Malawi Community Energy Sustainability Extension

Market Assessment Training

20th – 22nd January 2016

Lilongwe

Community Owned Renewable Energy Minigrids

Aran Eales

University of Strathclyde

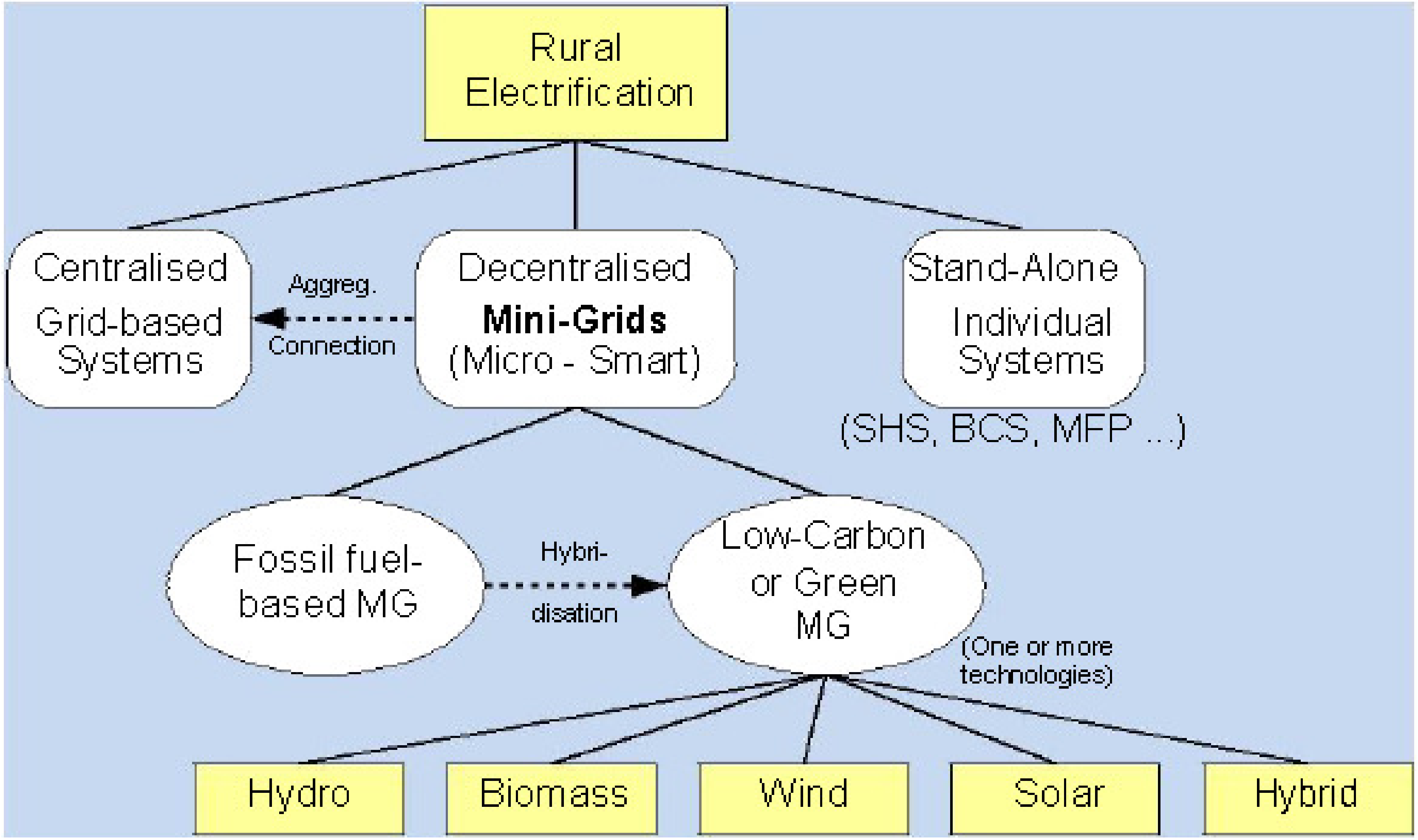
Contents

- Minigrids overview and definition
- Examples
- Discussion: Identifying Opportunities for CEM

