Renewable energy deployment in Africa: opportunities, challenges & perspectives

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Outline

1. Electricity access in Africa
2. The energy paradox of Africa
3. Renewable Energy opportunities and challenges in Africa
4. Conclusions

Africa hosts 17% of the world population but almost 50% of the population w/o access to modern energy live in Africa

	Population [10^6 inhabitants]	% world population
Africa	**1265**	**16.7%**
America	1010	13.3%
Asia	4516	59.6%
Europe	742	9.8%
Oceania	41	0.5%
World	**7574**	**100.0%**

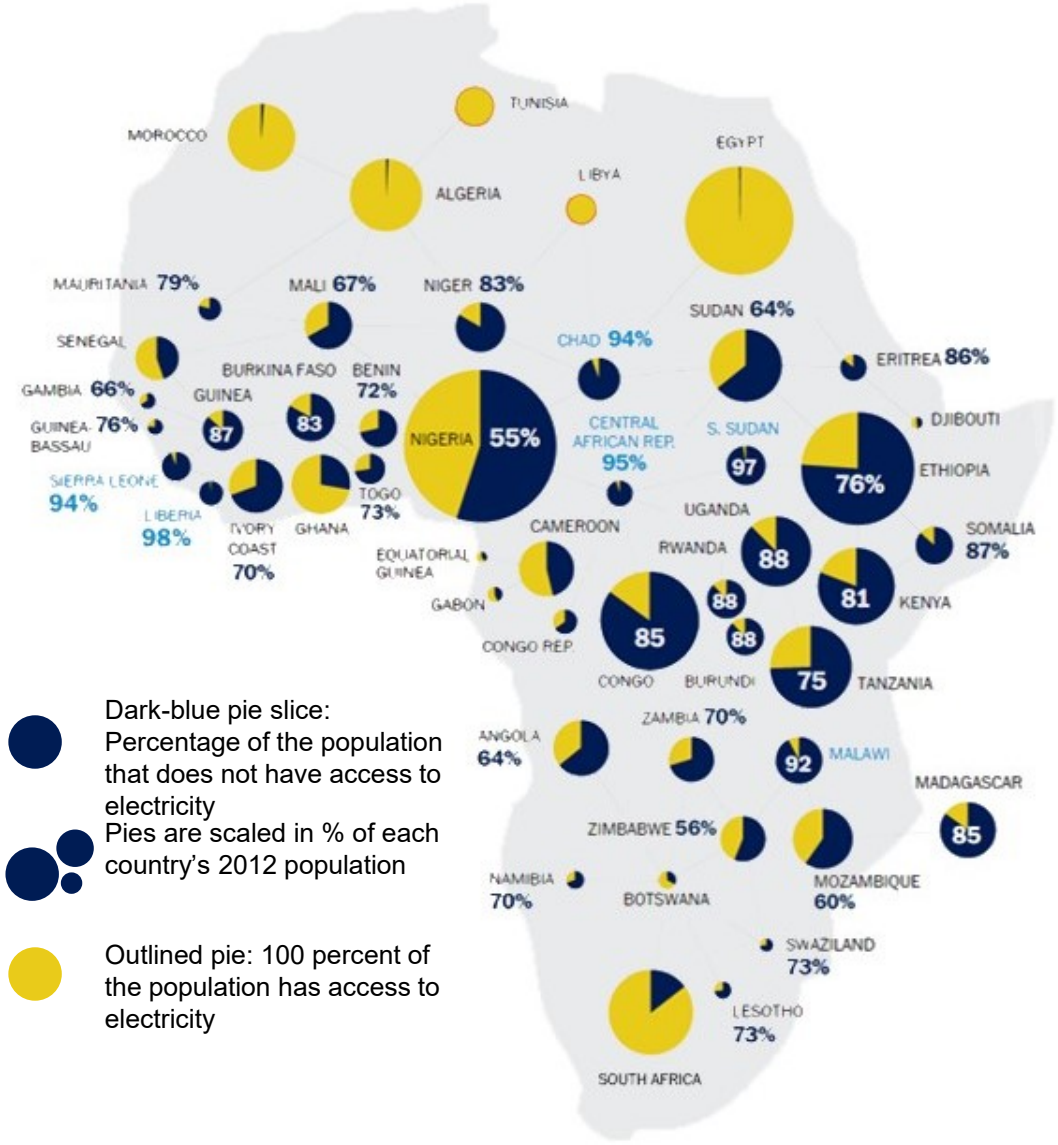
Source: http://www.worldometers.info/world-population/

1-1 to 1.3 bn people in the world don't have access to modern sources of energy, of which approx. **600 millions in Africa**

Cooking : wood, charcoal, agricultural residues

Lighting : kerosene lamps, drycell batteries, candles, etc.

