Renewable Electricity Generation: Implications of Cost, Returns and Investments to African Economies

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Introduction

- The opportunities that manifests from investing in Renewable Energy (RE), have recently come to be considered critical and substantive worldwide.
- From public sector; renewable energy are anticipated to have: positive effects on economic growth, public health, reduction of carbon dioxide emissions, enhances energy diversity and security, transmits to lower electricity prices, and creates jobs, e.t.c.
- While financiers put focus on investment opportunities that can repay their debt/cost and offer a return on equity that commensurate with the risk.
- Studies on cost and returns of electricity renewable generation within African countries are few except for South Africa
- SA has Low costs renewable project which when adopted by other African countries may be misleading: 5.1 USDc/kWh for wind and 6.5 USDc/kWh for solar PV

Introduction

- RE resources in Africa are abundant; from solar, wind, biomass, and hydro to geothermal among other forms of power. However, the renewable energy resources availability is largely location or geographical based.
- Therefore the cost of capital may vary by; not only geographical/location based, but also by type of technology, and the discount rates used.
- Though cost of capital is important to investment decisions taken by firms; It is impossible to know a priori, the cost of capital ascribed to a specific investment.
- Estimating cost of capital is inherently difficult due to information asymmetries and the heterogeneity of investment methodologies used by firms/businesses.
- From the public perspective, understanding that investments in renewable energy will have different impacts on different african economies is critical

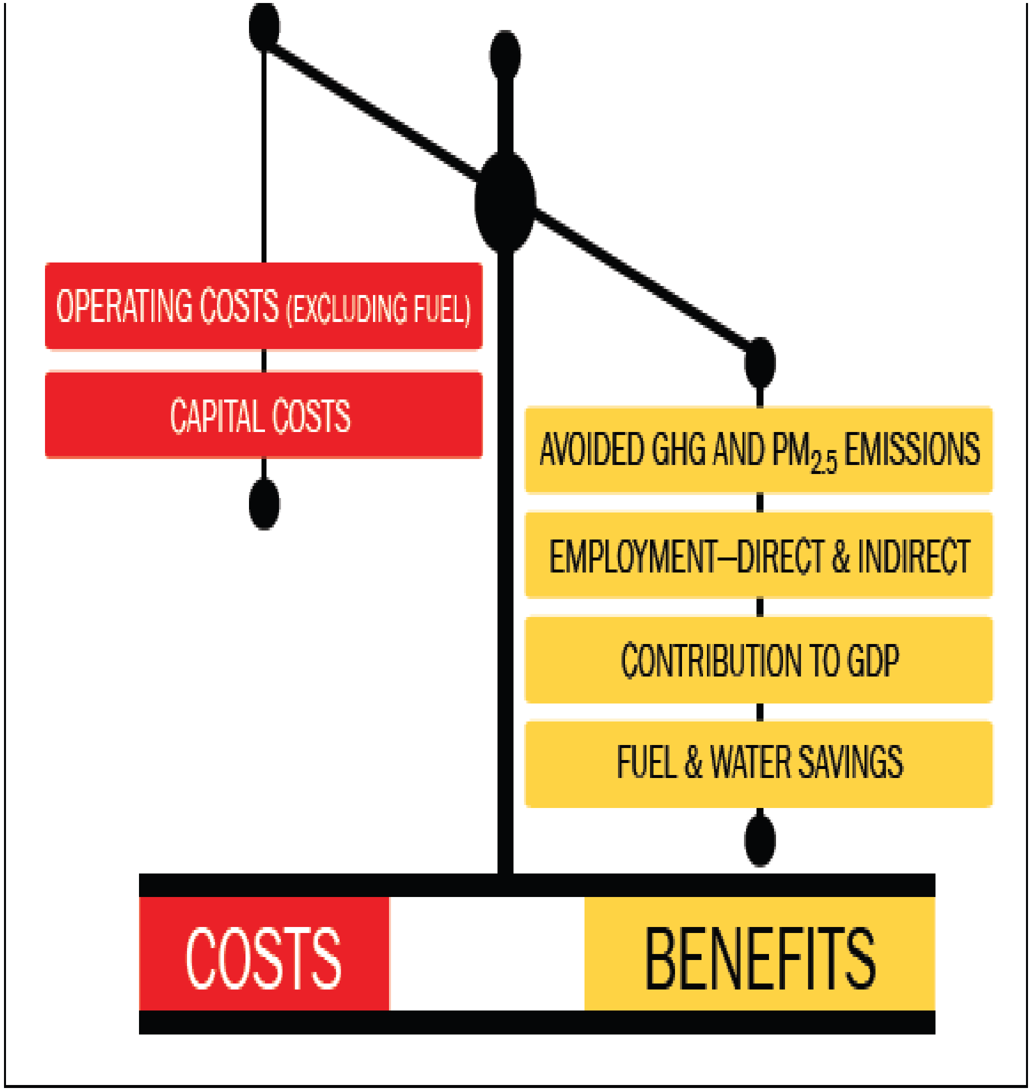
Research Questions

The paper addresses two research questions:

1. What is the cost of RE generation in African countries

2. How does the share of renewable electricity generated impact on economic growth (reduction of carbon dioxide, employment generation)

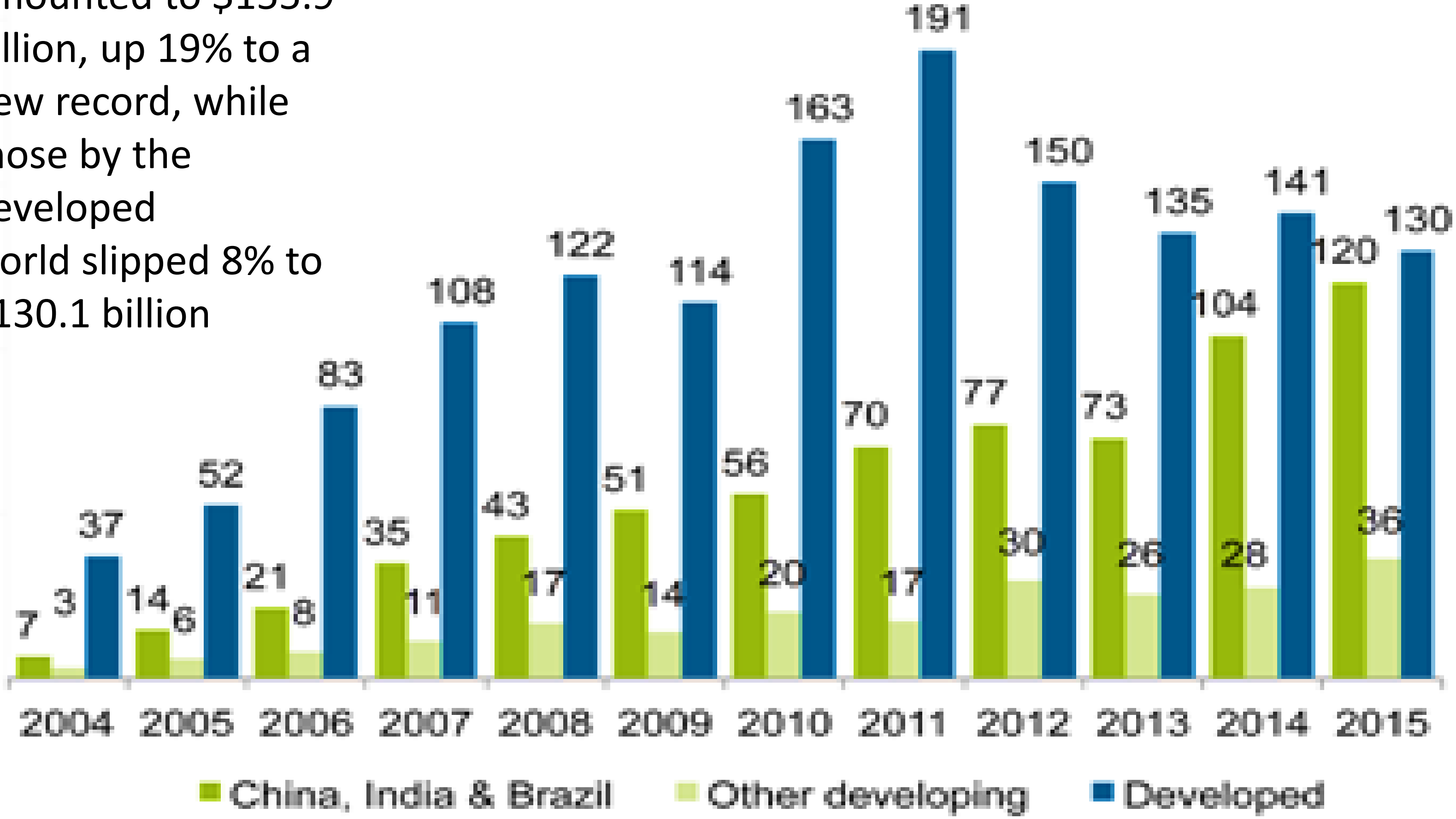
- The figure shows the importance of costs when making RE investments by firms and anticipated public benefits from RE investments



Landscape of Renewable Energy (RE)