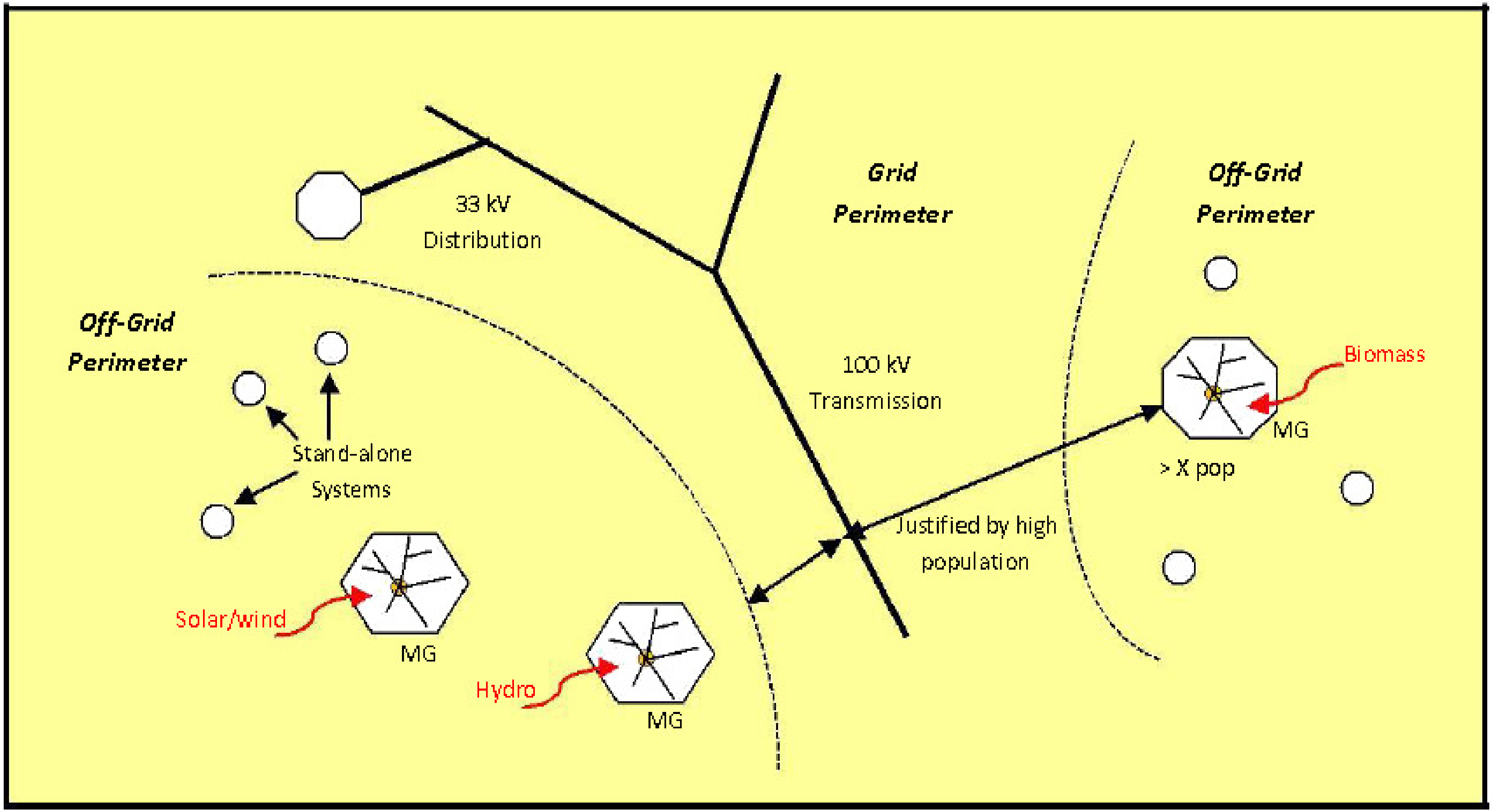
Predictions for Electrification in SSA

Method of Electrification	Grid extension/ densification	Mini-grids (multi-user systems)	Household systems (one user systems)
Example	3MW Hydro Power Plant	100kW Wind-Diesel Hybrid	Solar Home System
Predicted Number of People in SSA	550 million	225 Million	225 million

Options for Rural Electrification



Minigrids are far from the grid



alawi: Population density and distance to grid

Table 3: Malawi Population Density and Distance to the MV Network

	Population living at less than 5km of medium voltage (MV) line	Population living at more than 5km of medium voltage line	Total
Population living where density <250 hab / km^2	2,285,822 (14%)	4,508,842 (27%)	6,794,664 (40%)
Population living where density >=250 hab / km^2	5,437,076 (32%) Extension of MV	4,545,807 (27%) Mini-grids	9,982,883 (60%)
Total	7,722,898 (46%)	9,054,649 (54%)	**16,777,547**

Green Mini-Grids (GMG)

"*local power networks that uses distributed energy resources and manages local energy supply and Demand*" (Lilienthal, 2013).

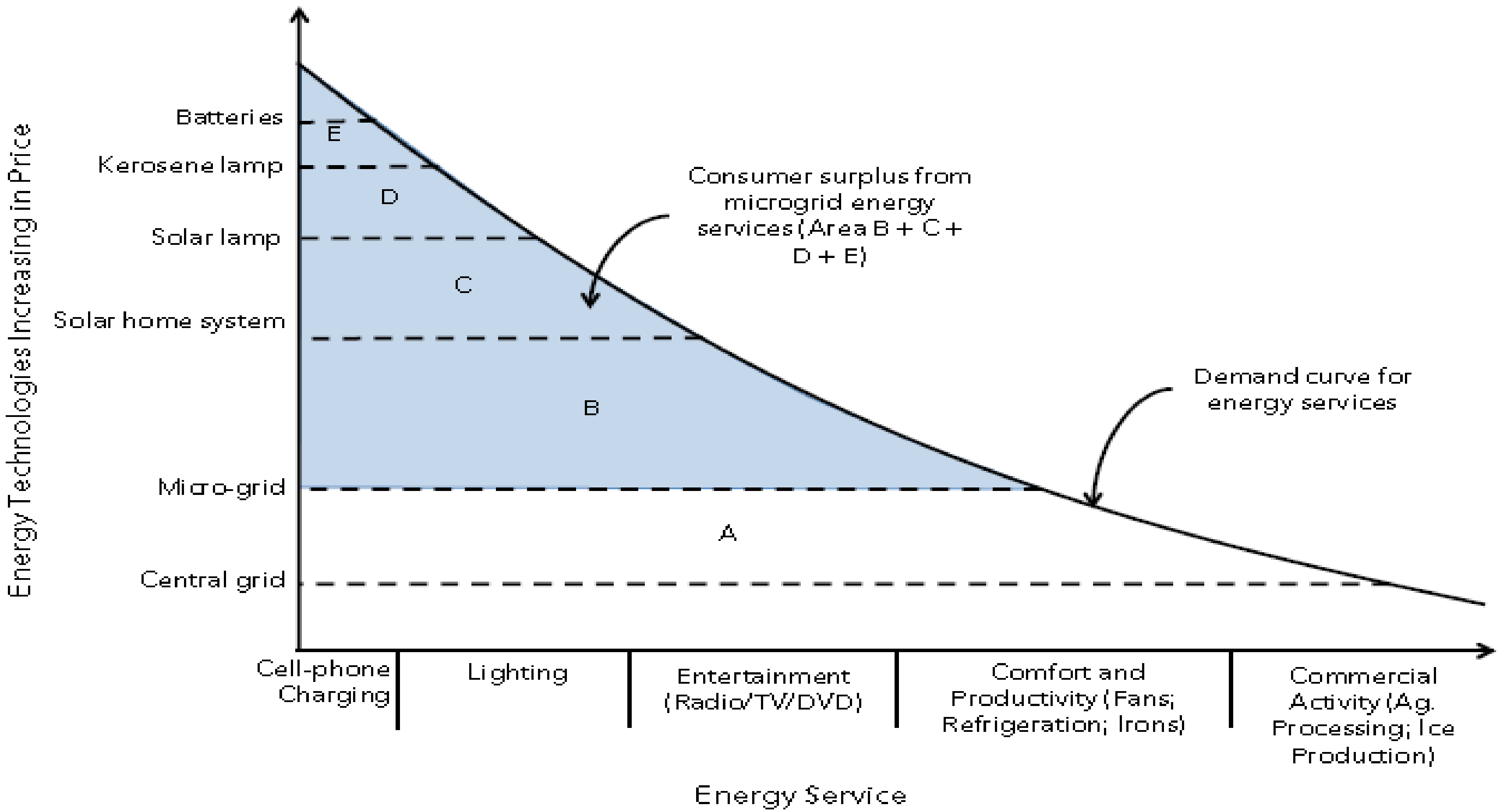
Benefits:

