

INNOVATIVE BUSINESS MODELS TO POWER AFRICA:

Distributed Renewable Energy Generation and Aggregation Platforms for Peer-to-peer Trading

RES4MED

WHITE PAPER

RES4AFRICA

INTRODUCTION

This white paper takes place within the thematic framework of the 5th RES4MED Annual Conference the 22nd of may 2017 and RES4MED's new strategic focus on the catalyzing role of innovation in driving sustainable economic development in Africa. Besides taking a look back on 5 years RES4MED activities and achieved results, the conference introduces a thematic discussion on the role of sustainable energy innovation to empower Africa.

The white paper gathers the contributions of the members of the RES4MED Innovation Working Group and aims to present key insights on the role of innovation in driving economic development in Africa. The main findings and proposed approaches in this document reflect RES4MED's new strategic positioning dedicated to innovative practices and business models for sustainable economic growth in Africa.

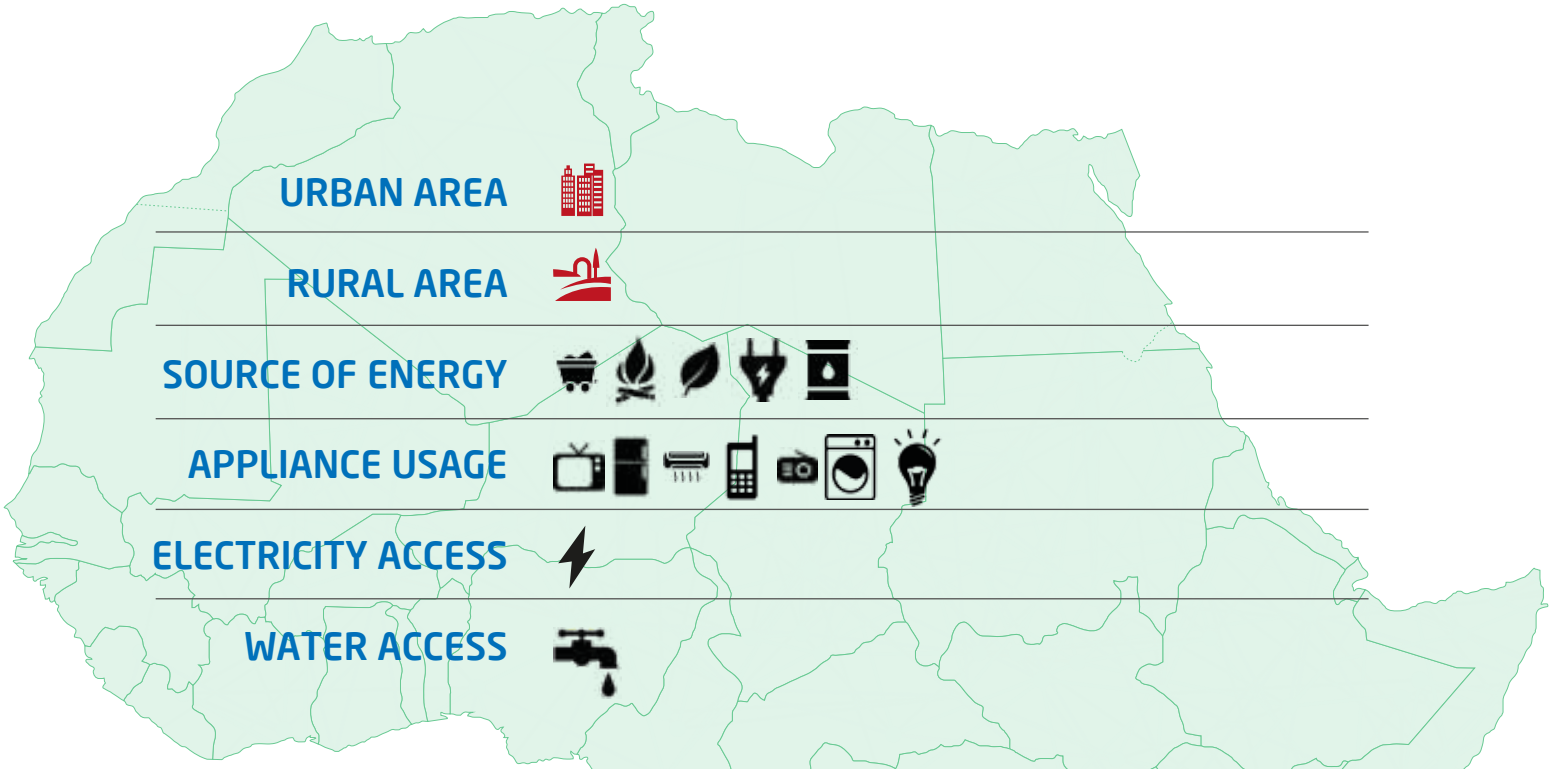
Access to clean, affordable and reliable energy is fundamental to drive Africa's sustainable economic development. The deployment of renewable energy technologies and grid enhancement represents the most effective strategy to accelerate Africa's socio-economic transformation. Because Africa's energy challenges are so diverse and large scale, a conjunction of decentralized renewables and grid enhancement will be key to unlocking economic transformation and sustainable development in Africa.

To enable these solutions we need to disrupt the way we have previously addressed the issue. This will require a strong focus on innovation. Thanks to the continent's dynamic economic growth, its young population, its renewable energy abundance, a growing entrepreneurial start-up culture, and a proliferation of enabling digital technologies, prioritising real inclusve and open innovative thinking can lead to business models that present unique solutions to local challenges.

