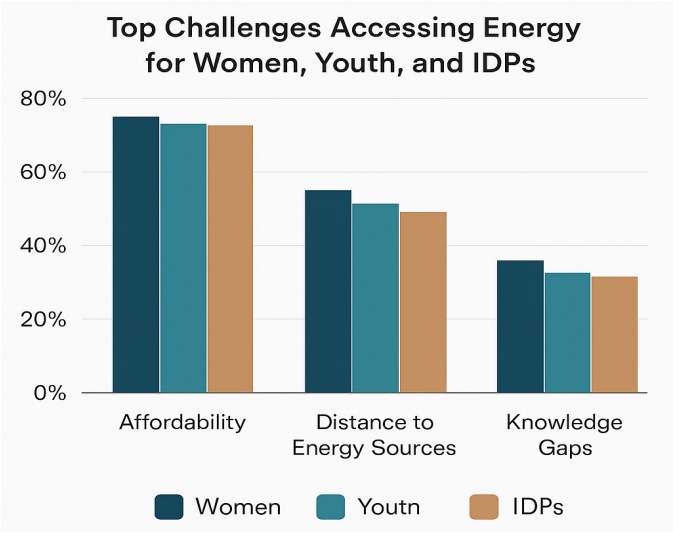

Figure 9: Barriers to Energy Access by Demographic Group
Source: SEforALL, 2020b

CONCLUSIONS

Summary of Key Insights

Sudan stands at a critical juncture as peace and global clean energy transition converge. The discussion below presents a timeline of lessons learned:

- **Abundance of Renewable Resources:** Sudan's solar, wind, and biomass resources are sufficient to supply domestic energy needs and power economic recovery.
- **Recurring Problems:** Political divisions, governance challenges, financial hardships, inadequate infrastructure, and weak technical capabilities are ongoing problems to the global application of RE.

- **Solutions from the People:** Women, youths, IDPs, and co-operatives on the ground must be involved in solutions to ensure that projects are sustainable and acceptable.
- **Learning from Comparable Experience:** Learning from similar experience in nations such as Kenya enforces the importance of regulatory certainty, decentralised distribution, and PPP.

The Road Ahead: A Vision for Sudan's Sustainable Energy Future

Sudan needs to target an integrated and inclusive energy policy blending reconstruction and green growth towards a sustainable energy future. Some of the most important pillars of the vision are:

- **Integration of Electricity Sources:** Integration of hydroelectricity with other sources of RE has the potential to complement a large portion of electricity supply in Sudan and address most problems affecting the energy sector. Some of these problems include a very high frequency of power outages, low coverage of remote rural villages to the national power grid, and limited ability to generate hydropower.
- **Harmonised Institutional Framework:** There should be a National RE Authority (NREA) to harmonise energy regulation, act as donors' co-ordination facility, policy-making, and project management.
- **Scaling Community-Based Off-Grid Solutions:** Decentralised solar micro-grids should cover rural schools, clinics, and water stations in order to cover social services and ensure energy equity.
- **Investment in Skills and Innovation:** Technical and vocational training and university research programmes will provide the human capacity for developing and maintaining the RE industry.
- **Green Investment Attraction:** Sudan will be able to attract climate finance, concessionary credit, and diaspora finance through providing regulatory transparency and bankable projects.
- **Building Climate Resilience:** As climate change intensifies, Sudan's energy planning must include adaptive technologies, dust-resilient panels, water-efficient cooling systems, and disaster risk management strategies.

RE in Sudan is not just a technical and policy requirement, it is an humanitarian and development necessity. With concerted effort, visionary leadership, and the active participation of communities, Sudan can transform its energy sector into a beacon of peace, resilience, and prosperity for all (Figure 10).

Figure 10: Sudan Sustainable Energy Future
Source: Constructed by authors

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BIOGRAPHY

Dr Hisham Salaheldin Shazali is a distinguished Environmental Consultant and academic leader with over 30 years of multidisciplinary experience spanning environmental sustainability, climate change adaptation, agricultural innovation, and business development. He currently serves as the Director of the Institute of Environmental Studies at the University of Khartoum, where he leads strategic initiatives in education, applied research, and community outreach. Dr Shazali holds a PhD in Animal Production, and advanced degrees in Tropical Animal Production and Business Administration from the University of Khartoum. His academic profile is further enriched by advanced studies in business development at the University of Nottingham (UK) and a diploma in experimental design and statistical analysis. His research in environmental sciences centres on climate resilience, the Water-Energy-Food Nexus, and renewable energy governance. He has served as a key researcher on several multidisciplinary projects funded by FAO, DAAD, SIDA, FORMAS, and the Swedish Research Council. His work exemplifies the integration of science, policy, and practice in pursuit of environmental and social resilience in fragile and transitional settings.

Dr Izzet A. Almubarak holds a PhD in Petroleum and Natural Gas Engineering from the University of Khartoum. With over 25 years of international experience managing large-scale oil and gas projects, he has excelled in leading multidisciplinary, multicultural teams. His academic contributions include lecturing and research in specialised fields such as surface production system design, and oil and gas storage and transportation facilities, bridging industrial practices with academic rigour. Dr Almubarak is also well-versed in environmental impact assessment, risk mitigation, and sustainable development. His expanding engagement with renewable energy reflects a forward-thinking approach to integrating cleaner solutions in energy systems.

Dr Nadir M. Hassanien Yousif is a civil engineering consultant and academic with dual Canadian-Sudanese nationality. He holds a PhD in Civil Engineering from Imperial College, London (1996), and has over 35 years of experience in academia and practice. He is the Managing Director of the University of Khartoum Consulting Corporation (UKCC) and co-founded the Khartoum Center for Technical Consultation and Resources Development (KCD). Dr Hassanien specialises in structural engineering, concrete durability, environmental and feasibility studies. He is an Associate Professor at the University of Khartoum, dedicated to fostering local capacity and has contributed to numerous national and international projects.