•Increased participation of local people in the supply of energy services
•Increased equity in distribution and consumption
•Empowerment through local management

Drawbacks:

•Unpredictability and intermittency of renewable sources of energy
•Leads to additional costs for energy storage
•Long project development times

Cost savings to the consumer



Solar Diesel Minigrid Overview

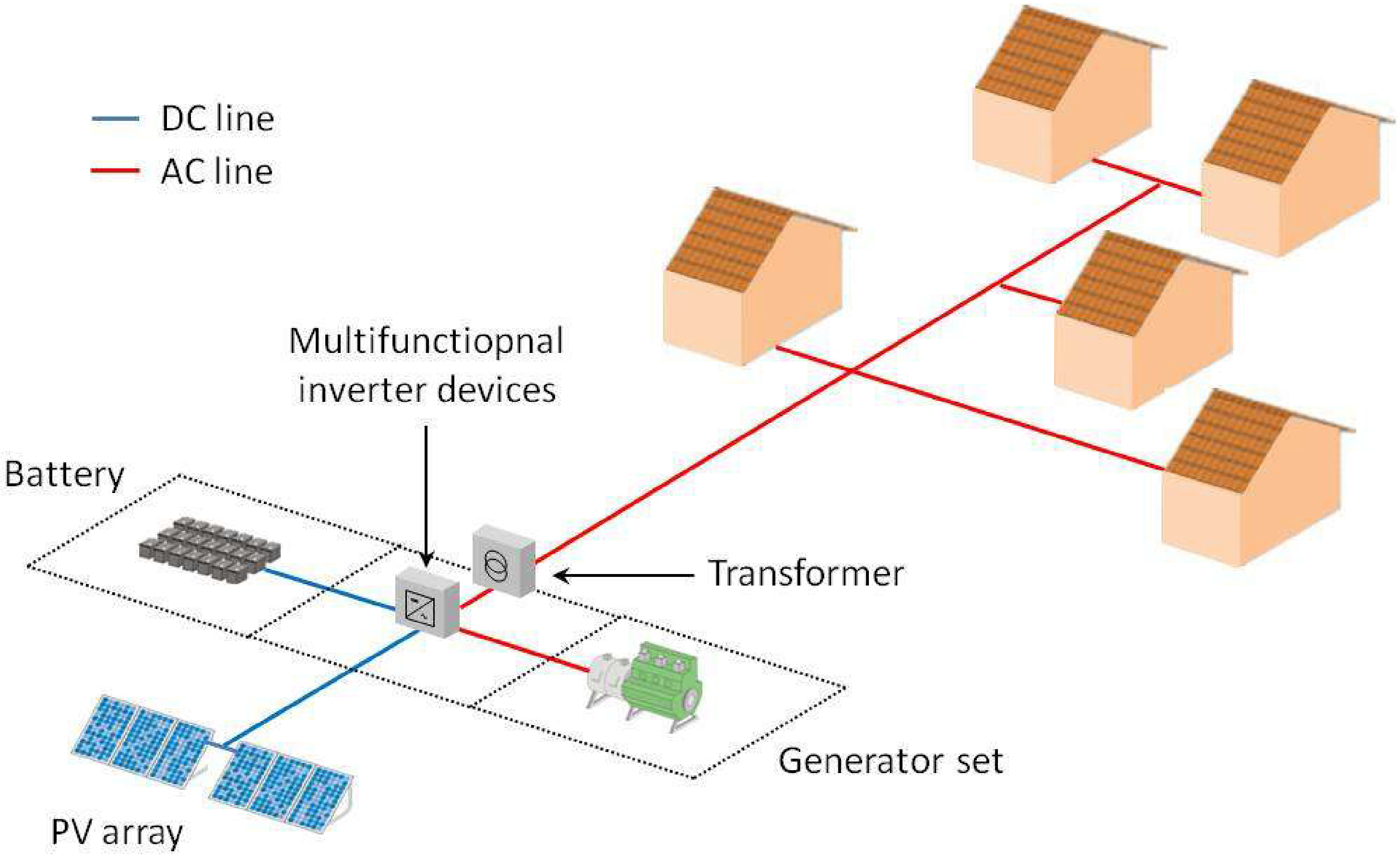


Figure 3. Schematic of a solar-diesel hybrid mini-grid system (DfID, 2013).

DE Benefits – Energy Access

What is decentralized electricity?

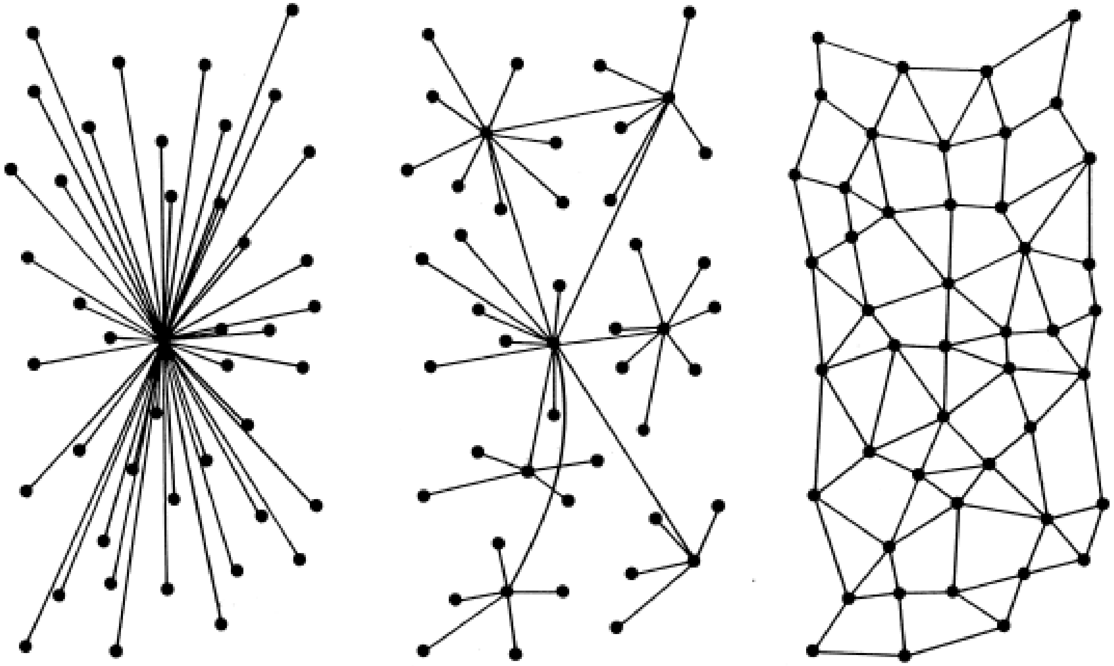
- Decentralized electricity: generating electricity from many *small, local energy sources*
  - High efficiency cogeneration
  - On-site renewable energy
  - On-site power
- Centralized electricity: large power plants generally located far from loads
  - Coal
  - Nuclear
  - Large hydropower
  - Natural gas (CCGT)