What is needed is to gather innovative technological solutions, business models and capable players to scale up investments into projects and initiatives that can deliver clean, affordable and reliable electricity to African communities. The different consumer profiles and entire value chain has to be considered in order to obtain a successful business model. Far beyond R&D, innovation needs to be integrated in a holistic and cross-sectoral manner connecting energy, health, business, education, technology and environment. The business models presented in this white paper offer a first step in that direction.

The white paper highlights the energy profile of 3 African countries – Kenya, Ethiopa and Rwanda – and how those characteristics reflect a market potential that can benefit sustainable energy business models. A trading platform business model is proposed encompassing technological, economic, social and educational advancements based on environmental benefits to create sustainable energy access for these markets and consumer profiles.

By applying innovative thinking to real time situations with technology as a stepping stone, new markets are revealed for Africa's economic take-off.



This section depicts a map of the African continent and presents selected data per country regarding energy and electricity usage. The green tables include identical indicators for all 3 countries, followed by selected additional tables & information points.

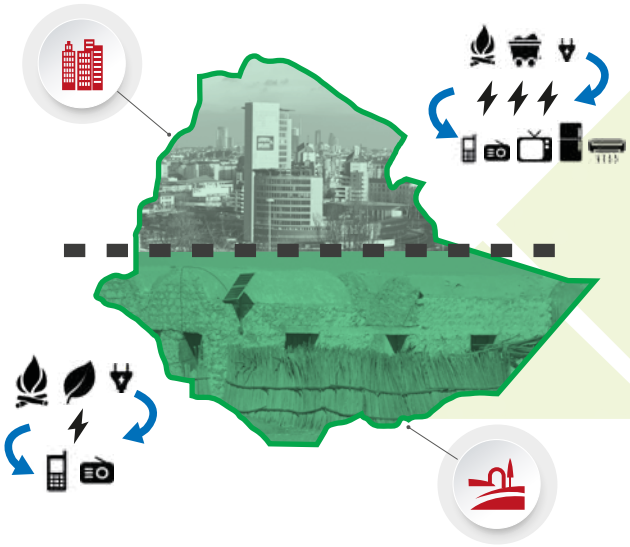
Also consumer profiles need to be understood in order to find a basis for the business model. In these countries consumer profiles can typically be distinguished based on geographic location (Rural vs. Urban population), and income level (high-mid-low).

Here below some general points applying to all countries:

- Electrical Appliances usage: mobile phone & radio are the most prevalent. Remarkable mobile phone usage across urban and rural zones.
- Fuel for cooking: both urban & rural areas use biomass (mostly firewoord and charcoal) for cooking. Electricity absent. Electric cooking only in urban Kenya.
- Economic activity: In rural zones, agriculture is the main employing sector. In urban zones, mostly agriculture, followed by transport, public administration, and communications.
- Electricity consumption: medium for urban zones, very low for rural. In general, a big gap divides urban and rural zones across income, development, electricity access and usage levels (Especially Ethiopia – almost as if two different countries).

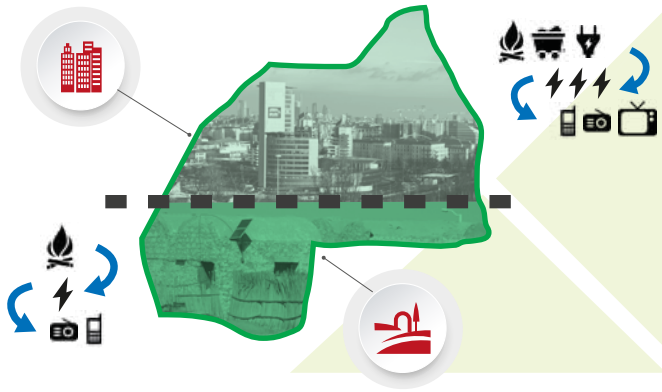
Those general points are depicted in the miniatures of each Country considered in the analysis.





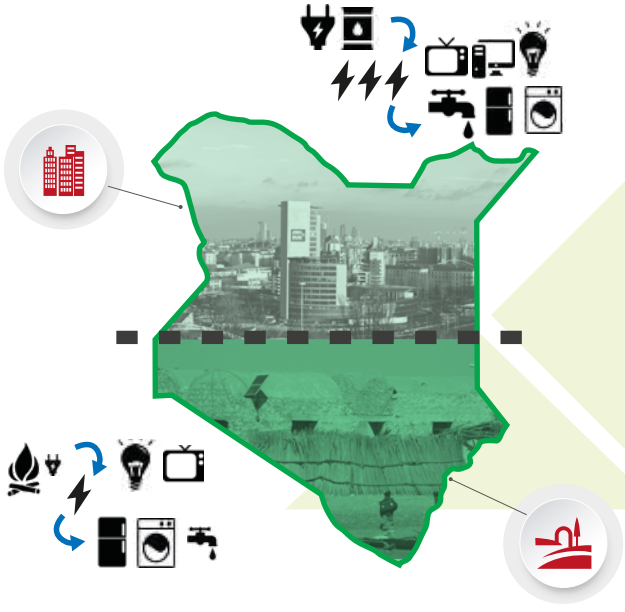
ETHIOPIA GLOBAL INDICATORS

POPULATION: **102 Million**
ELECTRICITY CONSUMPTION: **6,7 bn kWh**
ELECTRICITY ACCESS:
URBAN POPULATION: **92%**
RURAL POPULATION: **12,2%**