Electricity access is still very low in Sub-Saharan Africa less than 15% in rural areas



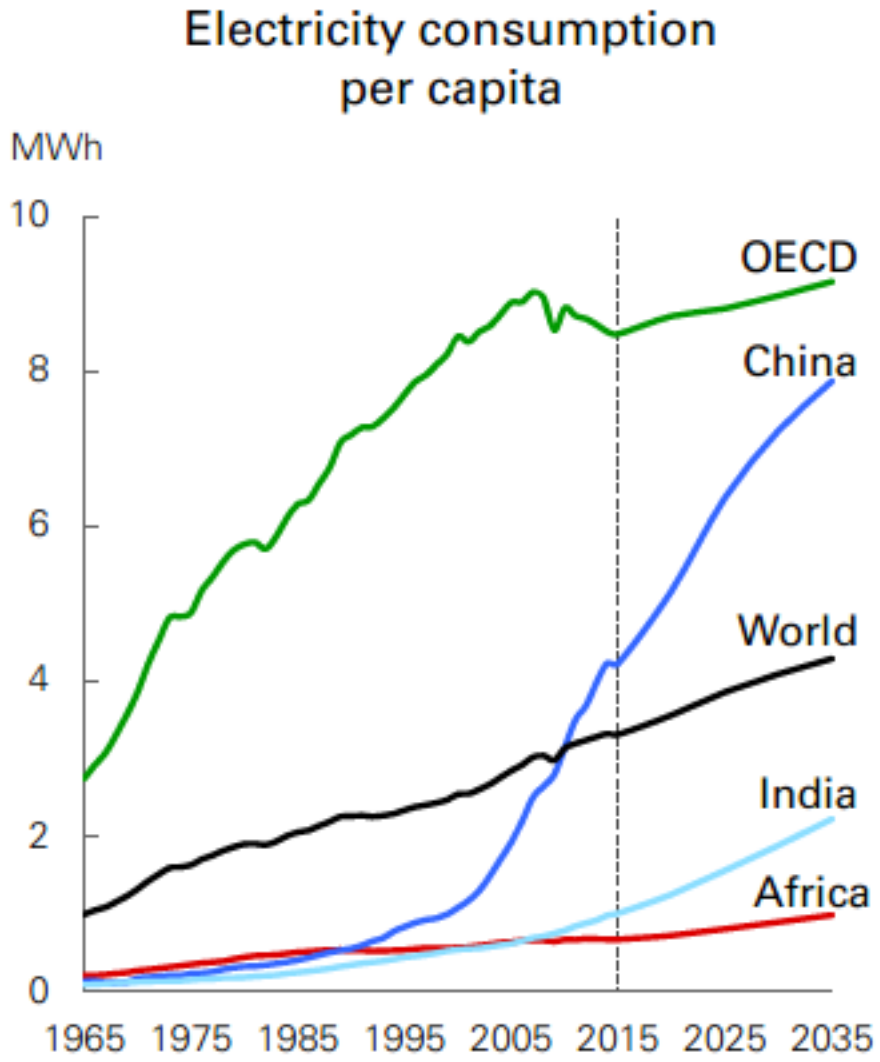
Dark-blue pie slice: Percentage of the population that does not have access to electricity

Pies are scaled in % of each country's 2012 population

Outlined pie: 100 percent of the population has access to electricity

Projections are pessimistic about Africa's electricity consumption

	Per capita power consumption [kWh/y]
Senegal	210
Ghana	70
Nigeria	144
Cameroon	281
Ethiopia	70
Kenya	168
Uganda	90
Rwanda	22
Tanzania	99
Zambia	703
Namibia	1564
South Africa	4229

