AFRICA ELECTRICITY SYMPOSIUM 2025

Mapping Renewable Energy Transition and Policies on Uganda's Development: A Structural Vector Auto-Regression Approach

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MINISTRY OF ENERGY AND MINERAL DEVELOPMENT
THE REPUBLIC OF UGANDA

1. Introduction

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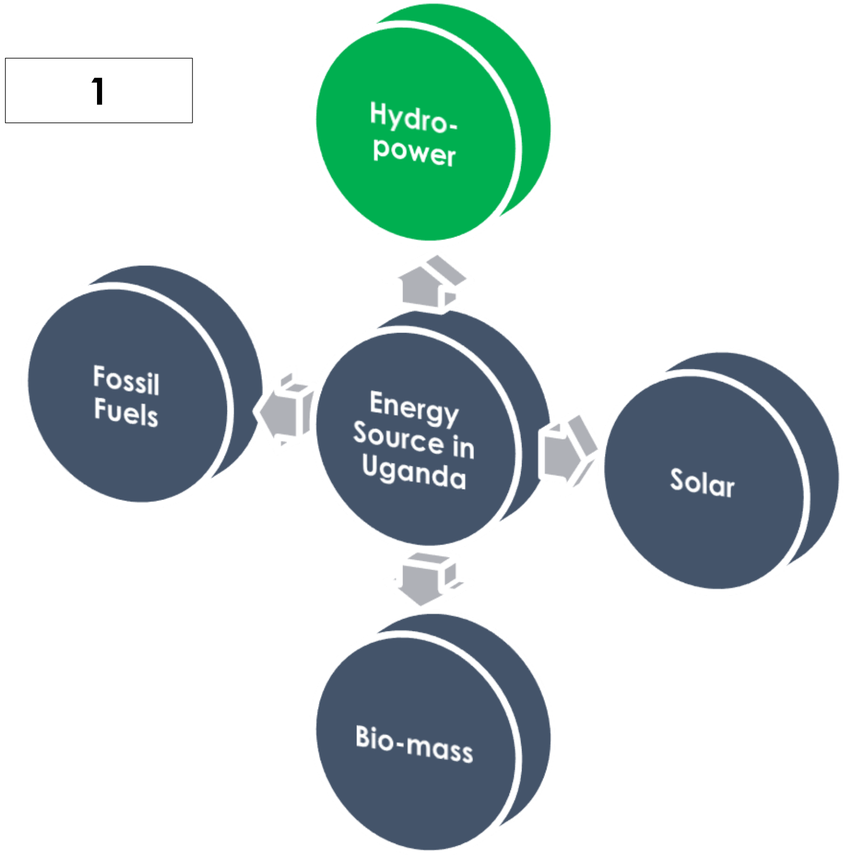

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Uganda faces challenges in sustainable energy

In

Rural electrification

Uganda's energy transition

- Limited investment.
- Inadequate infrastructure.
- Regulatory hurdles that affect the efficient distribution of power.

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3 important axis for this research

1. RE policy

- First introduced in 2007, set ambitious targets to increase the share of RE in the national energy mix and improve access to modern energy services.
- Fostering private sector investment in RE through regulatory frameworks and financial incentives.

2. Energy access and economic development

- Energy utilization and adaptation in Uganda's urban areas, revealing that low-income settlements face significant energy insecurity due to high costs and unreliable supply.
- Relationship between electricity generation and key socioeconomic indicators such as GDP growth, industrial sector performance and employment levels.

3. Significance of SVAR modeling in energy policy analysis

- Foundational SVAR applications in energy economics
- SVAR in RE and policy analysis
- SVAR in energy poverty and electrification
- Country-specific SVAR studies
- Methodological guides for SVAR