RWANDA GLOBAL INDICATORS

POPULATION: **11,3 Million**
ELECTRICITY CONSUMPTION: **0,5 Bn kWh**
ELECTRICITY ACCESS
URBAN POPULATION: **71,8%**
RURAL POPULATION: **9,1%**



KENYA GLOBAL INDICATORS

POPULATION: **44,9 Million**
ELECTRICITY CONSUMPTION: **7,6 Bn kWh**
ELECTRICITY ACCESS
URBAN POPULATION: **68,4%**
RURAL POPULATION: **12,6%**



ETHIOPIA

Urban population:

- Electricity usage: Higher use of electricity consumption than rural zones, although degree varies with income (high income elasticity);
- Source of fuel for cooking: mix between firewood (37%), charcoal (21%) and electricity (23%))
- Electrical appliances usage: Use more electrical appliances (radio, television, satellite dish, mobile phones, refrigerator, AC,...). Large prevalence of mobile phones.
- Profession: More diversified profiles of work (mostly agriculture but also sales/trade, transportation and public administration)

Rural population:

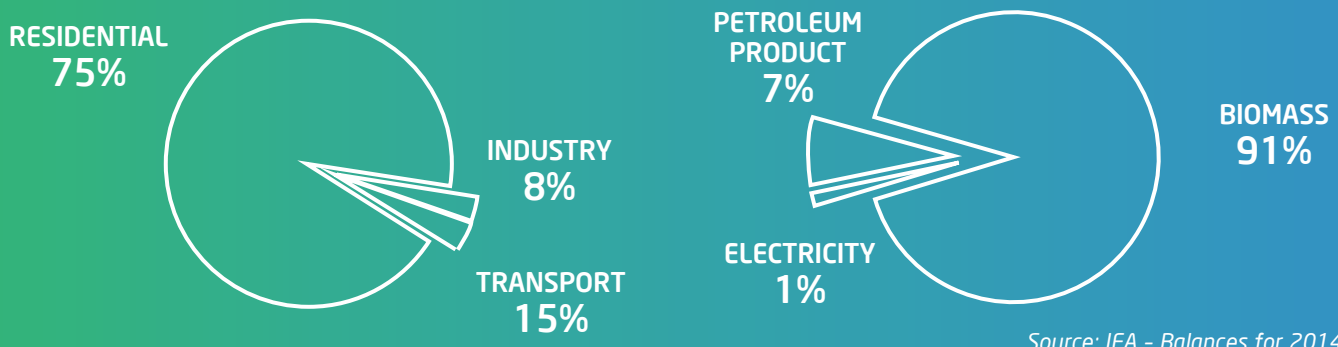
- Electricity usage: Very low degree of electricity usage, and even income variation does not affect as much as in urban zones.
- Source of fuel for cooking: firewood (77%), dung and leaves (no electricity at all);
- Appliances usage: Use very few electrical appliances, except for radio & mobile phones. May indicate a usage of SHS charging. Mobile phone is most used appliance followed by radio.
- Profession: Almost entirely agriculture work for men, and household chores for women

General Considerations

- In rural areas, male occupation is 97% in agriculture, whereas females work 50% in household chores. In urban areas, male occupation is more diversified.
- Business models targeting rural areas should target involvement or focus on agricultural activities or facilitation of household chores.
- Business models targeting urban areas should target agriculture, transport, communication professions.
- Business models in rural areas cannot for now count on existing electricity use or supply and in urban zones take into account predominance of firewood.
- Rural & urban areas differ in their use of electrical appliances except for radio, and for mobile phones. The mobile phone is the most used electrical appliance in rural areas, followed by the radio. Urban zones have higher and more diversified usage of electrical appliances. Business models can rely on mobile phone prevalence

INDICATOR	VALUES
Population (million)	**102.4** (2016)
Population grow rate (%)	**2.9** (2016)
Rural population (% of the total)	**80** (2015) **(81.9 million)**
Urban population (% of the total)	**20** (2015) **(20.5 million)**
Urbanization rate (%)	**4.9** (2015)
People without access to electricity (% of total)	**77** (2014)
GDP (billion USD)	**69.2** (2015)
GDP Per Capita (current USD)	**1,700** (2014)
Final Energy consumption by sector (%) *IEA - Balances for 2014*	**Residential: 93 Industry: 8 Transport: 4**
Final Energy Consumation by fuel (%) *IEA - Balances for 2014*	**Biomass: 91 Petroleum product: 7 Electricity: 1**
Off-grid population (million) *Off-Grid Solar Market Trends Report 2016*	**70**
Electricity Consumption (kWh/per capita per year *IEA - Balances for 2014*	**64**
Electricity cited as business constraint (% firm) *Africa Cooking with electricity - World Bank, Enterprise Survey Database (2015)*	**42.45**
Power outages (day) *Africa Cooking with electricity - World Bank, Enterprise Survey Database (2015)*	**44.16**

Share of Final Energy Consumption by sector and by fuel [%]