The Move to Decentralized Technology

vs.

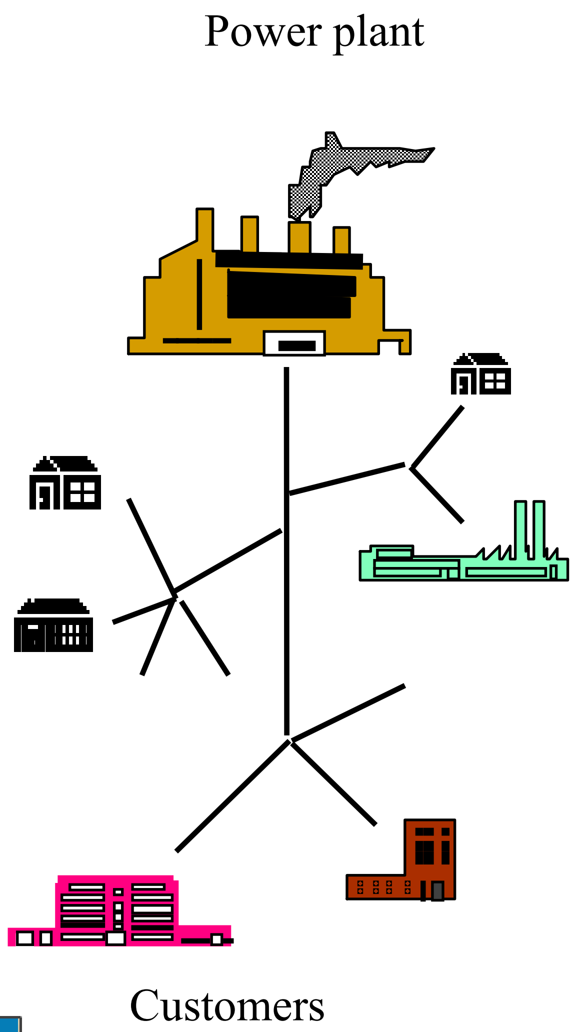
vs.