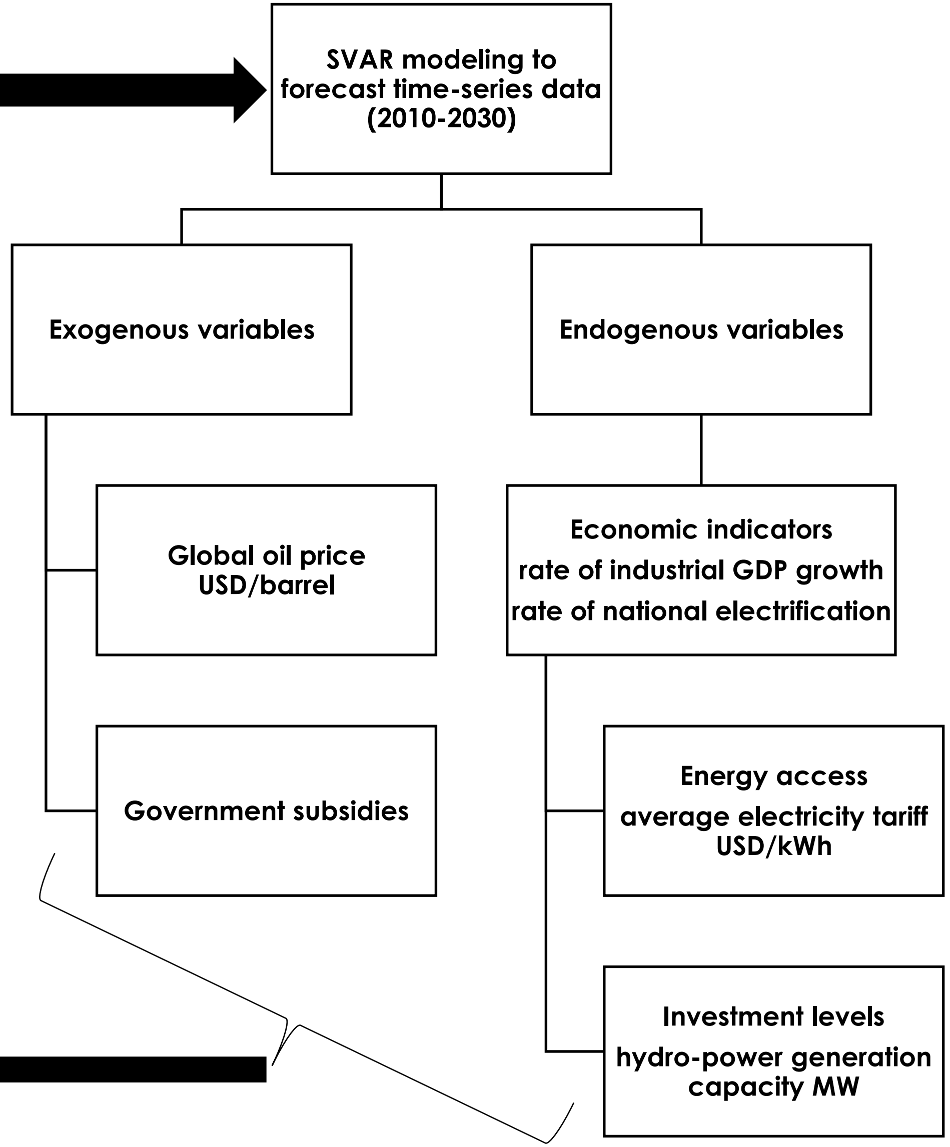
Research Plan

The research seek objectives to:

i. Assess the impact of RE expansion on economic growth in Uganda.

ii. Identify key factors influencing energy policy decisions and investment patterns.

iii. Evaluate the role of government policies and external shocks in shaping the energy transition process.



By structuring equations based on economic theory and policy mechanisms integrating SVAR techniques:

''This research will provide valuable insights into the long-term sustainability of Uganda's energy sector and informs evidence-based policy formulation.''

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Methodology

The general model of SVAR model can be written as:

$$AY_t = BY_{t-1} + CX_t + \epsilon_t \quad (1)$$

Therefore, SVAR model can be rewritten as:

$$HGC_t = f(C, GDP_{t-1}) \quad (2)$$
$$NER_t = f(HGC_t, AET_{t-1}) \quad (3)$$
$$GDP_t = f(NER_t, AET_{t-1}) \quad (4)$$
$$AET_t = f(HGC_t, i_{t-1}) \quad (5)$$

$$\begin{bmatrix} 1 & a_{12} & a_{13} & a_{14} \\ a_{21} & 1 & a_{23} & a_{24} \\ a_{31} & a_{32} & 1 & a_{34} \\ a_{41} & a_{42} & a_{43} & 1 \end{bmatrix} \begin{bmatrix} HGC_t \\ NER_t \\ GDP_t \\ AET_t \end{bmatrix} = \begin{bmatrix} b_{11} & b_{12} & b_{13} & b_{14} \\ b_{21} & b_{22} & b_{23} & b_{24} \\ b_{31} & b_{32} & b_{33} & b_{34} \\ b_{41} & b_{42} & b_{43} & b_{44} \end{bmatrix} \begin{bmatrix} HGC_{t-1} \\ NER_{t-1} \\ GDP_{t-1} \\ AET_{t-1} \end{bmatrix} + \epsilon_t \quad (6)$$