Source: IEA - Balances for 2014 (online data

Electricity Consumption (in 2013): 64 kWh/per capita

Occupation (%)	Country	Rural	Small town (urban)	Large town (urban)
Agriculture	Males: 87.4 Females: 43.9	Males: 97.1 Females: 49.9	Males: 64 Females: 26.4	Males: 45.8 Females: 19.5
Mining	Males: 0.2 Females: 0.1	Males: 0.1 Females: 0.1	Males: 0.1 Females: 0.2	Males: 0.6 Females: 0.0
Manufactory	Males: 0.9 Females: 1.1	Males: 0.1 Females: 0.8	Males: 2.3 Females: 2.4	Males: 4.3 Females: 2.4
Professional/scientific	Males: 1.0 Females: 0.2	Males: 0.1 Females: 0.1	Males: 5.0 Females: 0.8	Males: 4.3 Females: 1.0
Construction	Males: 1.0 Females: 0.2	Males: 0.2 Females: 0.0	Males: 1.9 Females: 0.0	Males: 4.5 Females: 0.8
Transportation	Males: 0.9 Females: 0.0	Males: 0.3 Females: 0.0	Males: 1.0 Females: 0.0	Males: 3.9 Females: 0.1
Buying and selling	Males: 3.0 Females: 3.2	Males: 0.6 Females: 0.8	Males: 10.2 Females: 10.9	Males: 12.8 Females: 13.0
Public administration	Males: 1.2 Females: 0.4	Males: 0.2 Females: 0.1	Males: 2.4 Females: 0.9	Males: 5.9 Females: 1.7
Household chores/housewife	Males: 0.2 Females: 48.9	Males: 0.1 Females: 47.7	Males: 0.7 Females: 51.7	Males: 0.5 Females: 54.0

Souce: LSMS - Integrated Surveys on Agriculture Ethiopia Socioeconomic Survey (ESS) 2015-2016

Source of fuel for cooking (%)	Country	Rural	Small town (urban)	Large town (urban)
Collected firewood	61.5	77.2	34.6	14.0
Purchased firewood	12.1	3.2	46.7	33.0
Charcoal	5.2	0.5	6.4	21.7
Crop residue/leaves	6.8	8.9	0.7	1.3
Dung/manure	6.6	8.2	2.1	2.0
Electricity	5.2	0.1	4.5	23.3
None	0.9	0.3	2.3	2.8
Other	1.8	1.7	2.7	1.9

Souce: LSMS - Integrated Surveys on Agriculture Ethiopia Socioeconomic Survey (ESS) 2015-2016

Electronics (%)	Country	Rural	Small town (urban)	Large town (urban)
Radio/radio and tape/tape	30.5	24.8	42.6	47.3
Television	17.8	3.3	41.8	61.8
CD/VCD/DVD/Video deck	11.0	1.5	26.4	40.0
Satellite dish	13.1	2.2	33.8	45.3
Mobile phone	54.4	42.6	75.8	89.3
Fixed line telephone	6.3	2.1	15.5	18.5



KENYA

Urban population:

- Source of fuel for cooking: Cook a lot more with electricity and fuel compared to other countries;
- Appliances usage: Spend most of their electricity consumption by end use on 1) entertainment & ICT, 2) lighting, 3) sanitary water, 4) refrigeration and 5) laundry

Rural population:

- Source of fuel for cooking: mostly with firewood, very little with electricity
- Appliances usage: Spend most of their electricity consumption by end use on 1) lighting, 2) entertainment & ICT, 3) refrigeration 4) laundry, 5) sanitary water.

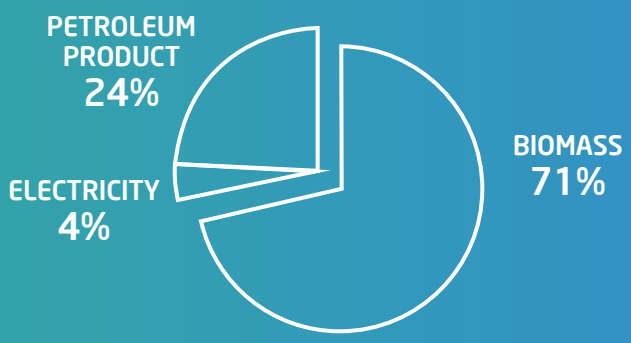
General Considerations

- Rural communities cook mostly with wood and very little with electricity. However, compared to other countries, urban communities cook much more with fuel & electricity.
- Business models should take into account low access or demand for electricity on cooking.

INDICATOR	VALUES
Population (million)	**44.9** (2014)
Population grow rate (%)	**2.6** (2014)
Rural population (% of the total)	**75** (2014) **(33.7 million)**
Urban population (% of the total)	**25** (2014) **(11.2 million)**
Urbanization rate (%)	**5.9** (2014)
People without access to electricity (% of total)	**82** (2014)
GDP (billion USD)	**60.9** (2014)
GDP Per Capita (current USD)	**1,358** (2014)
Final Energy consumption by sector (%) *IEA - Balances for 2014*	**Residential: 75 Industry: 8 Transport: 15 Other: 2**
Final Energy consumption by fuel (%) *IEA - Balances for 2014*	**Biomass: 71 Petroleum product: 24 Electricity: 5**
Off-grid population (million) *Off-Grid Solar Market Trends Report 2016*	**35**
Electricity consumption (kWh/per capita per year *IEA - Balances for 2014*	**168**
Electricity cited as business constraint (% firm) *Africa Cooking with electricity - World Bank, Enterprise Survey Database (2015)*	**48.15**
Power outages (day) *Africa Cooking with electricity - World Bank, Enterprise Survey Database (2015)*	**53.40**