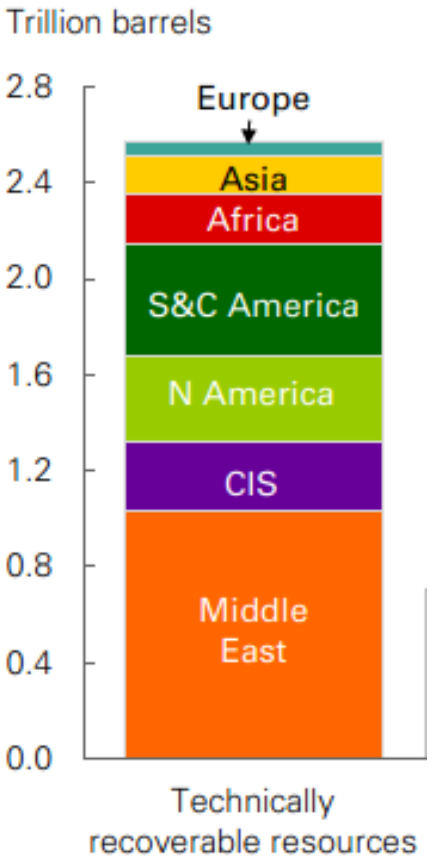


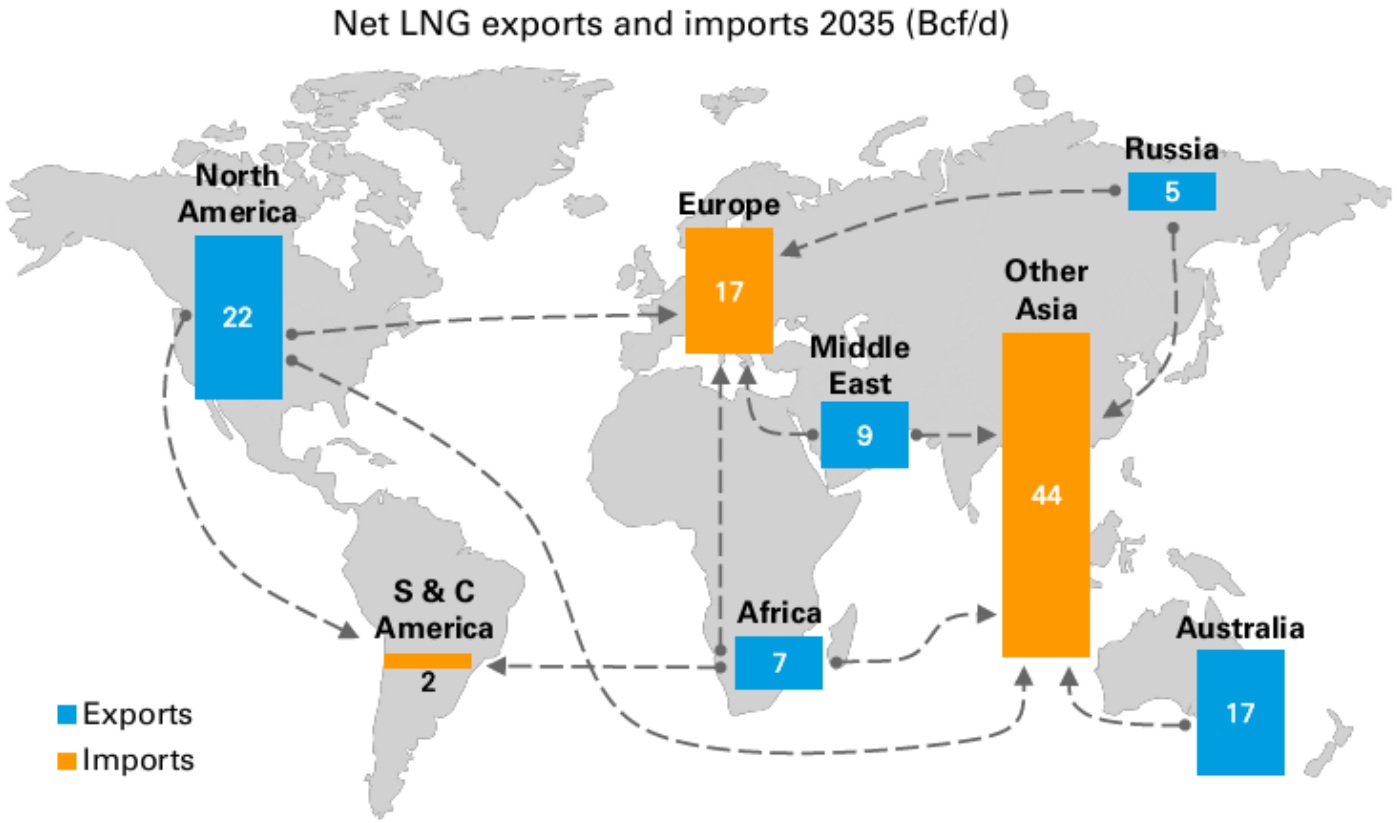
Few reasons for low power consumption……?

- Low industrialization and industrial farming
- Low productive uses of energy
- Poor planning policy
- Low investment in the power sector
- Old distribution grids and high losses
- Unreliable electricity services : Load shedding in more than 25 SSA countries
- High cost of power generation due to emergency thermal plants
- Inappropriate grid expansion/densification tension considering low population density
- No steady enabling Environment for clean energy development

Africa’s Energy poverty is a paradox

Oil resources are abundant & Africa a NET LNG exporter





World	2.6Tn Barrels
Africa	0.23Tn Barrels
Share Africa	**8.8%**

Renewable energy potential (1)

Hydro	Solar PV
280 GW, 10% world resources	**Average sun irradiation 2000 à 2500 kWh/m²/y**
Main rivers ***Congo :*** *Grand Inga (44 GW),* *Gabon (> 10 GW),* *Cameroun (> 20 GW)* ***Nil :*** *Ethiopia (> 30 GW)* ***Zambezi :*** *Angola (>18 GW),* *Mozambique (>12 GW)* ***Niger :*** *Nigeria (> 10 GW)*	**100-300 kWhe/m²/y on 47% of SSA** **75 – 200 kWhe/m²/y elsewhere**