Impulse response function IRF calculation

The IRF traces the effect of a one-time structural shock ϵ_j on y_{t+h} over horizons h = 0,1,2,…

Matrix polynomial representation as:

$$Y_t = \left(I - \sum_{i=1}^{p} \phi_i L^i\right)^{-1} A^{-1} C X_t + \left(I - \sum_{i=1}^{p} \phi_i L^i\right)^{-1} A^{-1} \epsilon_t \quad (8)$$

The moving averages representation is:

$$Y_t = \sum_{h=0}^{\infty} \Psi_h \epsilon_{t-h} + exogenous\ terms \quad (9)$$

Forecast error variance decomposition VD

$$VD_{i,j}(h) = \frac{Isolate\ shock\ j's\ contribution}{Accmulate\ squared\ IRFs\ up\ to\ horizon\ h} = \frac{\sum_{k=0}^{h-1}(e_i' \Theta_k e_j)^2}{\sum_{j=1}^{n}\sum_{k=0}^{h-1}(e_i' \Theta_k e_j)^2} \times 100\% \quad (11)$$

Setting parameters

Open-Source Tool R (vars package)

1. Model assumptions
2. Impulse response function IRF calculation
3. Estimated Matrices for Uganda’s SVAR model
4. Forecast error variance decomposition VD

Results & Discussion

Assumptions of the Model

- Data lags of official reports of (UBOS 2014; ERA 2024) often release data with 1-2 year delay.
- SVAR policy modelling requires time series data and estimates bridge gaps.
- The sources of estimates based on projections of historical trends (electrification growth rates).
- Government targets such as Uganda's energy transition plan stated by International Energy Agency (IEA 2023).
- Expert interpolations for missing years such as 2023 data not yet published.
- Setting shocks as 1-SD increase in hydro-power investment (USD 50 M/year).
- The drivers of new projections such as Achwa II 2026 and Nyagak 2027 and averagely a conservative estimate of +150 MW/year for hydro-power capacities.
- The electrification rate is supposed to be +3.5%/year for grid expansion and off-grid solar programs.
- The industrial GDP is assumed elasticity 0.4 to electrification that aligned with African SVAR studies.
- Tariffs declined by 5%/year due to economies of scale in hydro-power.
- The policy constrains that represent in delays in project execution (land acquisition) could reduce capacity by ~10%.
- Climate finance shortfalls may slow electrification by +2.5%/year versus +3.5%.

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Results & Discussion

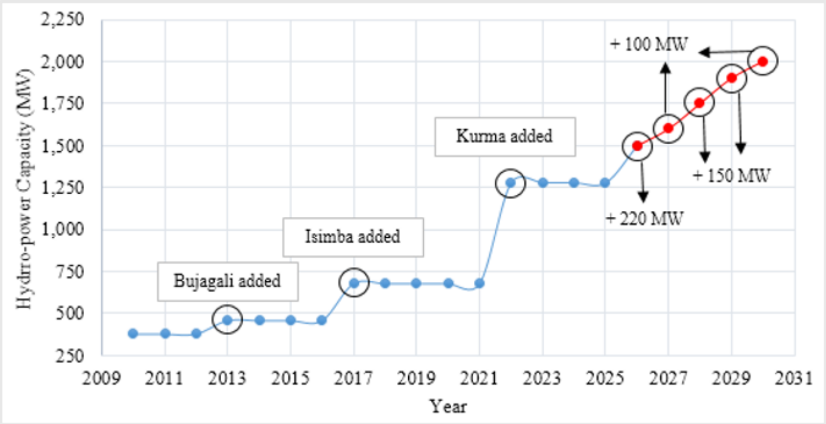

Figure.3: Cumulative hydro-power capacity growth in Uganda.