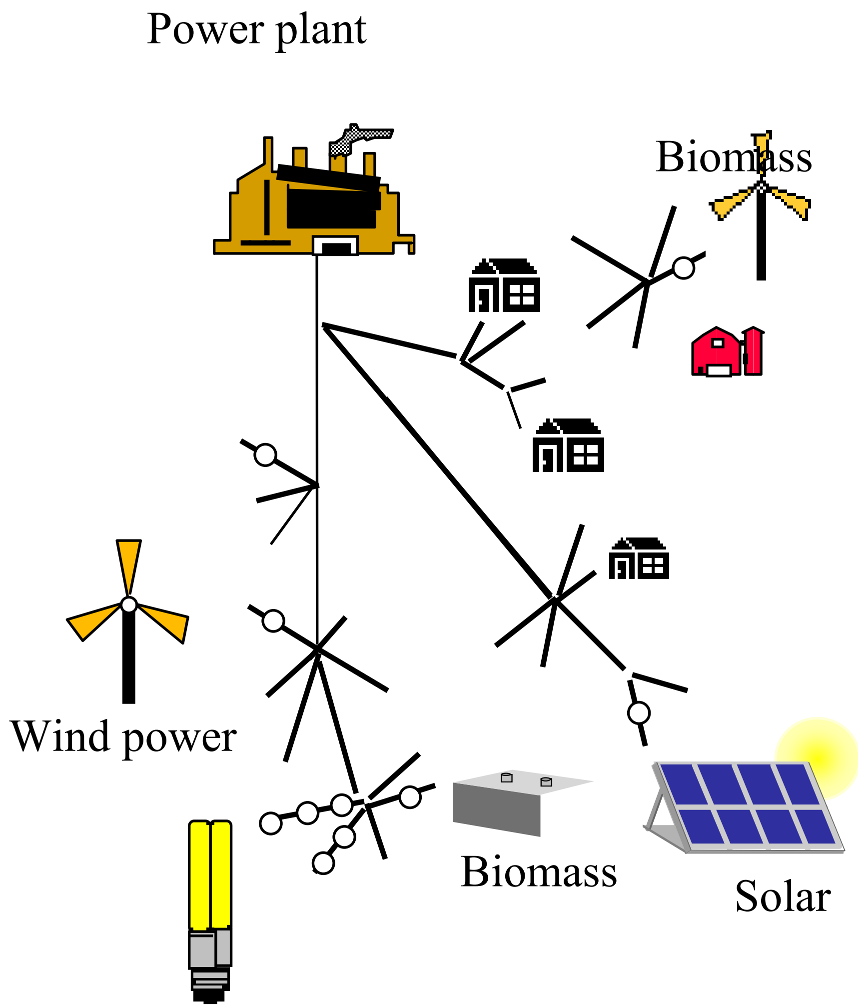
Decentralized Technologies



Centralized Decentralized

Old vs New





Energy efficient end-use, or dispatchable loads

Micro-grid vs. Mini-grid

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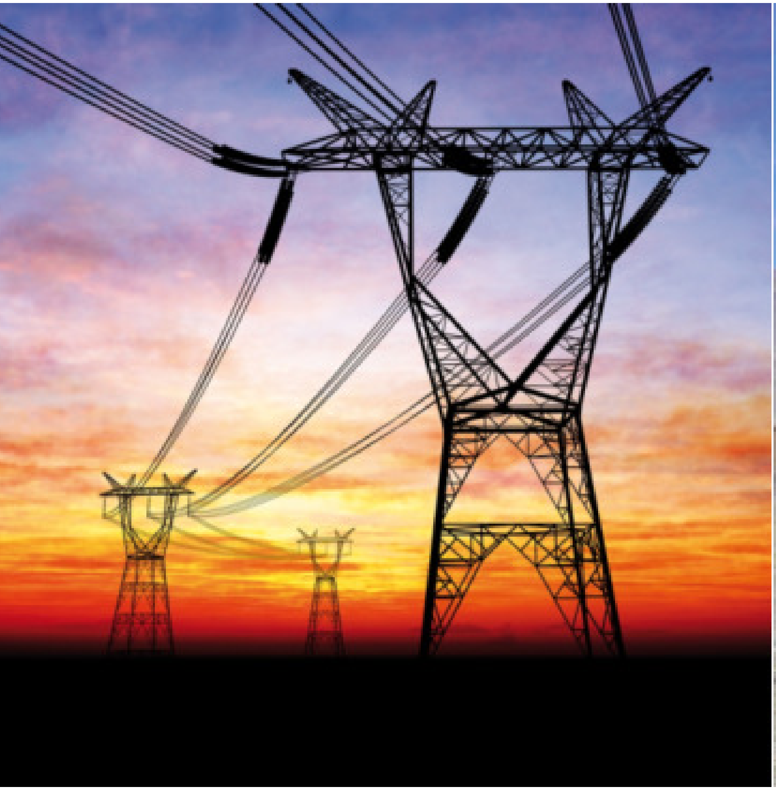

GRID EXTENSION

MINIGRIDS

STAND-ALONE

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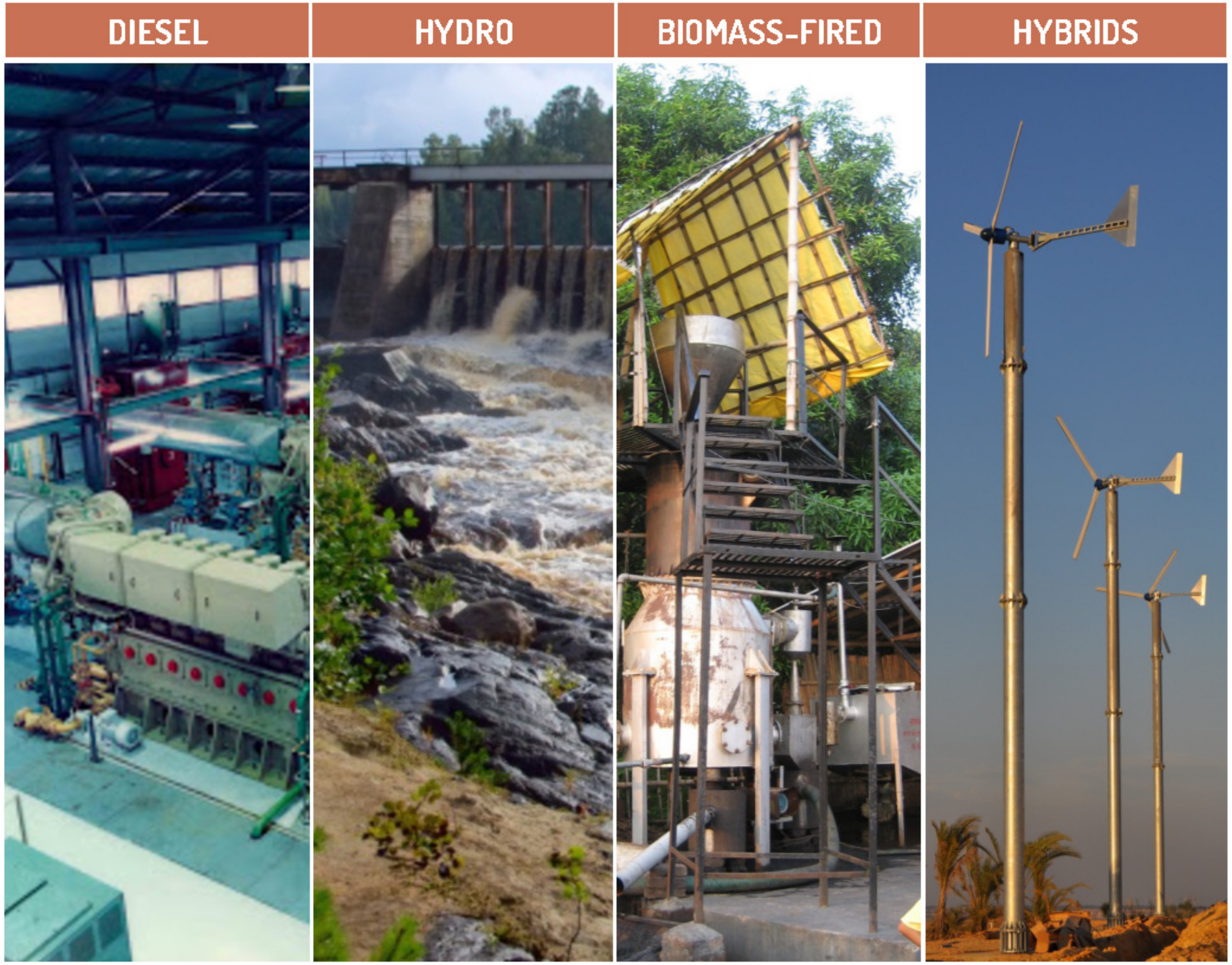
Types of Mini gird technology



DIESEL | HYDRO | BIOMASS-FIRED | HYBRIDS

TECHNOLOGY

DIESEL MINIGRIDS

- powered by diesel or fuel-oil
- Remote towns, tourism resorts and business centres.
- Distribution grid.
- Operation times depend on load requirements and ability to pay.