Share of Final Energy Consumption by sector and by fuel [%]





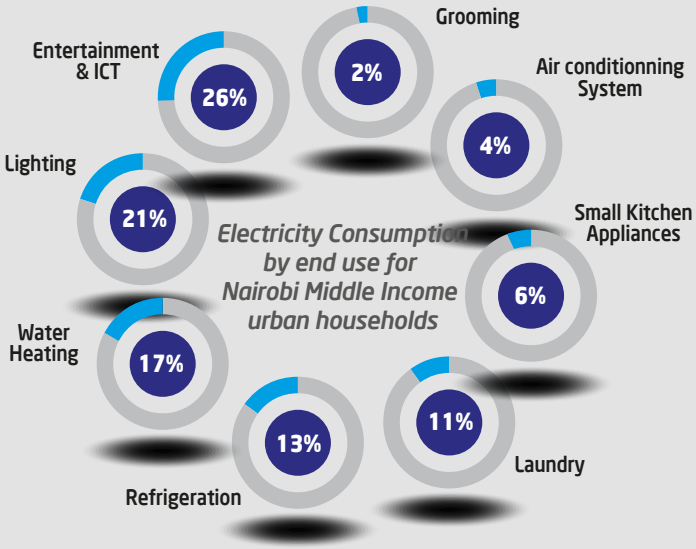
Electricity Consumption (in 2013): 168 kWh/per capita

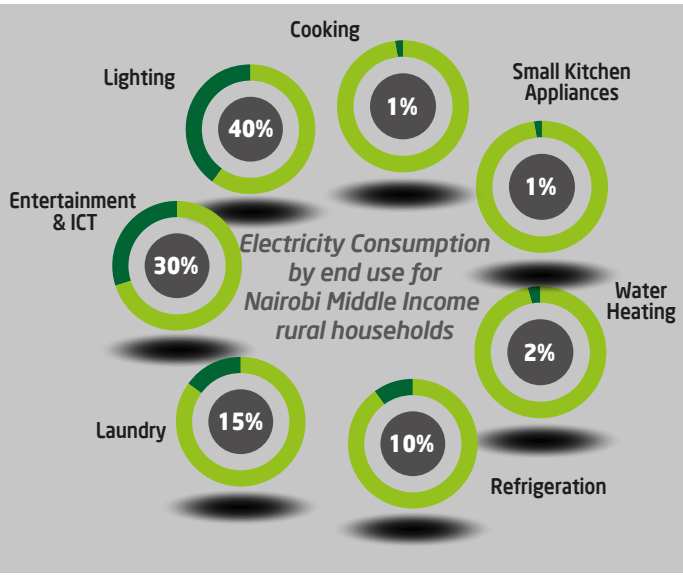
NAIROBI URBAN - MI

Cluster	Consumtion (kWh/year) (E	% Share of total consumption	Average % access
Entertainment & ICT	417	25,40%	30%
Lighting	340	20,71%	100%
Sanity water	284	17,30%	20%
Refrigeration	214	13,03%	12%
Laundry	183	11,14%	49%
Small kitchen appliances	95	5,79%	18%
Air Conditioning System	67	4,08%	7%
Cooking	30	1,83%	10%
Water supply	6	0,37%	7%
Grooming	2	0,12%	8%
House cleaning	2	0,12%	3%
Fitness	1	0,06%	0,01%
Space heating	1	0,06%	2%
Dsihwashing	0	0,00%	0%
E (kWh/year)	1642	100%	

NAIROBI RURAL - MI

Cluster	Consumtion (kWh/year) (E	% Share of total consumption	Average % access
Entertainment & ICT	288	39,29%	100%
Lighting	235	32,06%	22%
Sanity water	110	15,01%	35%
Refrigeration	77	10,50%	5%
Laundry	14	1,91%	4%
Small kitchen appliances	5	0,68%	3%
Air Conditioning System	4	0,55%	3%
Cooking	0	0,00%	2%
Water supply	0	0,00%	0%
Grooming	0	0,00%	0%
House cleaning	0	0,00%	0%
Fitness	0	0,00%	0%
Space heating	0	0,00%	0%
Dsihwashing	0	0,00%	0%
E (kWh/year)	733	100%	





Fuel used for cooking (%)	National	Rural	Urban
Population with access to modern fuel (electricity, Gas or Kerosene) (%)	17	4	58
Population using wood (%)	69	88	10
Population using charcoal (%)	13	8	30
Population relyng on solid fuel that use improved cook stoves (%)	3	3	4



RWANDA

Urban population:

- Electricity usage: 72% access to electricity
- Source of fuel for cooking: dependent on firewood and charcoal, no electricity
- Appliances usage: mostly mobile phone, radio and television

Rural population:

- Electricity usage: 12% access to electricity
- Source of fuel for cooking: entirely dependent on firewood,
- Appliances usage: rural household mostly radio & mobile phone, nothing else

General Considerations

- In Rwanda, urban and rural use of electric appliances differ a lot except for radio and mobile phone usage. Rural household electrical appliances are almost exclusively radio and mobile phones.
- Rural population depends entirely on firewood for cooking. Urban population about half of that and the other half on charcoal. So very little electricity available.
- In Rwanda, 72% of Urban households use electricity, whereas only 12% of rural households do