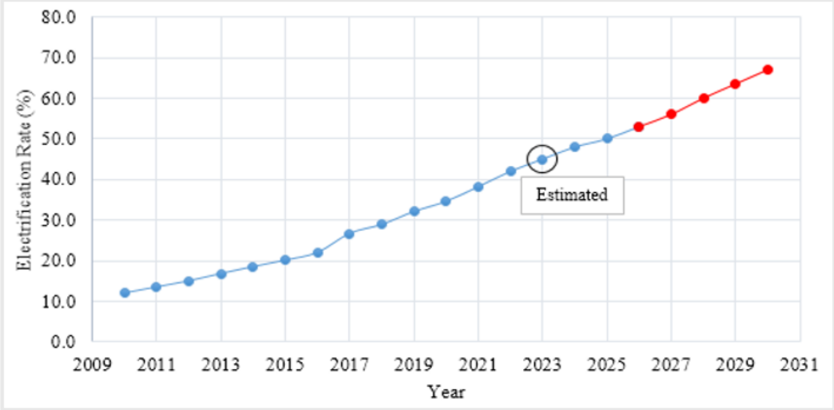

Figure.4: Trends in Uganda's rural electrification rate.

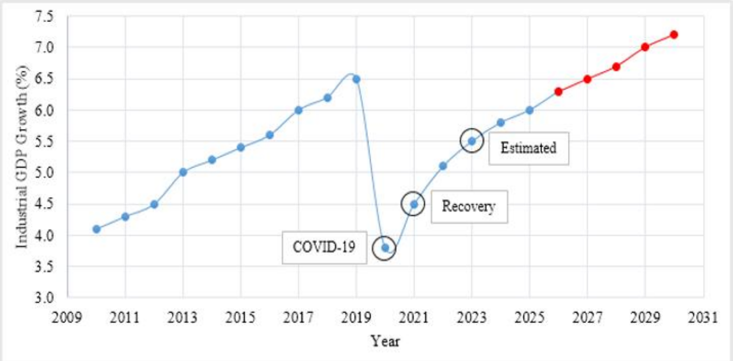

Figure.5: Industrial GDP growth trends in Uganda during pandemic shock and energy-dependent recovery.