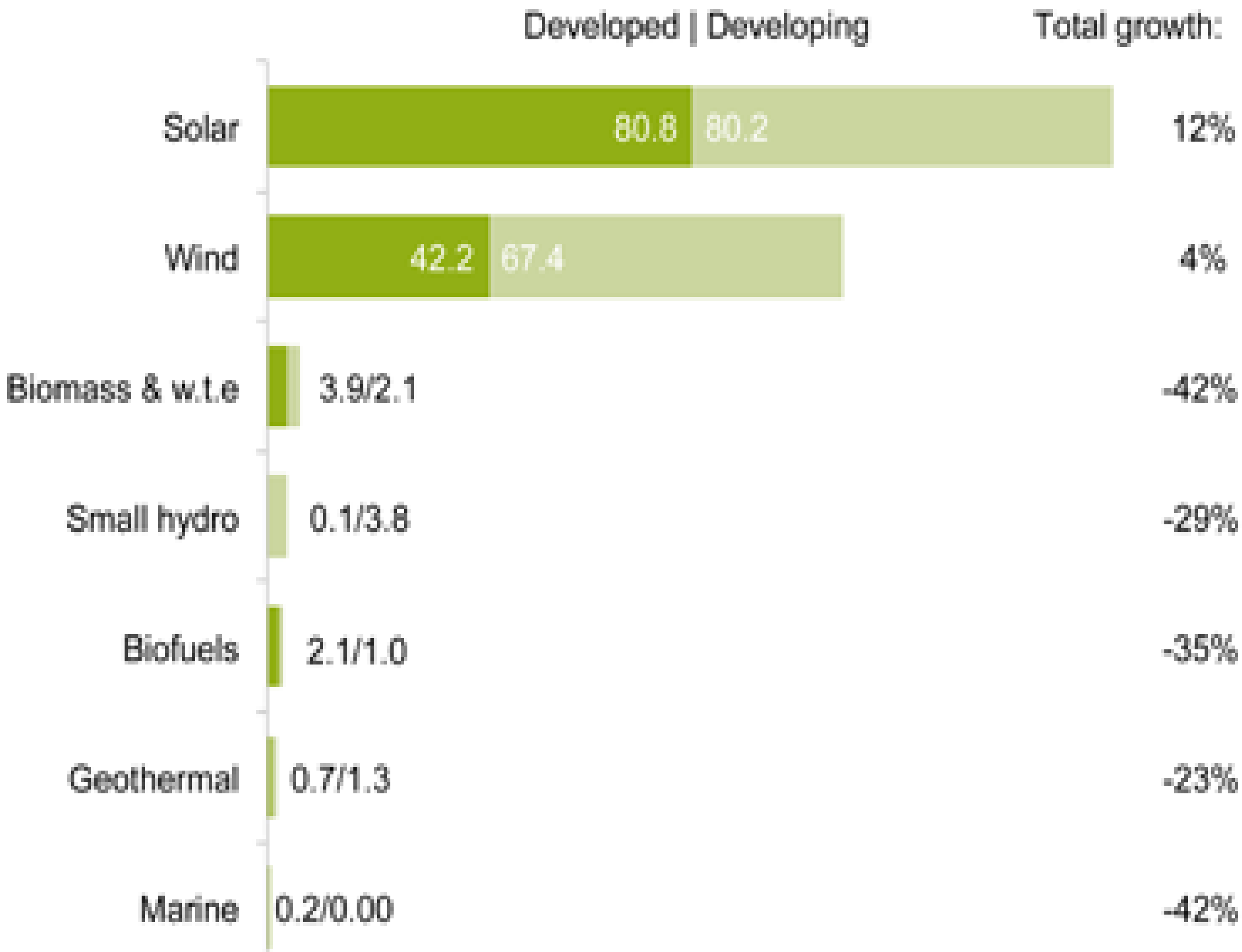
Figure 1: Global New Investment in Renewable Energy: Split by Type of Economy, 2014 – 2015, $BN

Commitments by the developing world amounted to $155.9 billion, up 19% to a new record, while those by the developed world slipped 8% to $130.1 billion



Source: UNEP, Bloomberg New Energy Finance (2016)