Additionally Small hydro sites are abundant across SSA

Renewable energy potential (2)

TABLE 1: TECHNICAL POTENTIALS FOR POWER GENERATION FROM RENEWABLES (NUMBERS ARE SUBJECT TO UNCERTAINTY, TYPICALLY +/- 50%)

	CSP	PV	Wind			Hydro	Biomass	Geothermal
			Total	CF 30%-40%	CF > 40%			
	(TWh)							
Central Africa	299	616	120	16	6	1,057	1,572	
Eastern Africa	1,758	2,195	1,443	309	166	578	642	88
Northern Africa	935	1,090	1,014	225	69	78	257	
Southern Africa	1,500	1,628	852	100	17	26	96	
Western Africa	227	1,038	394	17	1	105	64	
Total Africa	4,719	6,567	3,823	667	259	1,844	2,631	88

Source: Herman, et al., 2011; IRENA, 2011a.

Estimated annual RE Potential: 20,600 TWh

Despite a quarter of the world's population estimated to live in Africa by 2050, only 25% of the hydropower potential is expected to be tapped

	Potential [GW]	Installed capacity 2016 [GW]	% exploited	power generation 2015 [TWh]	expected capacity 2030 [GW]	power generated 2030 [TWh]
Geothermal	15	1.123	7.5%	4.224	3	21
Wind		3.862		7.85	101	304
Solar (PV&CSP)		2972		3.65	69	230
Other Renewables					36	96
Hydro		32.43		122	101	402

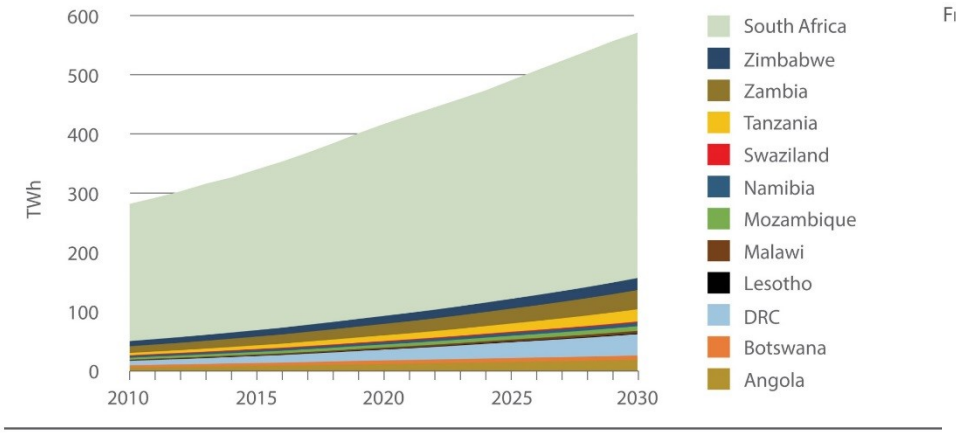
Renewable Electricity generation in Africa has considerably increased over the past 10 years.

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Renewable energy installed capacity [GW]										
World	994.2	1062.6	1138	1228.8	1331.4	1449.5	1568.7	1693	1849.5	2011.3
Africa	22.94	23.41	25.05	26.97	27.34	28.49	30.53	32.35	34.11	38.28
Renewable energy production [TWh]										
World	3530.6	3730.8	3845.5	4200	4440.8	4765.8	5057	5334.9	5537.2	
Africa	96.9	1028.6	1073	1134	1170	1186	1259	1358	1370	
Offgrid renewable energy capacity [MW]										
World	793.4	849.1	890.1	1111.7	1321.7	1568.4	1866.5	2195.7	2771	4031
Africa	197.4	210.1	221.4	259.5	344.3	406	456.6	510.4	649.1	887.4
offgrid Hydro	120.89	120.94	121.36	127.87	128.11	133.95	135.81	138.37	157.77	157.85
offgrid PV	68.66	81.31	91.94	122.75	187.32	237.55	281.71	317.96	435.46	672.47
Other offgrid RE	7.84	7.84	8.15	8.84	28.85	34.47	39.09	54.05	55.92	54.05

Way forward?

Africa final electricity demand to triple by 2030

FIGURE 7. SOUTHERN AFRICA: FINAL ELECTRICITY DEMAND BY COUNTRY



[5] This subsection is based on the executive summary of: Southern African Power Pool: Planning and Prospects for Renewable Energy (IRENA, 2013b).