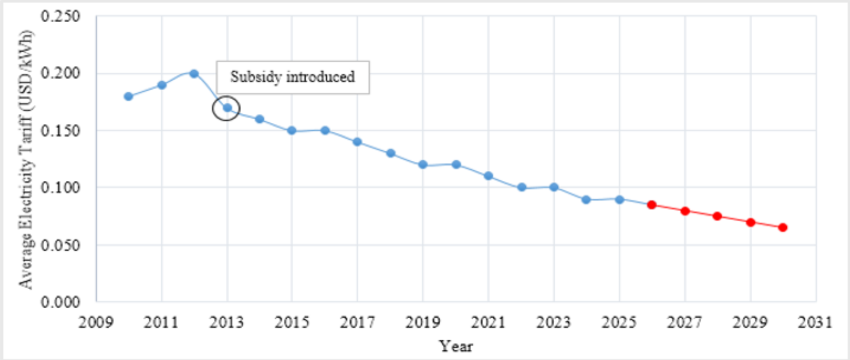

Figure.6: Uganda's electricity tariff reduction

Results & Discussion

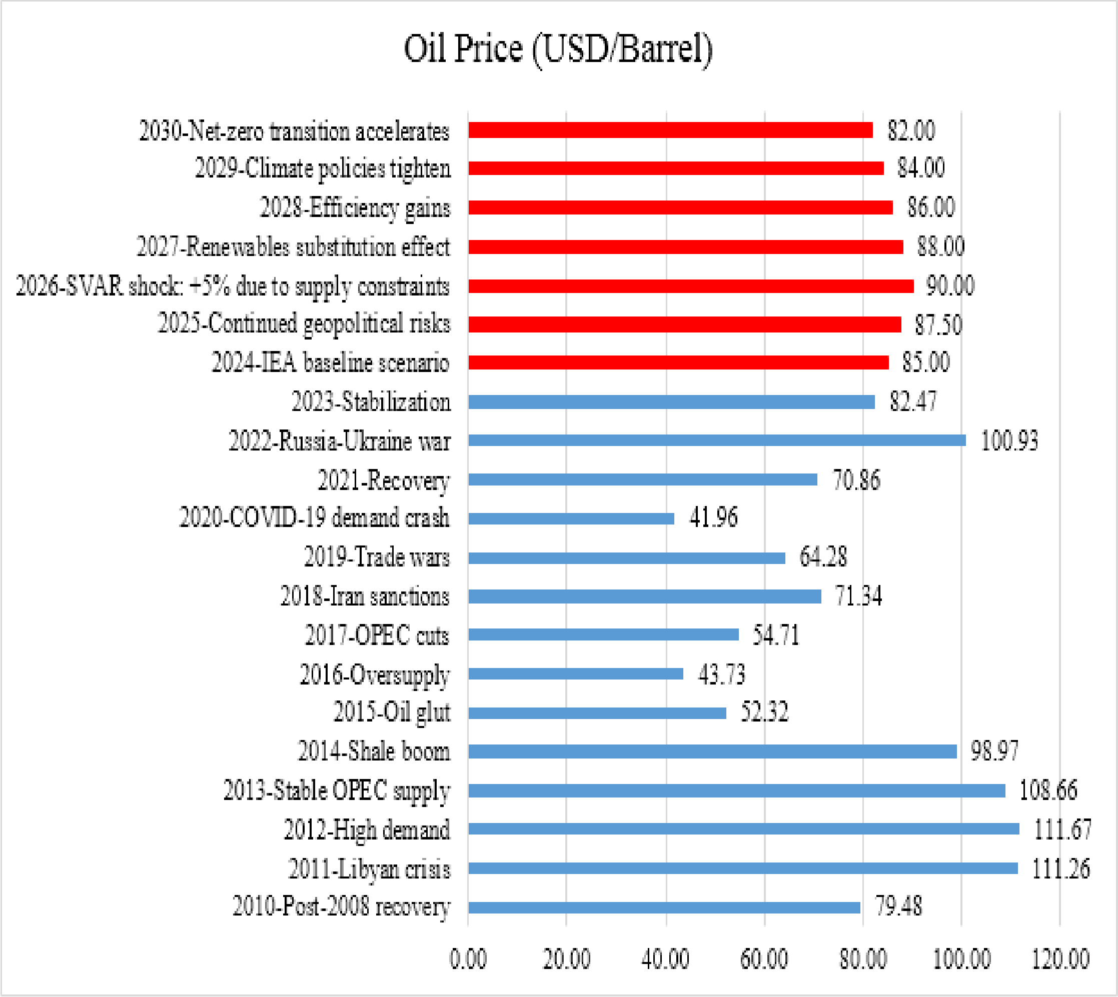

Figure.7: Transmission of oil price shocks to Uganda's economy.