TYPICAL SIZE & USES

10 kW to 1MW

- Village electrification
- off-grid & back-up power

EXPERIENCE AND LEVEL OF MATURITY

- Utility-provided. Rural electrification agencies subsidize connections --- consumers reduced prices (Africa-wide practice).
- **Commercial-model:** Operate on private basis --- consumers pay fee based on number of appliances

NUMBERS IN AFRICA

Thousands in use all over Africa

Case studies:

Somalia

Kenya

PROS

- Low CAPEX
- Mature technology
- Solar PV & wind can be added to lower cost,
- Commercial models established
- Potential for bio-diesel fuels

CONS

- High OPEX (fuel expense & delivery)
- Carbon emissions
- Fuel theft
- Intermittent use times

DIESEL | HYDRO | BIOMASS-FIRED | HYBRIDS

TECHNOLOGY	TYPICAL SIZE & USES	EXPERIENCE AND LEVEL OF MATURITY
HYDRO MINIGRIDS Powered by hydro plant (whether micro- or mini-) utilize cascading water to power electric turbines.	Up to 1MW; village electrification, plantations, tea sector, religious missions.	• Traditionally in remote settlements and religious missions in mountainous areas. • Asia: more active hydro market • In past: many mission settlements used hydro mini-grids. • Renewed interest in small hydro mini-grids tea sector & RE

438 kW micro-hydro project Musarara, Rwanda

NUMBERS IN AFRICA	PROS	CONS
Hundreds (?!) Cameroon, DRC, Ethiopia, Kenya, Rwanda, Tanzania, Uganda.	▪ Mature technology ▪ Low cost power ▪ No fuel needs	▪ Requires constant hydro resource ▪ Location-specific ▪ Many locations already near grid power

Case study:

Rwanda

DIESEL | HYDRO | **BIOMASS-FIRED** | HYBRIDS

TECHNOLOGY

BIOMASS-FIRED

Bio-waste, residues or biogas fueled generators. Power is distributed as with other types of minigrids.

Husk Power Systems, India
Xx MW in village xx

TYPICAL SIZE & USES

Up to 1MW
Sugar/wood plantations, sawmills, agro-industry.

EXPERIENCE AND LEVEL OF MATURITY

- Mature technology employed in plantations to reduce power expenditures.
- Sugar plantations: bagasse.
- Potential utility feed-in tariffs.
- Interesting Asian experiences (see India –Husk Power case study).

NUMBERS IN AFRICA

100's of sites.
Cameroon, Ghana, Kenya, Malawi, Mozambique, Swaziland, Uganda, Tanzania.

Case studies:

India
Tanzania

PROS

- Relatively low cost power
- Plentiful, low-cost fuel

CONS

- Limited African experience in rural electrification
- Location-specific

DIESEL | HYDRO | BIOMASS-FIRED | **HYBRIDS**

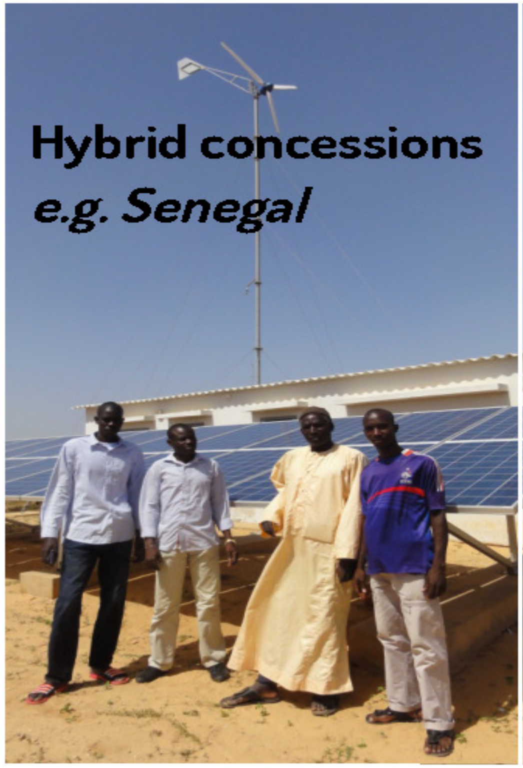
TECHNOLOGY	TYPICAL SIZE & USES	EXPERIENCE AND LEVEL OF MATURITY
AC-COUPLED INVERTER HYBRID MINIGRIDS Systems manage solar, wind, battery and generator combinations for supply to small distribution networks.	2kW to 300 kW	▪ Recent technical improvements. ▪ Advanced inverter, power management & metering --- increased opportunities. ▪ Greatest near-term potential -- size adaptability & combination with diesel generators.

Hybrid minigrid in Tsumkwe, Namibia 201 kW solar array

NUMBERS IN AFRICA	PROS	CONS
Scores of projects. Rural energy agency NGO, private sector. **Case studies:** Cape Verde Egypt Namibia Senegal	▪ Extremely flexible systems ▪ Falling PV prices ▪ Lower fuel consumption	▪ High investment, especially when battery storage is used ▪ Batteries ▪ Spare parts & maintenance

Mini-grid business models

No "best" mini-grid business model! Context is key.



Mini Grids Business Model

MODEL	POWER GENERATION	POWER DISTRIBUTION	MAIN SITUATIONAL ELEMENTS	LEVEL OF SUBSIDIES	EXAMPLE
rivate sector- Anchor load d)	Private	Private	Firms with power demand/ supply available (agro-industry, telecom or service company)	Moderate	Tanzania wattle
rivate sector- Free market)	Private	Private	Absence of regulation (free price setting)	Financially Viable	Somali diesel grid Tourism/telecomm??
rivate sector with latory ework)	Private	Private	Political preference for option Enabling policy environment	Extremely high up front	Mali concessions Senegal concessions
lity-led grids	Utility	Utility	Political preference for option Political will to pursue this	Extremely high	Kenya Tanzania
mmunity-led	Community	Community	Donor/NGO technical and financial assistance	Extremely high	Cape Verde Namibia
brids (e.g. ic Private nerships)	Private	Utility	Political preference for option Enabling policy environment	Moderate	Rwanda

What is a Small Power Producer (SPP)?