FIGURE 12: EAST AFRICA: FINAL ELECTRICITY DEMAND BY COUNTRY

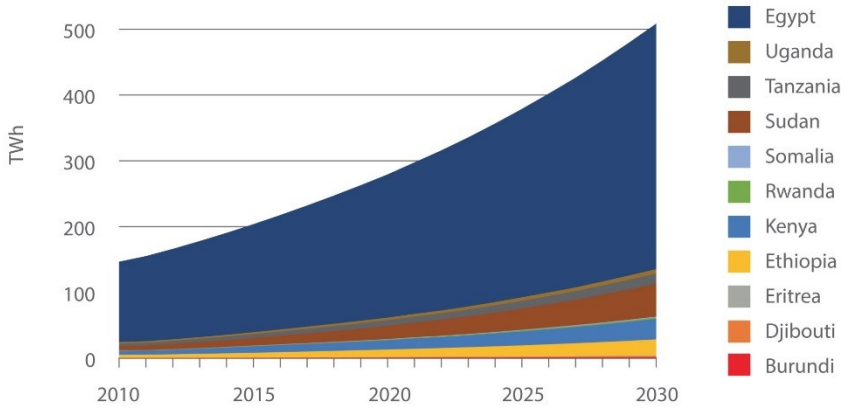


FIGURE 2. WEST AFRICA: FINAL ELECTRICITY DEMAND BY COUNTRY

