Expansion of electricity access in Kenya thanks to renewable energy sources

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Motivation

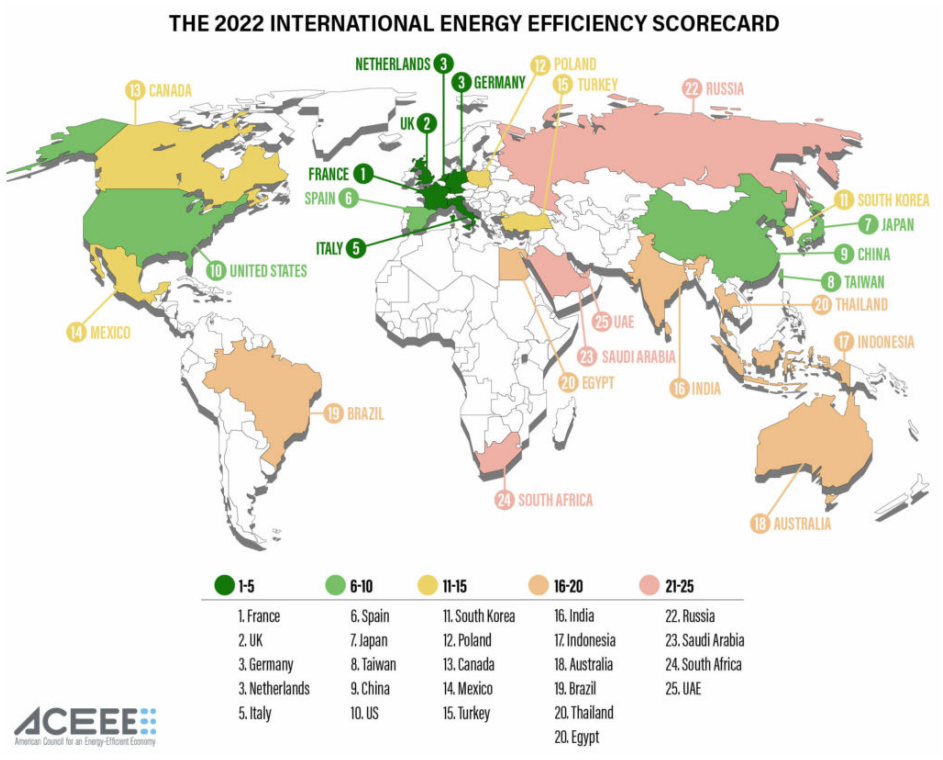
Electricity consumption nearly perfectly correlates with GDP. Emerging economies often rely on fossil fuels as their main energy source which brings known risks and problems:

- reliance on imports from authoritarian regimes [1]
- exacerbation of extreme weather events caused by climate change

[1] see history of oil cartels or Russian invasion of Ukraine

Motivation

- Oil crisis' of 1970s-80s had devastating consequences.
- The US "shale revolution" helped satisfy fossil fuel dependent economies and keep oil cheap.
- Low incentive to shift => energy inefficient compared to western Europe.



Motivation

Princeton's Geophysical Fluid Dynamics Laboratory[2] explains that by the late 21st century, assuming anthropogenic global warming of approx. 2°C:

- **Very Intense Hurricanes** The global proportion of tropical cyclones/hurricanes that reach very intense (Category 4 and 5) levels is projected to increase (medium to high confidence)
- **Overall Hurricane Intensity** Tropical cyclone intensities globally are projected to increase (medium to high confidence) on average.
- **Sea Level Rise** Human activities have very likely been the dominant cause of sea level rise since at least 1971 which in turn exacerbates coastal inundation risks associated with tropical cyclones.

[2] `https://www.gfdl.noaa.gov/global-warming-and-hurricanes/`

Motivation

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[3] All economies, which have already surpassed their fossil peak.

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- Of course they can! Kenya
- But also Austria, Bulgaria, Czechia, Denmark, Finland, France, Germany, Greece, Italy, Kenya, the Netherlands, Norway, Poland, Portugal, Romania, Spain and the United Kingdom [3]

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Motivation

Can economies grow without expansion of their reliance?

- Of course they can! Kenya
- But also Austria, Bulgaria, Czechia, Denmark, Finland, France, Germany, Greece, Italy, Kenya, the Netherlands, Norway, Poland, Portugal, Romania, Spain and the United Kingdom [3]
- Some can not - Canada, China, Chile, India, Israel, Ukraine, the United States and Peru

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Hypothesis

Hypothesis:

- H_0 - There is no positive correlation between share of renewable electricity and access to electricity in Kenya.
- H_1 - There is correlation between share of renewable electricity and access to electricity in Kenya.

Verification criteria:

- **R-squared** R^2 - $R^2 \geq 0.7$
- **Correlation coefficient** r - $r \geq 0.7$
- **p-value** - $\text{p-value} \leq 0.05$

History of investments in electrification

Major time periods in investments into electrification in Sub-Saharan Africa

- **1980s** - Stop migration from rural to urban areas
- **late 1980s - 90s** - High costs and low impact
- **90s - now** - Necessary condition to fight poverty

Problems with electrification

Electrification of rural areas doesn't come without it's own set of problems such as:

- **High upfront cost** - Connecting to grid as well as off-grid[4]
- **Lack of productive use** - Mainly used for home lighting, TVs, etc. Not used enough in agriculture, crafts and services.
- **Lack of known impacts** - Funding is based on supposed impacts with very little empirical evidence.

[4] Can be chaper than connecting to the grid. Discussed in the paper.

Findings from electrification in India

- Increased time spent studying
- Increased school enrollment
- Increased labor supply of both men and women
- Increased per capita household income and expenditure

However most of those benefits accure to wealthier households, while poorer households use electricity to a limited extent.