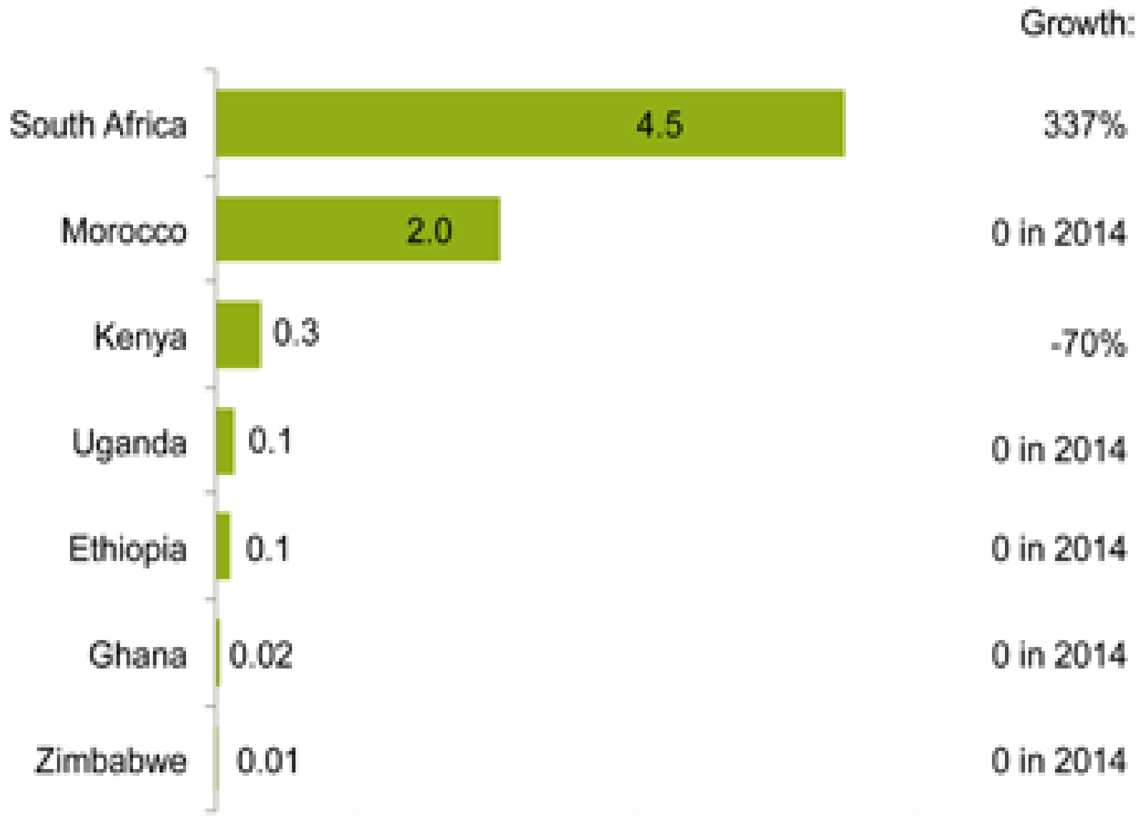
Figure 2: Global New Investment in Renewable Energy: Developed V Developing Countries, 2015 and Total Growth on 2014, $BN



Investment comparison by technology show gap between developed countries and developing countries reached $25.2 billion in 2015

Source: UNEP, Bloomberg New Energy Finance (2016)

Figure 3: Asset Finance in Renewable Energy in Africa by Country, 2015 and Total Growth on 2014, $BN



The biggest centres for asset financings in 2015 was South Africa, which saw investment rebound back up to $4.5 billion from $1 billion in 2014.

Source: UNEP, Bloomberg New Energy Finance (2016)

Landscape of RE

- Growing demand for electricity (around 9% for Kenya)
- Insufficient capacity (2831 MW Ghana, 2177 MW Kenya for populations of 27 and 45 million)
- Large share of hydropower (65% in Ghana, 45% in Kenya)
- Desire to diversify
- Ambitious expansion plans (+5GW by 2017 in Kenya, +1 GW by 2015 Ghana)

Landscape of RE

- Both Kenya and Ghana have:
  - Low implementation rates
  - Long lead times to financial closure and construction
  - Social discontent due to unreliable power and lack of access
  - Urgency: expensive short-term solutions
  - Some disposition to support renewables- FiT and RE targets, plus Gov. investment in solar PV in Ghana and geothermal and wind in Kenya.

Methodology

3 Approaches used to analyze cost and returns of RE:

1. Levelized Cost of Electricity (LCOE): The LCOE measures the total cost of producing a kilowatt-hour (kWh) of electricity over the lifetime of a project.
   - LCOE depends on discount rate. A higher discount rate not only inflate cost of loans but also drive up expected return on equity.

2. IRR and NPV are used to assess the financial performance and profitability of particular projects. While NPV is the sum of the present values of incoming and outgoing cash flows over a period of time.