INDICATOR	VALUES
Population (million)	**11.3** (2014)
Population grow rate (%)	**2.4** (2014)
Rural population (% of the total)	**72** (2014) **(8.1 million)**
Urban population (% of the total)	**28** (2014) **(3.2 million)**
Urbanization rate (%)	**5.5** (2014)
People without access to electricity (% of total)	**94** (2014)
GDP (billion USD)	**7.9** (2014)
GDP Per Capita (current USD)	**696** (2014)
Final Energy consumption by sector (%) *IEA - Balances for 2014*	**Residential: 91 Industry: 3 Transport: 4 Other:2**
Final Energy consumption by fuel (%) *IEA - Balances for 2014*	**Biomass: 86 Petroleum product: 10 Electricity: 4**
Off-grid population (million) *Off-Grid Solar Market Trends Report 2016*	**N/A**
Electricity consumption (kWh/per capita per year *IEA - Balances for 2014*	**80**
Electricity cited as business constraint (% firm) *Africa Cooking with electricity - World Bank, Enterprise Survey Database (2015)*	**N/A**
Power outages (day) *Africa Cooking with electricity - World Bank, Enterprise Survey Database (2015)*	**N/A**

Fuel used for cooking (%)	National	Rural	Urban
Population with access to modern fuel (Electricity, Gas or Kerosene) (%)	0.2	0	0.8
Population using wood (%)	92.1	98	58.2
Population using charcoal (%)	6.5	1.3	37
Population relying on solid fuel that use improved cook stoves (%)	-	-	-

Housing characteristics (%)		Urban	Rural	National Average
Electricity	Yes	72.9	12.4	22.8
	No	27.1	87.5	77.1
Cooking fuel	Electricity	0.3	0.0	0.1
	LPG/natural gas/biogas	1.5	0.1	0.3
	Kerosene	0.6	0.0	0.1
	Charcoal	65.5	4.8	15.3
	Wood	26.1	76.7	68.0
	Straw/shrubs/grass	2.9	16.7	14.4
	Agriculture crop	0.0	0.6	0.5
	No food cooking in household	2.9	1.0	1.4
	Percentage using solid fuel	94.6	98.9	98.1

Souce: Rwanda - Demographic and Health Survey 2014-2015

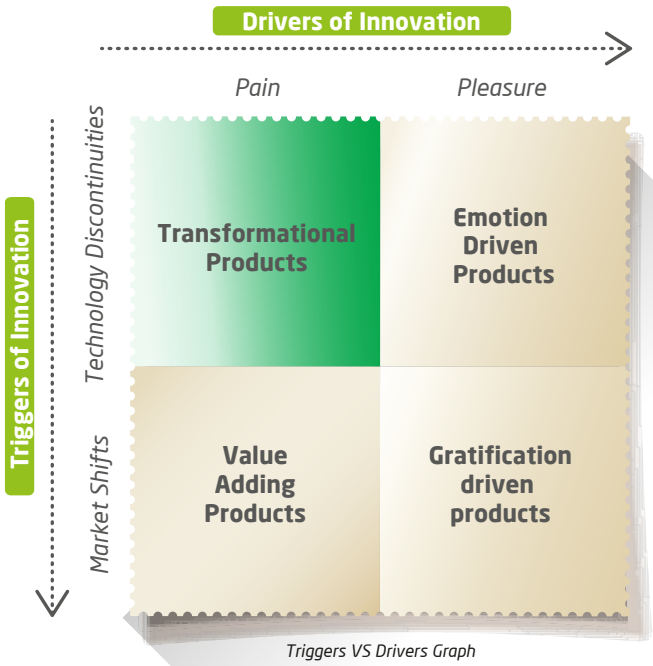
Housing possession (%)		Urban	Rural	National Average
Household effects	Radio	67.1	51.9	54.5
	Television	38.6	3.6	9.6
	Mobile telephone	86.4	54.2	59.8
	Non-mobile telephone	1.0	0.1	0.2
	Refrigerator	8.4	0.2	1.6
	Computer	13.9	1.0	3.2

BUSINESS MODEL

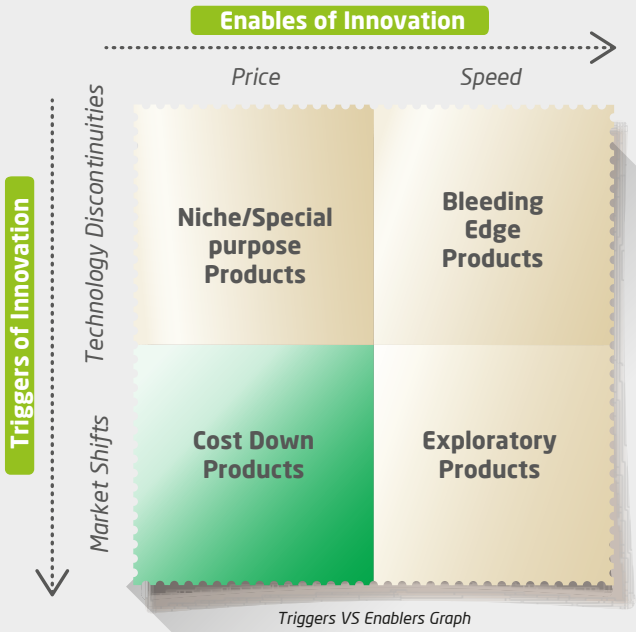
Drivers for an effective Innovative Business Model: The innovation cube theory

Giving the fact that the innovation could be pushed by several factors, it is interesting to visualize the different dimensions by using the "Innovation Cube" theory and thereby to assess where the business model presented in the paper could be located. Here below the classification of the Drivers, Triggers and Enablers according to the Innovation Cube theory.