- Small independently operated electricity generator (private, coop or community owned)
- Supplies and usually operates *an isolated mini-grid* or sells to a utility on the main grid or to existing utility-owned isolated grid
- Usually defined by regulators according to size, fuel and technology (10MW or less?). Shou include hybrid generators!
- AKA "distributed generation" (US and Europe) or "decentralized generation" or "decentra distributed generation" (India) or "mini-grids" (worldwide) or "mini-utilities" (IFC 2012)

Household Energy Use

HOUSEHOLD

Customer Type		Total Consumption (kWh/day)	Total Consumption per customer (kWh/day)
High-demand households (>2.92 kWh/day)	23	108.42	4.71
Medium-demand households (0.7 - 2.89 kWh/day)	22	43.37	1.97
Low-demand households (0 - 0.69 kWh/day)	60	47.31	0.79
(sub)total	105	199.10	

INSTITUTIONS

Customer Type		Total Consumption (kWh/day)	Total Consumption per customer (kWh/day)
Secondary school	1	88.71	88.71
Hospital	1	23.00	23.00
Church/Mosque	4	16.26	4.07
Cell phone company	1	6.57	6.57
NGOs	2	4.93	2.47
Youth polytechnic	1	4.11	4.11
Post Office	1	4.11	4.11
Police station	1	2.96	2.96
Commercial bank	1	2.46	2.46
District Officer's Office	1	2.46	2.46
(sub)total	14	155.57	