Methodology

3 Approaches used to analyze cost and returns of RE. ..Cont.:

3. Payback period which is rarely used.

- Data used- is mainly collected from project and country specific data in Kenya and Ghana on: unit investment costs (which costs that mainly capture capital cost), operational and maintenance, capacity factors (measures the percentage of total hours in year when a plant is operational), financing costs and renewable energy resource potential.

- Data for other African countries were provided only where available using Meta Analysis Approach.

- The LCOE approach is adopted in the paper

Methodology

5 Approaches used to analyze the impacts of renewable energy investments to the economy:

1. Econometric models
2. Input-output approach
3. Macro-economic models
4. Life Cycle Assessment (LCA)
5. A Meta-Analysis approach

- Data - data period is from 1992 – 2014 and targets Sub-Saharan, Data on GDP, Electricity consumption (GWh), electricity generated from renewable energy from electricity generation (%), electricity generated from fossil fuels, employment from electricity sector and carbon dioxide emission are captured from the world data bank

Methodology

- An econometric model is used in the paper to analyze the impacts of renewable energy investments to the economy:

- A translog production function is estimated where:
  - GDP is a function of Electricity consumption (GWh), electricity generated from renewable energy from electricity generation (%), electricity generated from fossil fuels, employment from electricity sector and carbon dioxide emission.

- Diagnostics tests including unit root tests that tests for stationarity, cointegration test that establishes whether there is a long run relationship among variables and the test for distribution of error terms were performed.

RESULTS for

cost of RE generation in African countries

Potential of Renewable Energy Resources

Country	Wind onshore	Solar PV	Hydro (large)	Hydro (small)	Geothermal (convectional)
Kenya	3,000 MW, Installed (100MW)	Average 4.5 kWh/ m2/day	4700MW, 561 MW installed.	3,000MW	10,000 MW
Ethiopia	10,000 MW	Solar irradiation of 5.2 kWh/m2/day and PV off-grid of 52 MW	45,000MW		700- 3,000 MW
Uganda	Some potential	Solar irradiation of 5 - 6kWh/m2/day and PV off-grid of 70 MW			450 MW
Tanzania	Short-term, 300 – 500 MW	Solar radiation of 5.0 kWh/m2/day and PV off-grid of 35 MW			600 MW
Ghana		4.5-6.0 kWh/m2/day and 1,800-3,000 hours annually	2480 MW	1.2 – 14 MW	
Nigeria		Average 4.0 kWh/ m2/day			
Africa		1 750 and 2 500 kWh/m^2/year			

Source: Pueyo et al. (2015) and IRENA (various issues)

Kenya has large potential for geothermal, Ethiopia for wind and hydro while Uganda and Ghana have potential for solar

Unit Investment Costs

	Wind onshore	**Solar PV**	**Hydro (large)**	**Hydro (small)**	**Geothermal (convectional)**
Kenya	2538.8	2150	3829	2589	3901 (4045.5 binary)
Tanzania		3000			
Ghana	1860	2014.52	2362.1	3199	-
Nigeria	1760	1500	3100	-	
Africa	2368.4	3472	2,538	2,645	-
World	1,316.1 (China) 1,787.3 (USA)	1,306 (lower) 5,425 (upper) 3,000 (LDC)	1,004.7 (lower) 3,516.4 (upper)		2,419 (conventional) 3,290 (binary)

Source: Pueyo et al. (2015), Mc-Kinsey (2015) and IRENA (various issues)

- The unit cost of solar PV in both Kenya and Ghana are lower than the African average
- Most of African renewable energy technologies have high cost overruns especially wind than world average.

Operation and Maintenance

	Wind onshore	Solar PV	Hydro (large)	Hydro (small)	Geothermal (convectional)
Kenya	3.25%	1%	-	2.8%	65 US$/kW (fixed) 0.0116 US$/kWh (var)
Ghana	2.40%	1%	1%	2.7%	-
World	0.80%	1.05%	1.40%	1.5%-2.5 %	3%-6%

Source: Pueyo et al. (2015)

- The operations and maintenance costs for solar and hydro are almost similar to those of the world average.
- Operation and maintenance costs are lower when capacity factors for the same technologies are higher

Capacity Factors

	Wind onshore	**Solar PV**	**Hydro (large)**	**Hydro (small)**	**Geothermal (convectional)**
Kenya	45%	20%	55%	50%	92%
Ghana	25%	17%	50%	34%	-
Africa	32%	22%	49% -		-
World	39%	20%	50%	-	90%

Source: Pueyo et al. (2015)