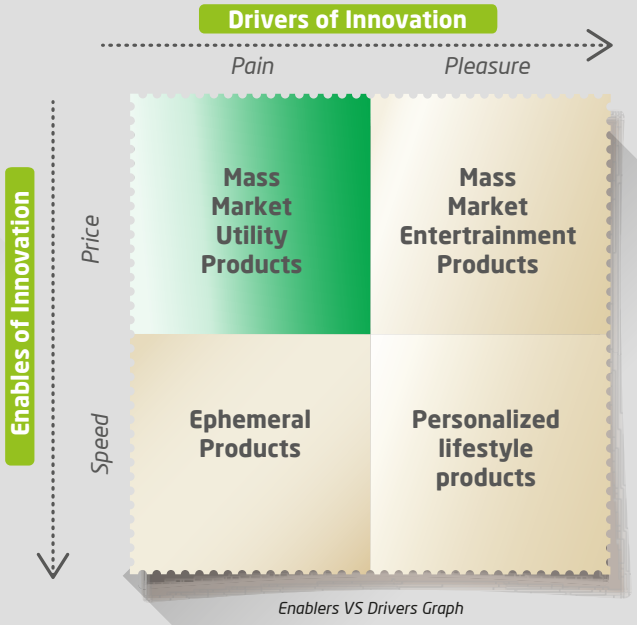
The three graphs show the three faces of the cube which combine the three axes (Triggers, Drivers, Enablers) in a way to indicate (in this case in GREEN) where the innovation is located and which needs and requests the innovative business model should address.



Triggers VS Drivers Graph



Triggers VS Enablers Graph



Enablers VS Drivers Graph

BUSINESS MODEL

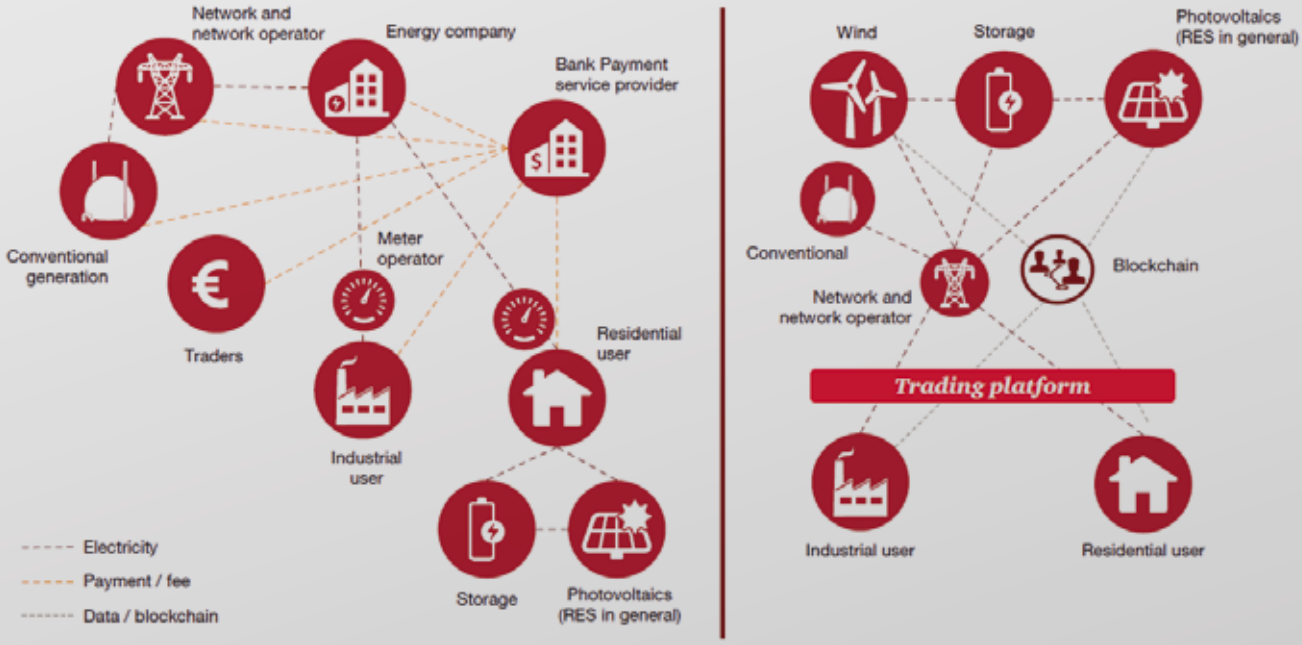
Innovative Business Model: Platform-based model for energy trading in peri-urban and rural communities in Africa

By summing up the considerations previously made with the innovation cube theory, it is possible to draft a business model that leverages on the main innovation drivers in a way to be economically viable, effective and with a real impact on the customers behaviors and preferences.

In this perspective, small-scale, community micro grids represent a decentralized and sustainable energy management solution maximizing the value of Distributed Generation which otherwise would not be used at its full potential. They also allow for its further optimized development by mostly using the existing energy infrastructure.