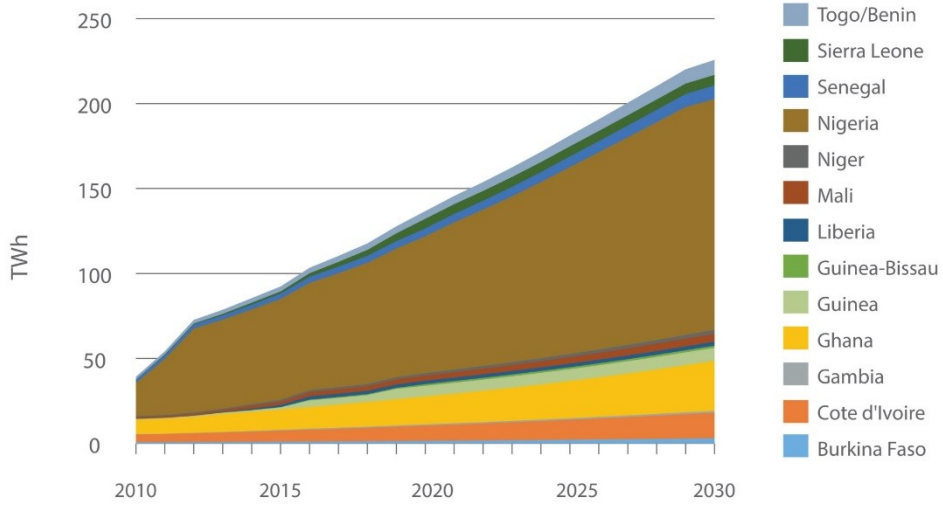
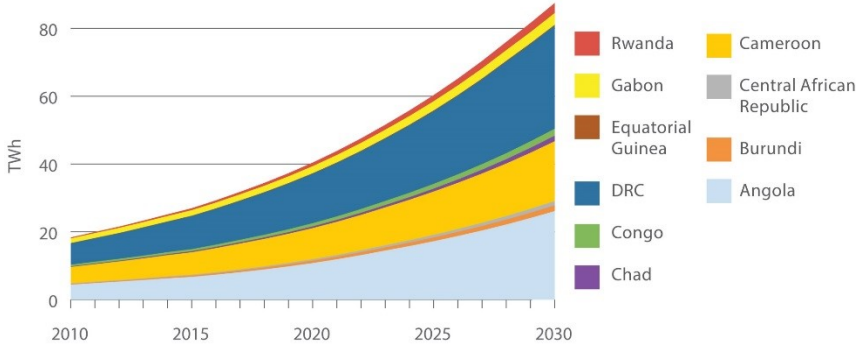
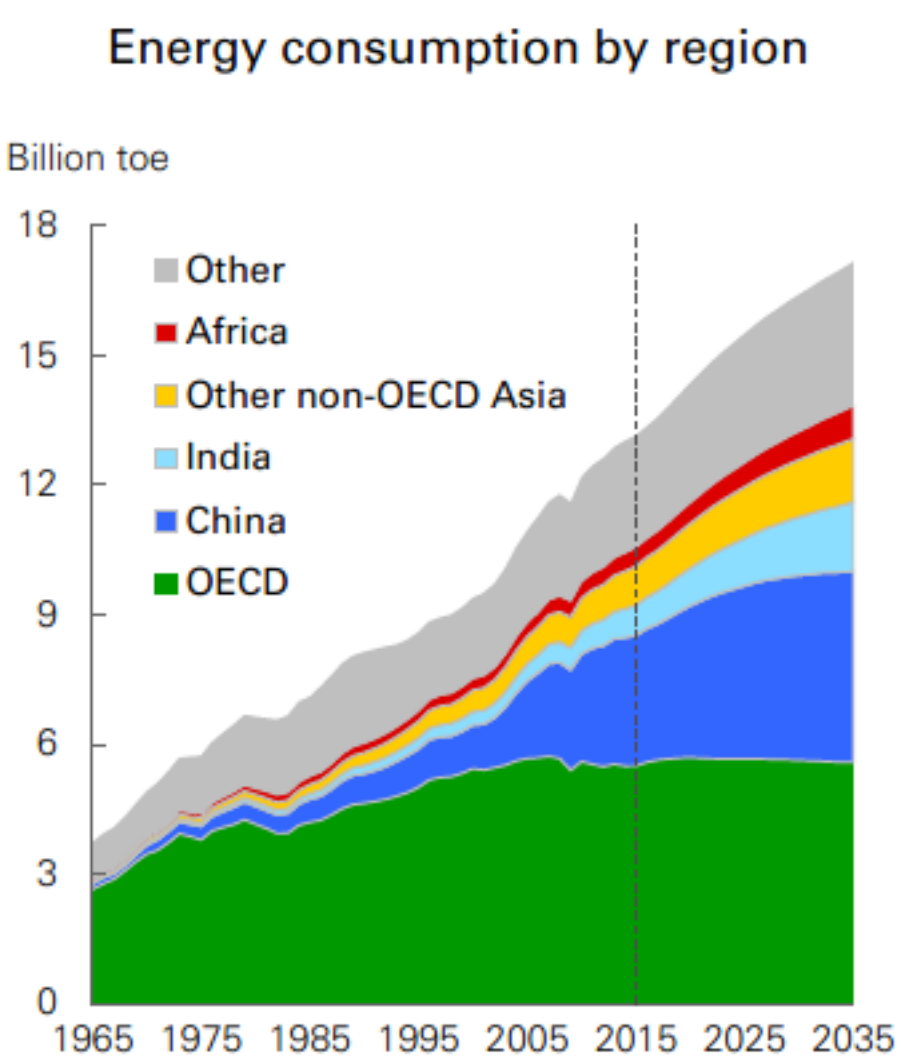
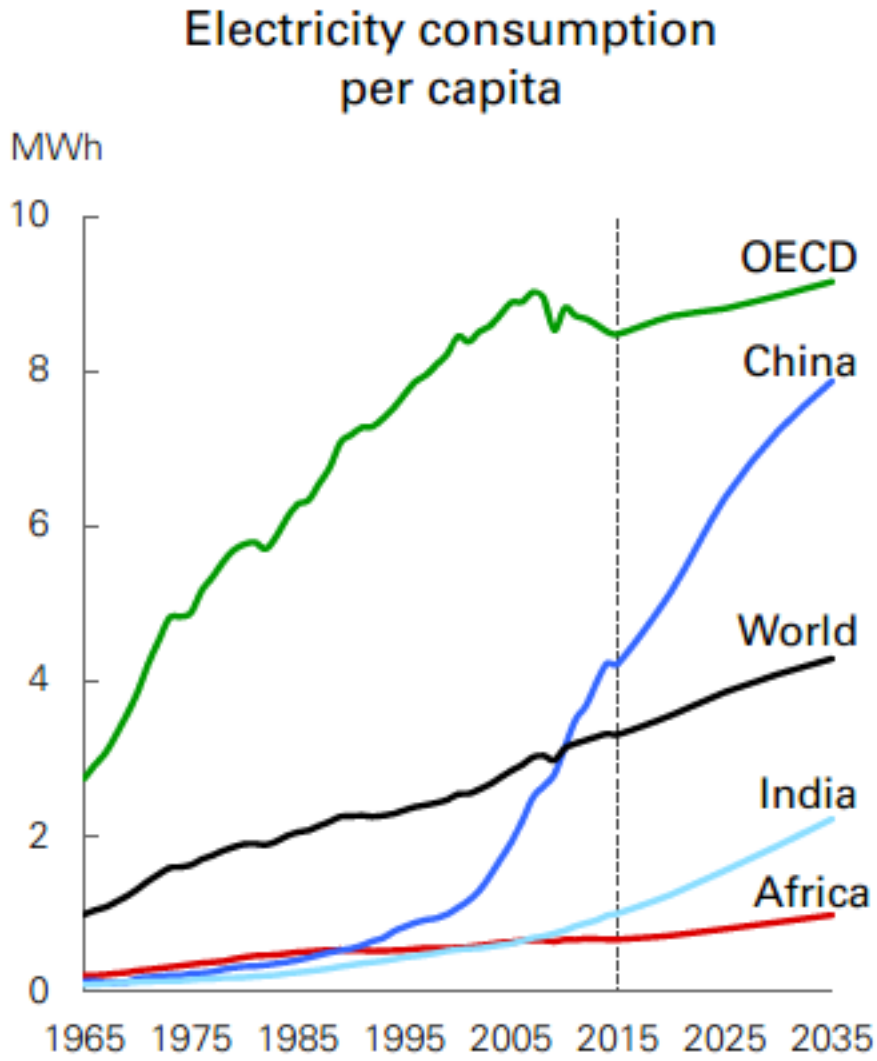