- The unit cost of solar PV in both Kenya and Ghana are lower than the African average
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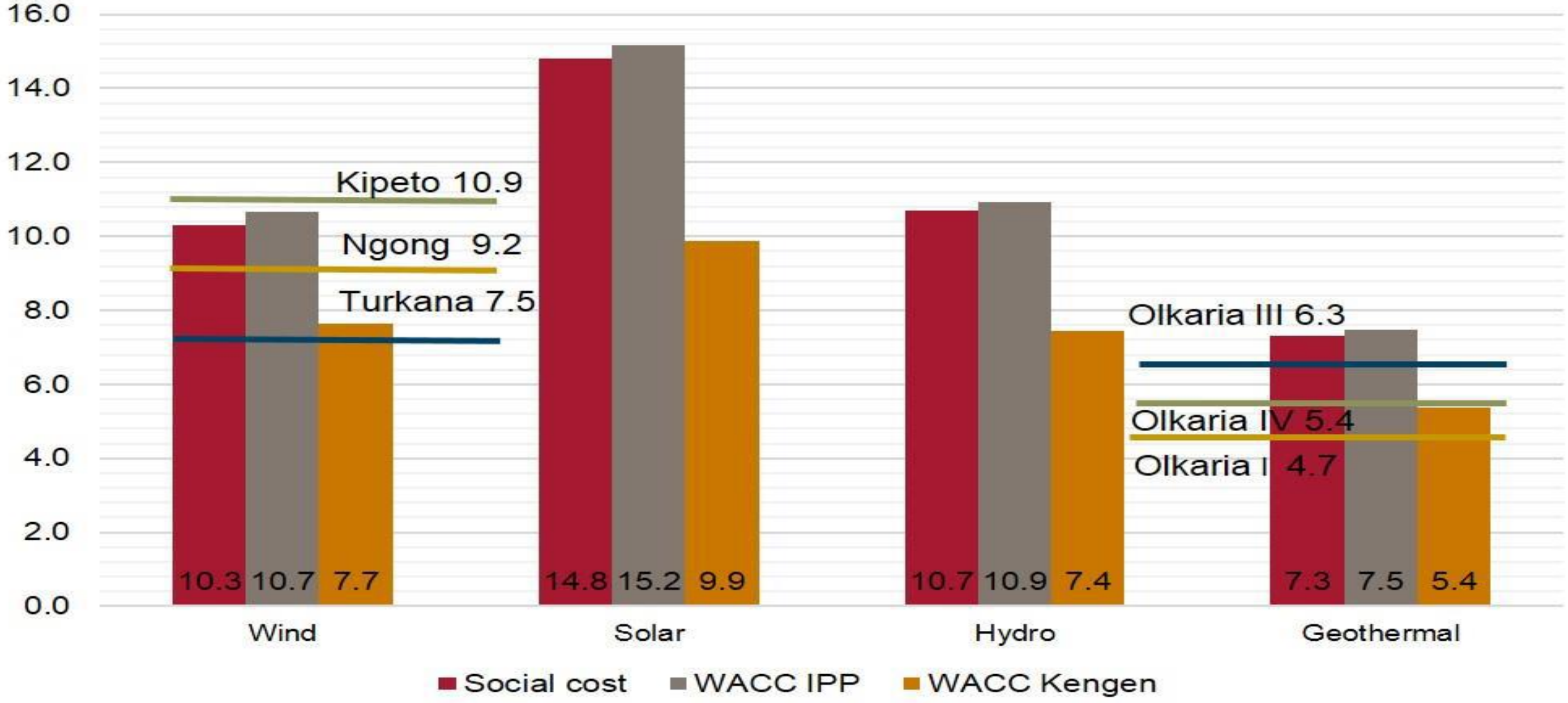
Financing Costs

	Social Discount rates	**Cost of Equity**	**Cost of Debt**	**Debt of Maturity**	**Grace Period**	**Debt-Equity Ratio**	**WACC**
Kenya	10%	10% KenGen (assumed18% IPP)	2.7% KenGen projects 8% IPPs	16.5 years	4.5 years (only public geothermal)	70-30	5% (KenGen) 11% (IPP)
Ghana	12%	27% IPP	7.5% (concessional-international) 15% (commercial-assumed)	12 years	-	70-30	10% (concessional) 18.6% (commercial)

Source: Pueyo et al. (2015)

- Cost of equity and cost of debt are higher in Kenya than for both Ghana
- Equity investors usually require rates of return of at least twice the cost of debt, as they assume a higher risk.
- Therefore, projects with high equity shares therefore bear higher financing costs.