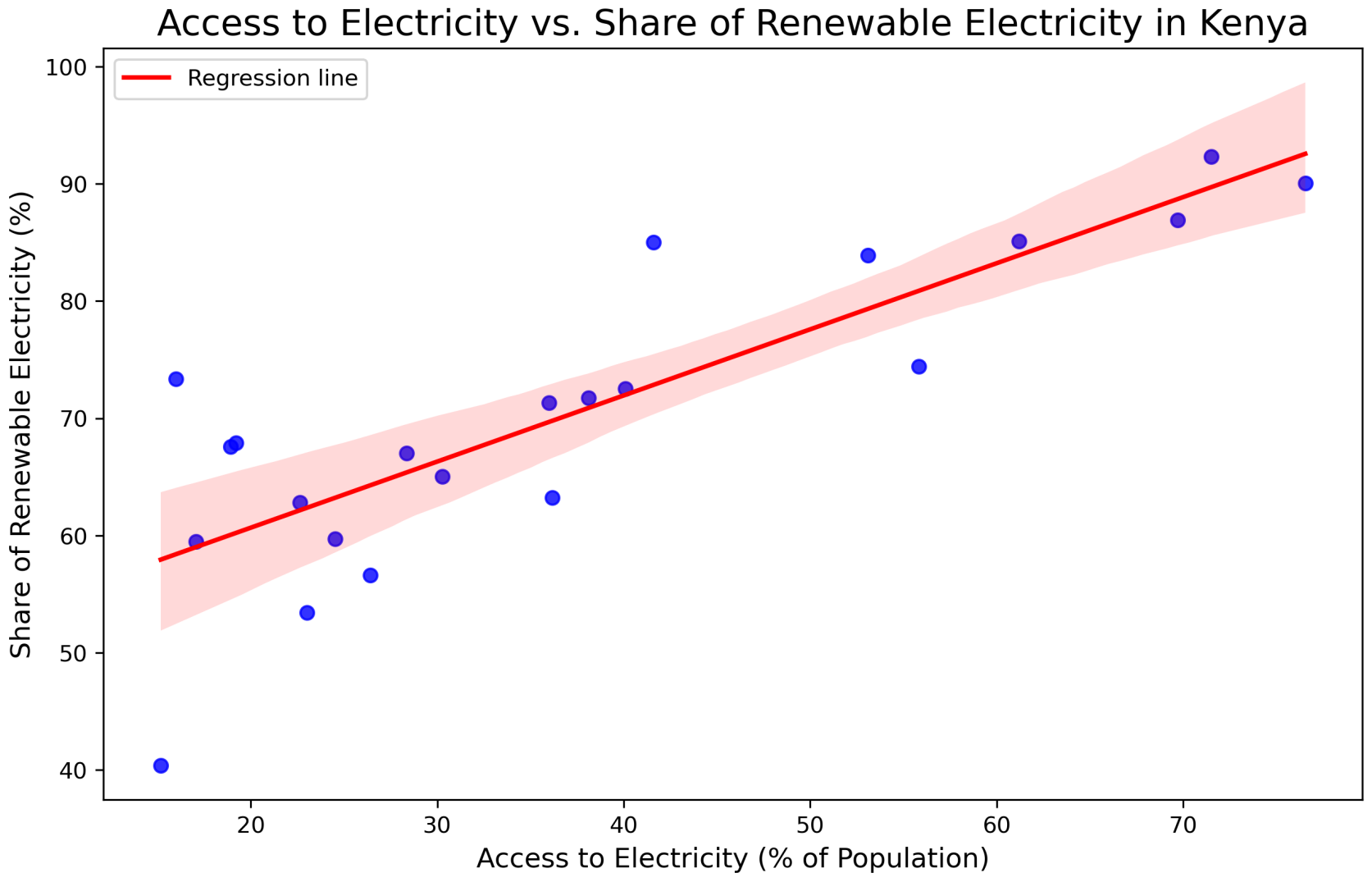
Optimal strategy for electrification in Kenya

Extensive spatial mapping of existing energy infrastructure in Kenya found that:

- Renewable energy plays a pivotal role in decentralized energy systems allowing energy access in rural areas.
- Solar power should dominate remote areas separated more than 10km form the grid.
- Solar generation could make electricity available to 5.98 million people.
- Hybrid mini-grids could electrify additional 390 thousand people.
- Diesel generators could cover 390 thousand people.[5]
- It is cheaper to invest in standalone solar solution for "under-grid" population.

[5] Maintenance & operational costs are significant for a long term solution.

Findings


Access to Electricity vs. Share of Renewable Electricity in Kenya
Regression line
Share of Renewable Electricity (%)
Access to Electricity (% of Population)
100
90
80
70
60
50
40
20
30
40
50
60
70

Findings

- **R-squared:** The coefficient of determination for the regression model is $R^2 = 0.704$, indicating a strong relationship between the variables.
- **Correlation Coefficients:**
  - **Electricity access and share of renewables:** $r = 0.834$, showing a strong positive correlation.
  - **Electricity access and GDP growth:** $r = 0.048$, indicating a weak correlation.
  - **GDP growth and share of renewables:** $r = 0.125$, also a weak correlation.
- **Electricity Access Coefficient:** The regression coefficient is 0.561, statistically significant with $\text{p-value} < 0.0001$.
- **GDP Growth Coefficient:** The regression coefficient is 0.177, not statistically significant with $\text{p-value} = 0.505$.

Conclusions

While the expansion of renewables correlated with electricity acces in Kenya, there still are problems with expansion of electricity access in Kenya, however

- the absence of fossil fuels is not one of them,
- they relate to economically inefficient use and
- further research and revision of government plans is needed.