FIGURE 16: CENTRAL AFRICAN: FINAL ELECTRICITY DEMAND BY COUNTRY



Projections are pessimistic about Africa's energy consumption





Primary energy consumption per source and prospect

	Consumption (Mtoe)		Shares (%)	
	2015	2035	2015	2035
Primary energy	13147	17157	100%	100%
By fuel:				
Oil	4257	4892	32%	29%
Gas	3135	4319	24%	25%
Coal	3840	4032	29%	24%
Nuclear	583	927	4%	5%
Hydro	893	1272	7%	7%
Renewables*	439	1715	3%	10%

Access to electricity is an essential component of accelerating human development

- Agriculture : water pumping for irrigation and livestock, added value food processing and conservation
- Education and health services enhancement
- Employment creation
- Improved social life and business development

Sustainable Improvement of electricity access in Sub-Saharan Africa requires a significant scale-up of electricity infrastructure

Electricity demand in Africa is projected to triple by 2030, offering huge potential for renewable energy deployment

Access: 12-20m households to be connected annually (2017-2030)

Transmission & Distribution:
Grid expansion/intensification/densification still considered as main solution but **offgrid electrification will play a key role in reaching the most dispersed rural population.**

Generation: 250 – 302 GW renewable capacity to be added

Estimated Total Investment : $50 - 70 bn per year on average (2017-2030).
Generation capacity: $30 - 45 bn/year
Transmission&distribution : $20 - 25 bn/year
Internal wiring: $2 – 3bn per year

Investment in Renewable electricity is limited by low tariffs and consumption in Africa

	Per capita power consumption [kWh/y]	%Renewable energy production	%Renewable energy consumption	LV domestic tariff [$/kWh]	LV commercial tariff [$/kWh]
Senegal	210	10.42%	43.60%	0.18 - 0.2	0.26
Ghana	70	99.90%	92.70%	0.08 - 0.22	0.22 - 0.37
Nigeria	144	17.60%	87.30%	0.07 - 0.086	0.12 - 0.14
Cameroon	281	74.30%	77.40%	0.09 - 0.18	0.14 - 0.18
Ethiopia	70	99.90%	92.72%	0.012 - 0.031	0.027 - 0.034
Kenya	168	75.00%	78.50%	0.025 - 0.205	0.07 - 0.13
Uganda	90	78.60%	89.22%	0.17 - 0.19	0.10 - 0.16
Rwanda	22	39.00%	88.40%	0.10 - 0.23	0.23
Tanzania	99	42.30%	86.70%	0.045 - 0.156	0.09 - 0.175

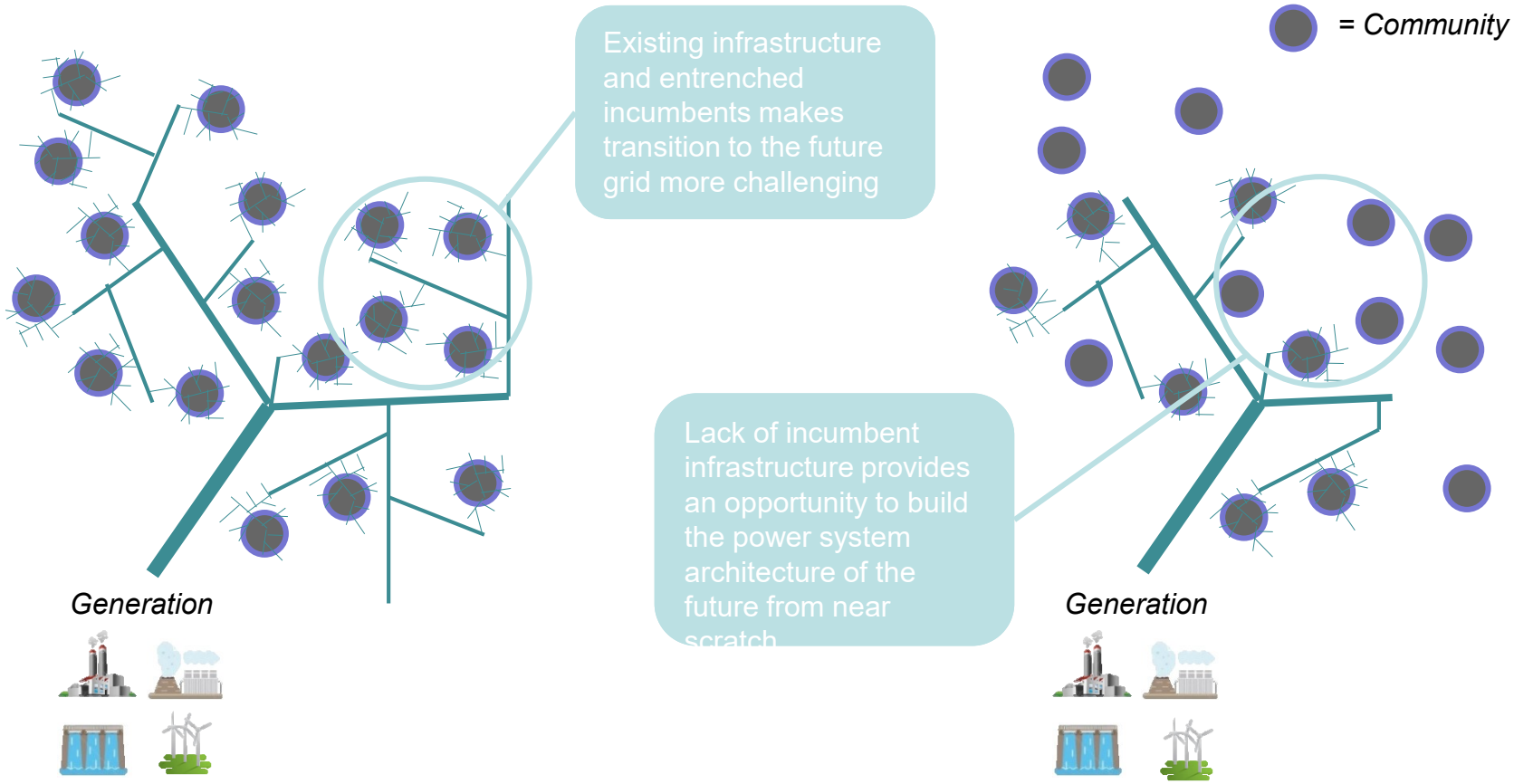
Off-grid mini-grids are the optimal solution for energy access in dispersed rural areas