Levelized Cost of Energy for Kenya using 3 different financing costs



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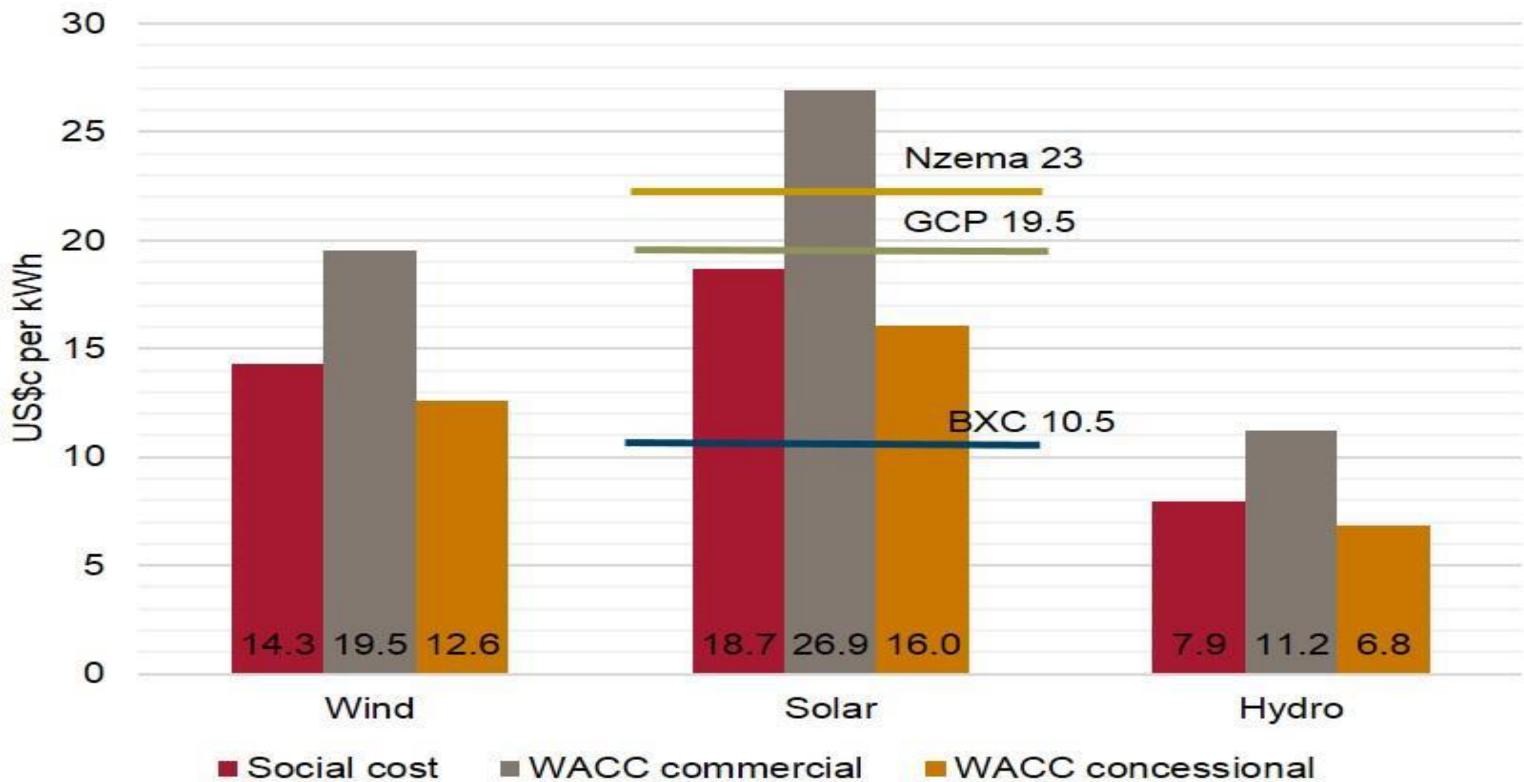
Levelized Cost of Energy for Ghana using 3 different financing costs



Source: Pueyo et al. (2015)

- Solar is found to be competitive because of low financing costs and low factor costs

Comparison of Indicators from Ghana and Kenya

LCOE (IRR %)		
Technology	Ghana	Kenya
Wind	14.3 (6.9 %)	10.3(14.3%)
Solar	18.7 (close to 0%)	14.8 (5.3 %)
Hydro	7.9 (33.5 %)	10.7(5,3 %)
Geothermal	-	7.3(16.8 %)

Source: Pueyo et al. (2015)

- Geothermal presents the lowest LCOE in all technologies between Kenya and Ghana. However hydro is the cheaper technology in Ghana followed by wind while in Kenya Wind and Geothermal are very competitive after geothermal.
- Kenya renewable energy technology offers attractive returns especially from Geothermal and Wind when compared to Ghana while Ghana has higher returns for hydro