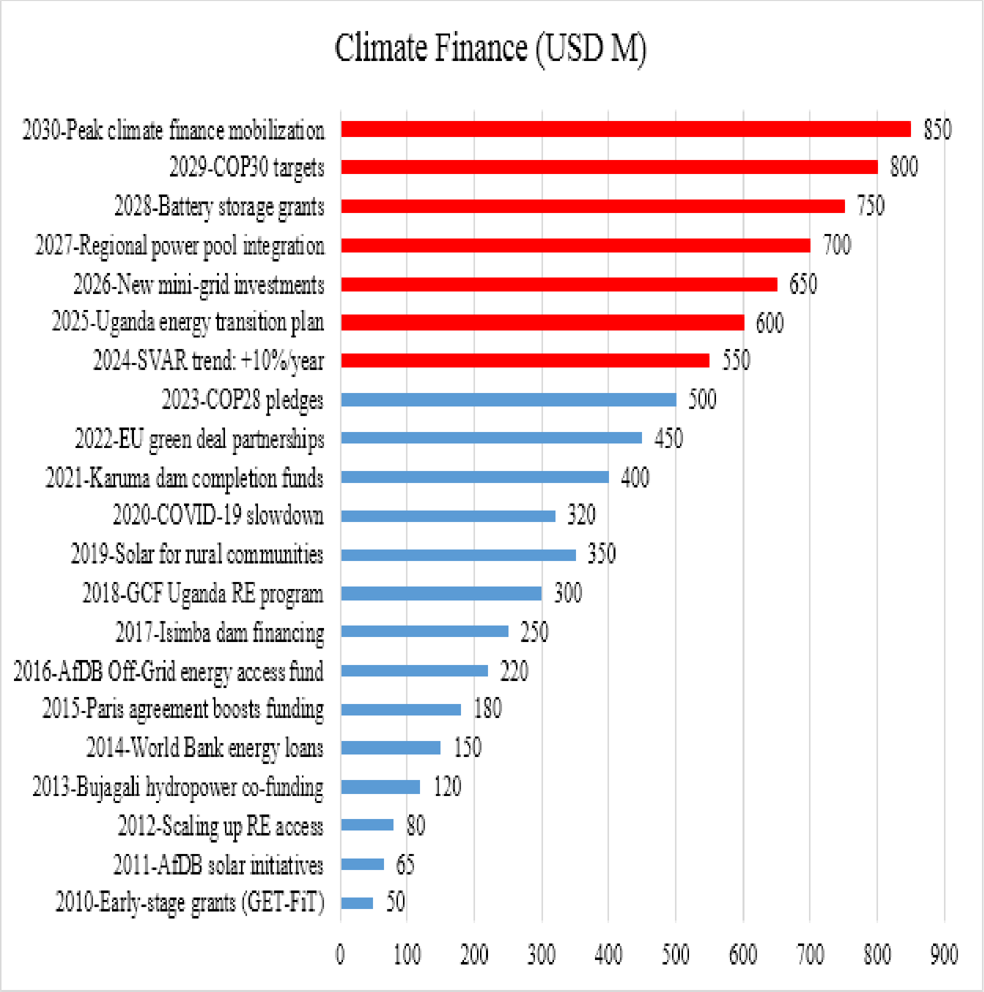

Figure.8: Sensitivity of Uganda's energy targets to climate finance cuts.

Results & Discussion

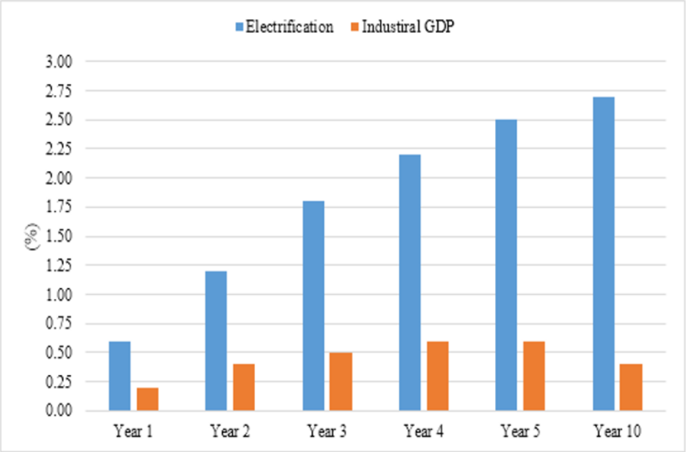

Figure.9: Uganda's energy system response to a 1-SD hydro-power capacity shock.

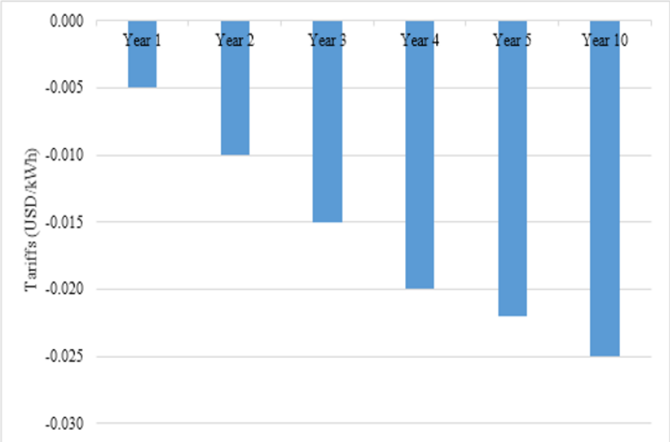

Figure.10: Delayed electrification gains and persistent tariff reduction.

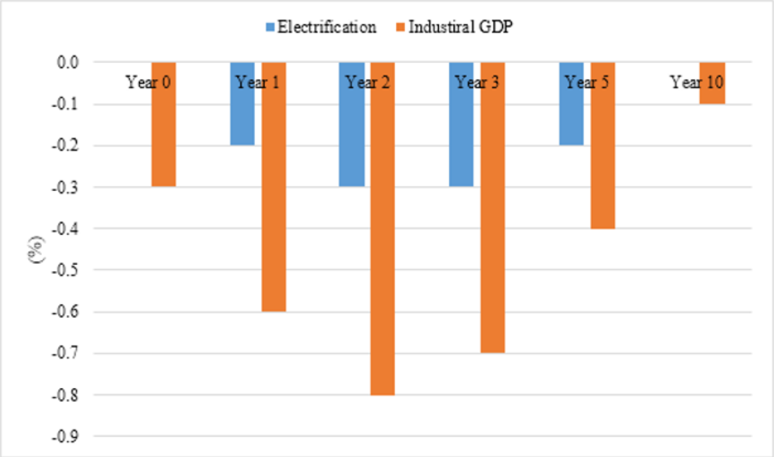

Figure.11: Peak GDP impact of diesel cost shock.