Policy and Regulatory Framework
Actors in Mini Grid Policy

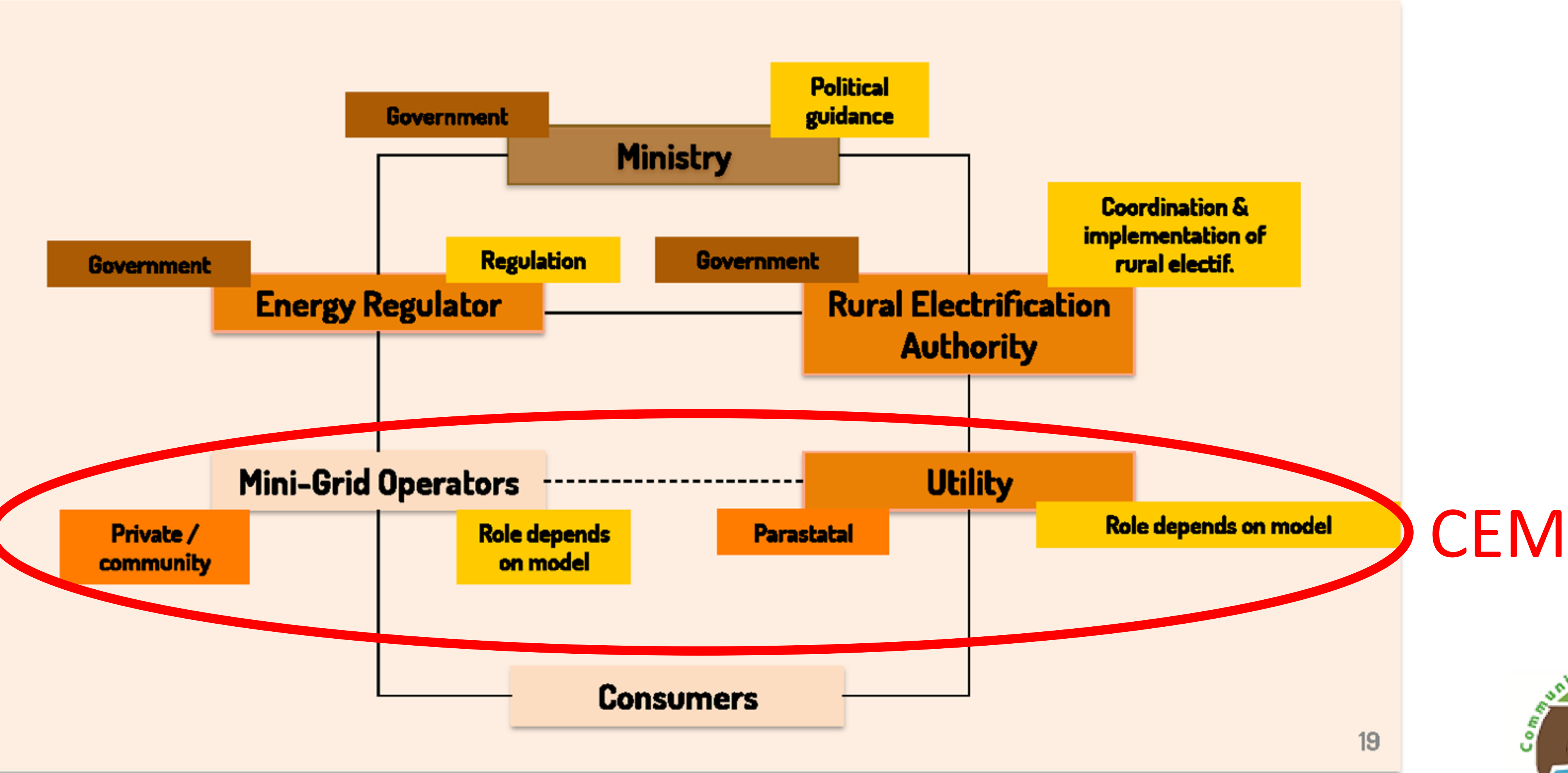
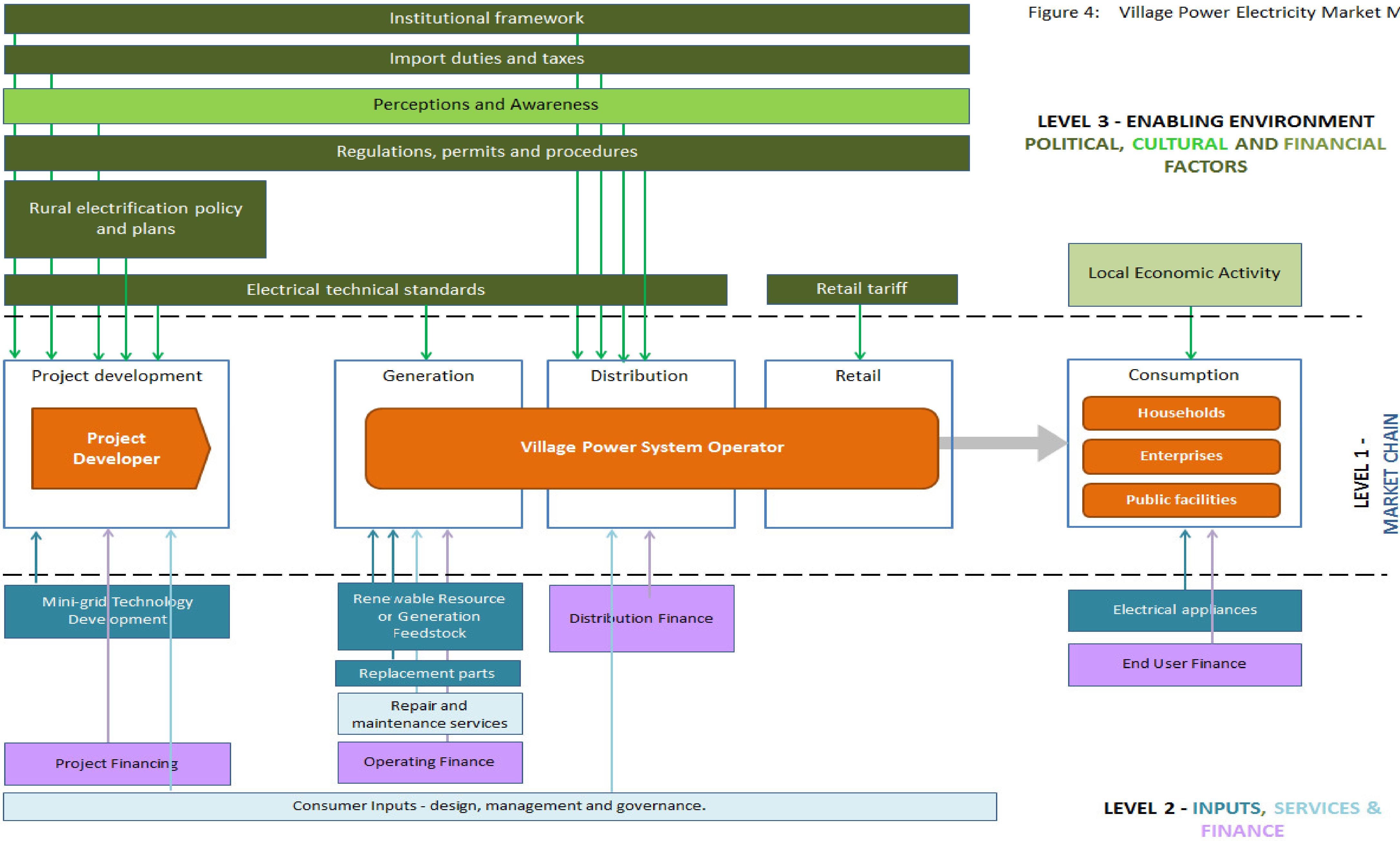
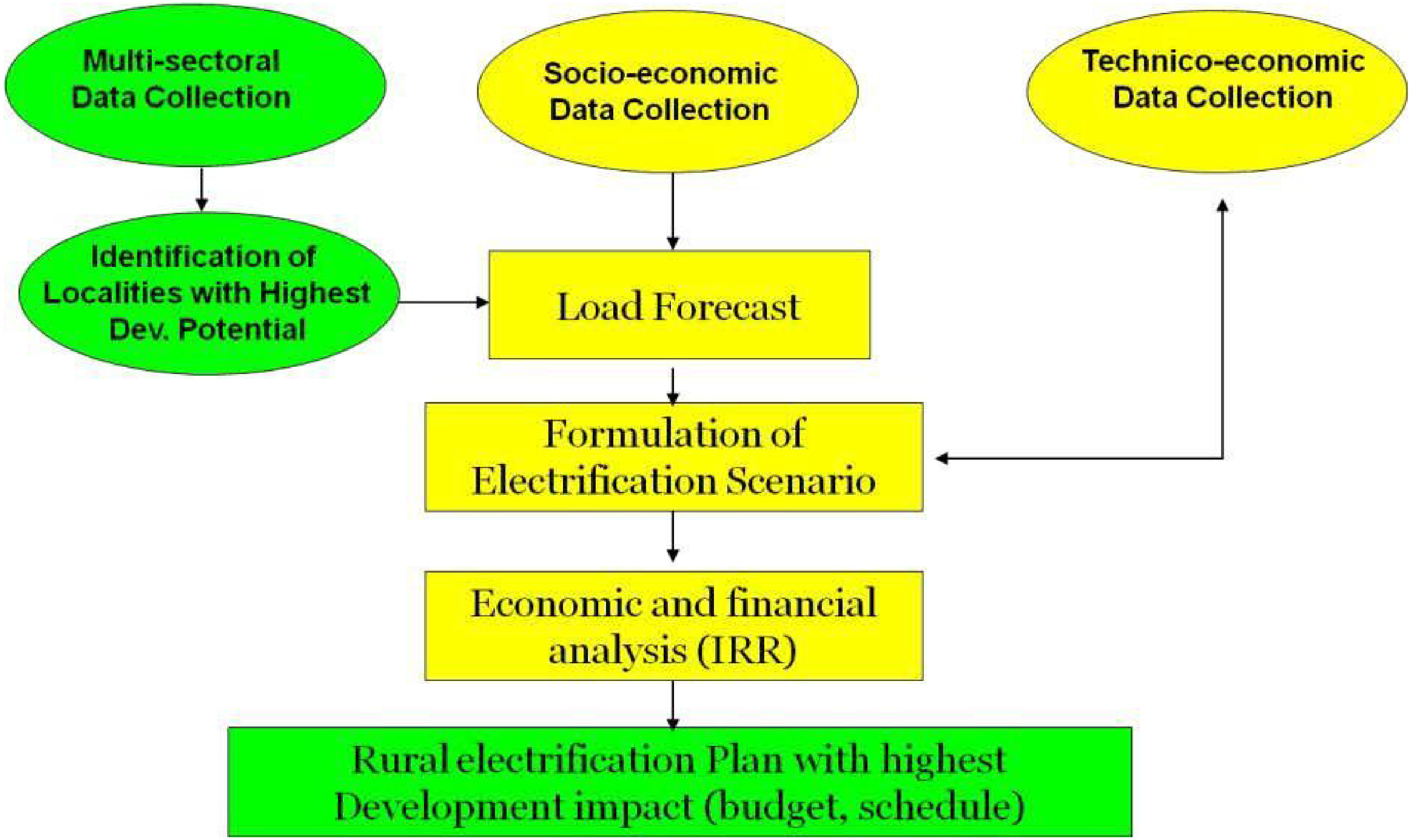


Figure 4: Village Power Electricity Market M



DFID Study on GMG Potential



Discussion:

hat role could CEM play in Minigrid development in Mala

hat gaps are required for CEM to play this role?

hat steps need to be taken to fill these gaps?

What Can CEM achieve?

- Identify potential minigrid applications in the CBO's
- Look out for settlements with houses close together
- Map the locations of the houses
- Run a software simulation for minigrid design
- Do a feasibility study for some of the communities