					Kenya Power	TANESCO
Electricity Delivered	N/A	DC	AC	AC	AC	AC
Upfront Payment ($)	12	35	Varies	10 - 20	150 - 350	120 - 250
Ongoing Costs	✘	✓	✘	✓	✓	✓
Installation Time	N/A	✓ Short Install Time	✓ Almost plug-and-play	✓ Quickly Deployable	✘ Multi-year Project Timelines	
Reliability	✘ Poor quality lighting	✘ Limited Product Life	✘ Requires regular maintenance	✓ Battery Storage	✘ Intermittent Power Cuts	
Full Energy Ladder? (Appliances / Productive Loads)	✘	✘ Only Low-Power DC Devices	✓ Yes, but expensive	✓ Grid-equivalent power	✓ Full Electrification	
Main Grid Integration	✘	✘ Not Possible	✘	✓ Built to int'l grid standards	N/A	N/A

* 1-year lease-to-own with 2-year warranty. PowerGen assumed a 3 year life for the SHS

Mini-grids build the energy system of the future from the grid edge in…

Developed Country Grid — — ***Less-Developed Country Grid***



Why will minigrids play an important role in electricity access in Africa?

- Tap into Africa's enormous Renewable Energy resources
- Faster deployment and more reliable than grid expansion
- Highlight real cost of electricity
- Drive new electrification policies and partnerships
- Stimulate electricity demand and PUE in rural areas
- Drive economic development
- prepare the ground for future grid expansion

Valuable policy and regulations changes are needed

Business & Ownership Models	Public, Private Public-private franchisee, PPA
Specific regulations	Clear demarcation of offgrid areas, Site allocation – top-down vs bottom-up Clear Licensing conditions & process, Tariff setting and approval, What happens when the main grid arrives?
Support mechanisms	Independent of technology, rural electrification is not economically viable. Transparency in subsidy types and allocation Keep the parity between off and ongrid customers

Conclusions (1)

Africa's energy situation is paradoxal with many inequalities:

- **The per capita energy consumption in Africa is a quarter of the average world PCEC**
-
- **75% of Africa's energy is consumed in Northern and Southern Africa, where 25% of the population live.**

- **Less than 10% in rural areas resp. around 40% of urban people have access to electricity**

- **African countries are net exporter of energy resources**

Conclusions (2)

Sustainable development of Africa's energy sector is possible:

Technology options :

- **Renewable energy potential (10000 - 20000 TWh/y)**
- **Rational use of fossil energy resources**
- **Valorisation of flare gas (41-58 GW, 356-511 TWh/y)**

Requirements:

- **Rural Electrification Master Plan to include offgrid strategy**
- **Off-grid Policy towards an enabling environment for strategic offgrid development**
- **Capacity building of stakeholders**
- **New financing and business models that take into account private sector involvement and support local SME contribution**

DEECC consulting
Development Energy Environment and Climate Change

Grand-Inga requires about $50bn

50 million shares @ $1000
5 million shares @ $10,000
1 million shares @ $50,000
500,000 shares @ $100,000
+
+
other combinations