RESULTS for
share of renewable electricity generated impact on economic growth

Descriptive for Sub-Saharan Africa

	Mean	Median	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis
Renewable electricity output	20.91423	20.75131	24.39726	17.8185	1.96592	0.16179	2.040755
Oil, gases and coal electricity output	68.69975	68.91872	70.8574	65.99061	1.409987	-0.246688	2.215033
Renewable electricity excluding power from hydro	17.47692	17.23335	20.20047	14.88386	1.604824	0.189704	2.054881
Unemployment, total (% of total labor force)	7.987667	7.942674	8.648306	7.493323	0303984	0.431500	2.34583
Renewable electric from hydro sources	3.437311	3.515248	4.196785	2.887826	0.378485	0.01968	2.061895
GDP	1.346645	1.110557	8.698292	-4.148	2.574488	0.548149	4.897314
Electric power consumption	510.7987	509.2221	555.5983	486.6513	18.86955	0.815942	3.043101
Carbon(co2) emission	0.853748	0.849322	0.918776	0.809688	0.029198	0.743197	2.941728

Regression - Sub-Saharan Africa

Autoregressive Distributed Lag (ARDL) model for SSA

Dependent Variable: GDP
Method: Least Squares
Date: 05/24/17 Time: 17:28
Sample (adjusted): 1993 2013
Included observations: 21 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-141.3294	24.05446	-5.875391	0.0011
CO	13.42701	5.551155	2.418778	0.0519
CO(-1)	-6.566422	5.455475	-1.203639	0.2741
EPC	0.034395	0.007470	4.604441	0.0037
EPC(-1)	-0.037638	0.008310	-4.529437	0.0040
H2O	0.210835	2.264569	0.093101	0.9289
H2O(-1)	5.601430	1.799827	3.112205	0.0208
NNH2O	3.898104	2.751162	1.416894	0.2063
NNH2O(-1)	-0.163814	2.049656	-0.079923	0.9389
NRO	0.460136	0.264507	1.739601	0.1326
NRO(-1)	1.104888	0.225127	4.907850	0.0027
UN	1.211012	0.511372	2.368163	0.0557
D2004	4.766931	0.548857	8.685203	0.0001
D2002	-1.700924	0.539680	-3.151729	0.0198
D2009	-1.499710	0.494289	-3.034078	0.0230

R-squared	0.990561	Mean dependent var	1.857674
Adjusted R-squared	0.968536	S.D. dependent var	2.020669
S.E. of regression	0.358427	Akaike info criterion	0.961628
Sum squared resid	0.770822	Schwarz criterion	1.707715
Log likelihood	4.902909	Hannan-Quinn criter.	1.123548
F-statistic	44.97496	Durbin-Watson stat	2.469554
Prob(F-statistic)	0.000068		

Regression - Sub-Saharan Africa

- In estimating the relationship between the variables, this study adopted Autoregressive Distributed Lag (ARDL) model developed by Pesaran et al (2001), because all variables were I (1) except the GDP per capita growth.

- The year 2004 had a significant and positive impact on GDP per capita growth his could be explained by improved macro-economic stability.

- Additionally, growth in oil producing countries was boosted by the increase in oil production and high oil prices while increase in agricultural output favored growths in Ethiopia, Malawi and Rwanda, which were seriously affected by drought in 2003.

- The year 2002 and 2009 had a significant and negative on GDP per capital growth in SSA and is attributed to; sharp decline in agricultural output particularly in Southern Africa, weak non-oil commodity prices, impact of drought, continued conflicts and political instability in some countries in the region.

Regression - Sub-Saharan Africa

- The relationship between electricity consumption and economic growth is negative and significant. Similar studies shown that this was attributed to the efficient use of energy and reduced levels of energy dependence for countries studied.
- The coefficient for electric power from hydro and its first lag is positive and statistically significant. The coefficient for fossil fuel and its first lag is positive and significant. This result is expected because most African countries still have large share of fossil fuel electricity generation when compared to renewable electricity share.

Conclusion

- Hydro and wind in Ghana and Kenya respectively were found to have the lowest levilised cost of electricity.
- The highest returns are from geothermal and wind for Kenya and Hydro for Ghana. Both Kenya and Ghana presents stronger fundamentals for the successful implementation of renewable energy projects.
- The paper has established that renewable electricity share which is mainly driven by hdro power in Africa has a positive impact on growth using the Autoregressive Distributed Lag (ARDL) model.
- It is important to note that each country has different particulars which need to be considered by policy makers when allocating finance for renewable generation.
- Even though SSA countries are looking at private investment through IPPs as the solution to their electricity deficit, our analysis shows the capacity of the public sector to access finance at better terms.

THANK YOU FOR YOUR ATTENTION!