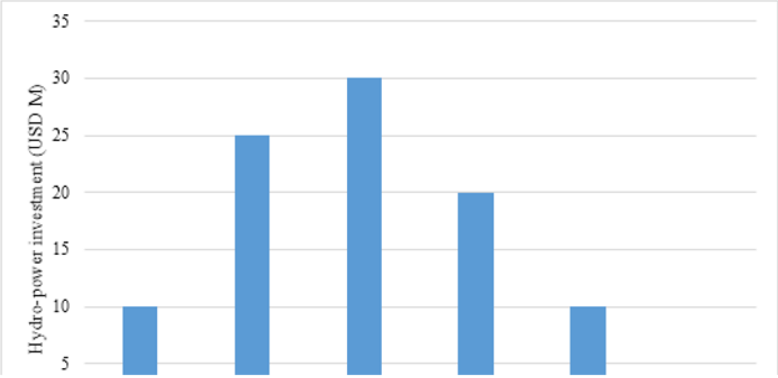

Figure.12: Investment response to energy shocks.

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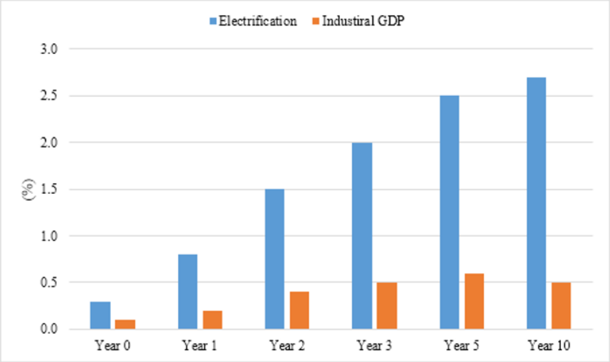

Figure.13: Simulated effects of a +100 USD M climate finance injection.

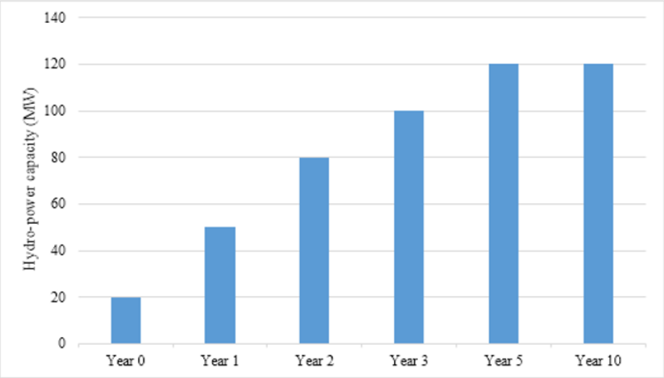

Figure.14: Diminishing returns in hydro-power investments.

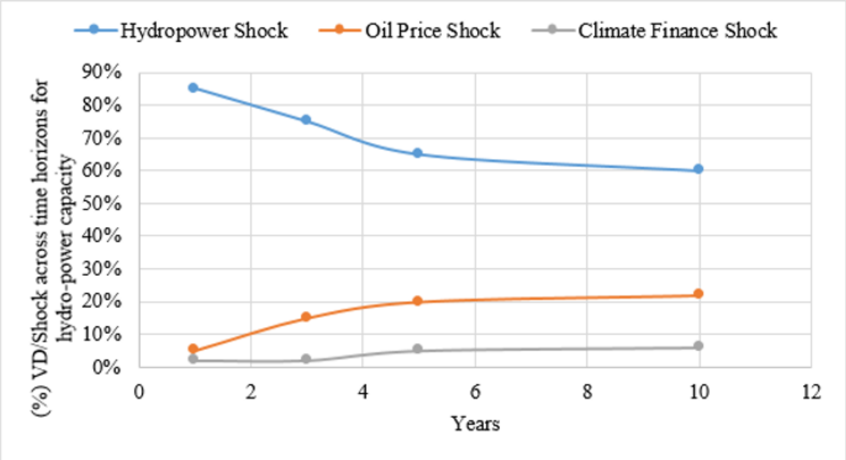

Figure.15: VD of Uganda's energy system.