The implementation of the trading platform is based on blockchain, the same technology that underpins open source, peer-to-peer cryptocurrencies like Bitcoin. Local residents through their cellphones can sell their excess energy from rooftop solar power installations, batteries, or diesel generators or buy electricity in case of shortage. The figure shows a possible re-arrangement of a grid based on the peer-to-peer exchange platforms in respect of a traditional set up of the grid mostly based on the centralization of the energy generation.

The platform gives communities better access to electricity, sustainable cooking and most of all the possibility of making profit from electricity trading with reduced transaction costs. By buying energy locally, rather than from a national entity, financial resources flow back to the people in the community contributing to its further development. The ability to have a "auto-balanced" electricity community generates also additional benefits to the grid as a whole, contributing to grid balancing and grid stability and reliability, which in turn provides local industries with more stable power provision.



Source: Blockchain – an opportunity for energy producers and consumers? – PwC global power & utilities

BUSINESS MODEL CANVAS

For making the virtual trading platform available and running, the provider charges a fixed fee for platform use in addition to an on-top transaction fee for each MWh traded. The provider receives also an additional revenue stream from the distributor for the provision of balancing services.

Here is the so called Business Model Canvas which depicts what just explained above. The canvas aims to show in a clear and synthetic way the revenues stream and the cost structure, the value propositions. key partners, activities and resources and finally the customer relationship by focusing on the segment and the channels.

Key Partners

- GOVERNMENTS
- LOCAL DISTRIBUTORS
- REGULATORS
- LOCAL COMMUNITIES
- BATTERY PROVIDES
- PV PANEL PROVIDERS
- BOP PROVIDERS
- SYSTEM INTEGRATORS
- COOKING APPLIANCES PROVIDES
- SMART METER PROVIDERS
- LARGE INDUSTRIAL PLAYERS

Key Activities

- Grid balancing mgmt
- Asset mgmt
- Trading platform mgmt
- Energy sales
- System installation

Key Resources

- Grid distribution
- Data management algorithms
- Trading platform
- Commercial network

Value Proposition

- Profits from trading
- Grid stability & reliability
- Pay-as-you-go
- Energy access
- Sustainable cooking
- Industrial benefits from grid stability
- Value from otherwise unused DGs
- Grid balancing
- Reliable user profiles
- Capacity building

Customer Relationship

- Fidelization
- Services sold with the assets
- Social responsability and CSV projects

Channels

- Local distributors
- Advertising
- Door-to-door publicity

Customer Segment

- Sub-urban populaton with un-reliable access to electricity
- Industrial sector
- Agri-tech sector
- Rural population

Cost Structures

- Storage system
- Distribution grid (off-grid)
- PV generators
- O&M trading platform
- Smart meters
- Grid balancing
- Trading platform by blockchain
- Capacity building

Revenues Structure

- Energy sales
- Transactions among prosumers
- Fixed cost for system loan
- Fees from distributors for system balancing
- Trading on existing diesel generators

CONCLUSION

The development of renewable energies in Sub Saharan countries is a challenge and an opportunity. The countries in the region represents a rare playground for innovation and sustainable projects, as they need not only cheap electricity but electrification. This allows to implement local renewable energies, in a micro or mini grids model needing cutting edge technologies to be monitored.

With the quick integration of the internet and mobile phones in these countries and the important share of unbanked population, numerous companies are looking towards innovative technologies like pay-as-you-go devices and cryptocurrencies. Hence, the white paper explores the possibilities of Distributed Ledger Technologies (DLT), commonly known as blockchain, to monitor off-grid areas and allow an internal electricity market between peers. With the grid fed mainly with RE and the support of batteries, the DLT allow an automated and optimal repartition of the electricity between customers and batteries, so the grid is permanently balanced.

However, the business model highly depends on evolutions in different sectors. Indeed, real time smart meter prices need to decrease and so do the DLT monitoring costs, with the difficult transition from a Proof of Work security system, consuming tremendous amount of energy, to a Proof of Stake system, with almost no costs and no energy used. The storage plays also a key role and its costs need to get much lower for an implementation in the poorest areas of Africa. Collateral innovations such as electric cooking systems could establish a virtual mechanism in which healthier and less polluting technologies could first improve the quality of live of millions of people and secondly increase the energy consumption and so foster the deployment of the decentralized generation and the aggregation platforms. In this perspective, a frugal approach to innovation, meaning to do better with less, will surely play an important role to make this real.

This may seem quite a few conditions, but each of these technologies are in their respective areas the very centre of the research, which makes them most likely to be improved in efficiency and cost in the near future. And although there is a growing scepticism towards the use of the blockchain in the energy sector, there is also more and more start-ups going towards these innovative models, often backed by big companies and gathering millions of euros to start their projects.

Finally, the paper also explored the possibilities for vehicle to grid applications, tokenisation of the electricity produced, using a cryptocurrency inside the system to flatten the price curve along the day for the customers while allowing arbitrage opportunities for investors. These new opportunities are found to be relevant considering the predictions of future grid architecture: integration of the IoT, the V2G, the tremendous data collection, the interconnection between all kinds of devices.

About RES4MED&Africa

RES4MED&Africa promotes the deployment of large-scale and decentralized renewable energy solutions in Southern-Mediterranean and Sub-Saharan African countries to meet local energy needs. Since its inception in 2012, the association gathers the perspectives of a member network from across the sustainable energy value chain.
RES4MED&Africa functions as a platform for members and partners of emerging markets to foster dialogue and partnerships, share knowledge and build capacity to advance sustainable energy investments in Southern-Mediterranean and Sub-Saharan African countries.

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