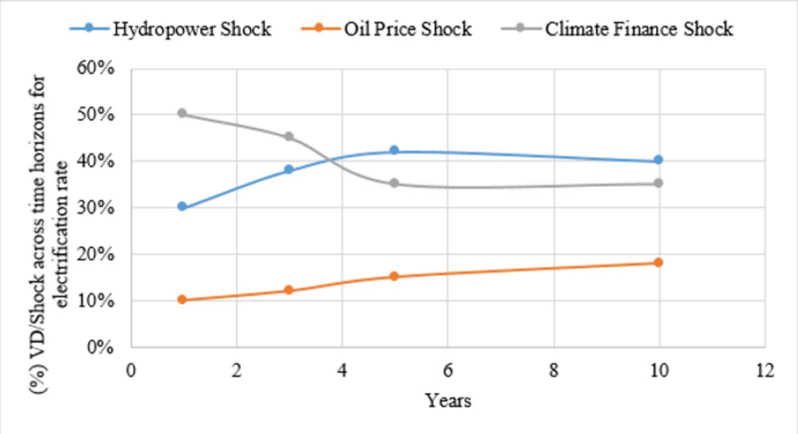

Figure.16: Temporal dynamics in electrification determinants.

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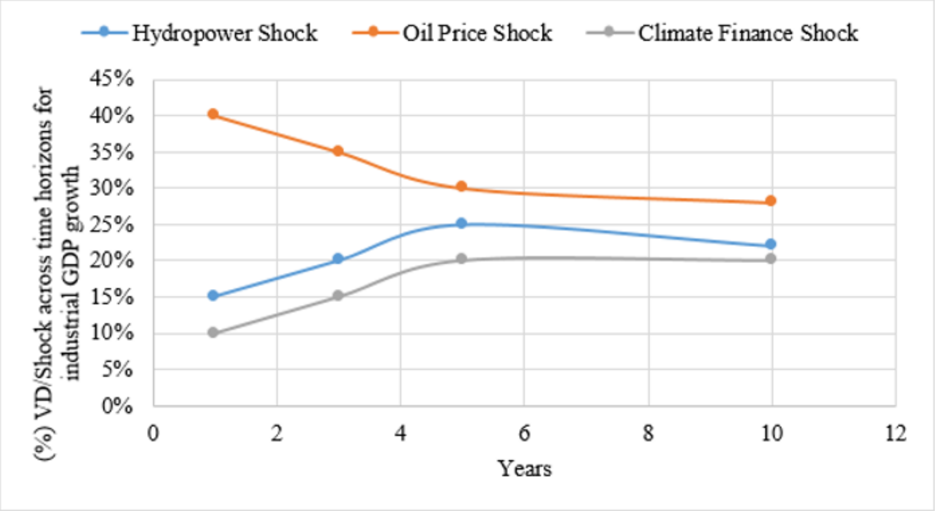

Figure.17: Contrasting drivers of GDP volatility.

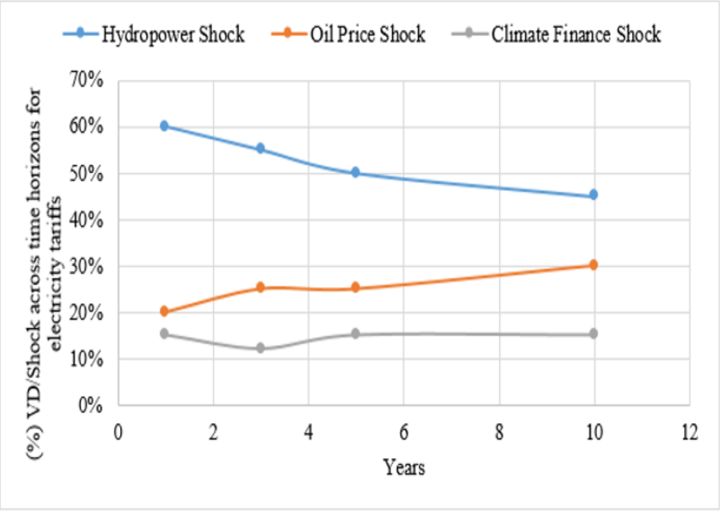

Figure.18: The dual forces shaping Uganda's electricity tariffs.

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Conclusion

Research Conclusion

1. Hydro-power drives growth but has lags
2. Oil price volatility hurts GDP
3. Climate finance is critical for electrification
4. Tariffs decline with hydro-power expansion

Conclusion

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Policy Recommendations

1. Accelerate hydro-power investments with long-term planning
2. Mitigate oil price risks through energy diversification
3. Optimize climate finance for rural electrification
4. Stabilize tariffs via hydro-power cost-sharing
5. Strengthen data systems for real-time policy adjustments

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Thank You!