Economics of RE-based mini-grids: Developers's perspective

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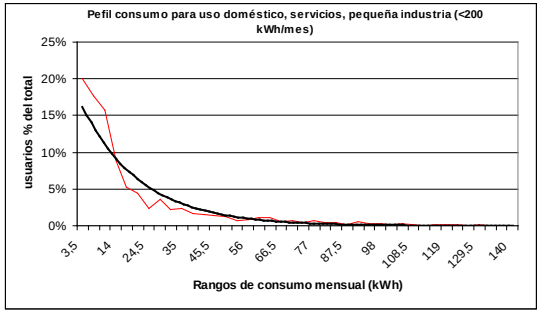
Key question #1 Demand projections – how realistic?

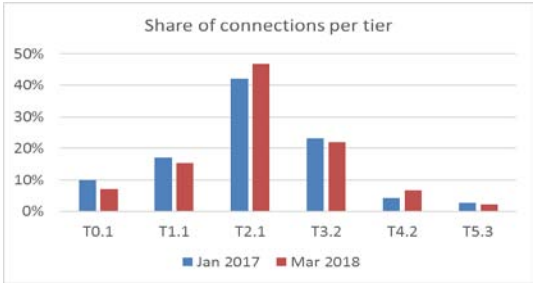


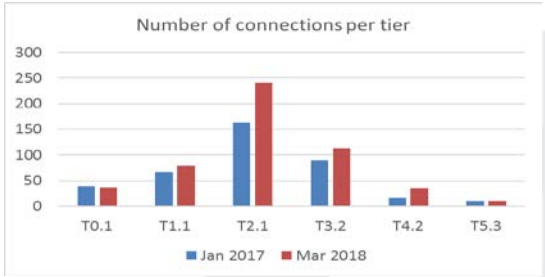
solar individual kits

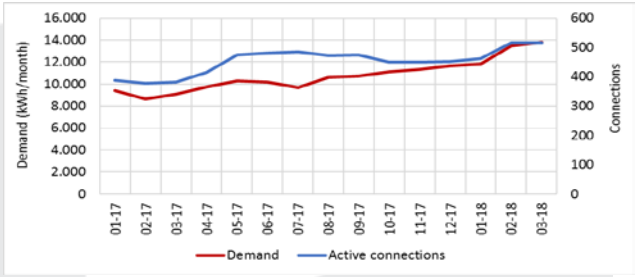
	Tier 0	Tier 1	Tier 2	Tier 3	Tier 4	Tier 5
Capacity	No electricity	> 3 W	> 50 W	> 200 W	> 800 W	> 2 kW
Daily energy		> 12 Wh	> 200 Wh	> 1 kWh	> 3.4 kWh	> 8.2 kWh
Duration (h/day)		> 4	> 4	> 8	> 16	> 23
Reliability		Unscheduled outages			No unscheduled outages	
Quality		Low		Good		

RISK OF: OVERSIZING (grid extension approach) or

UNDERSIZING (not considering potential growth, even short term)

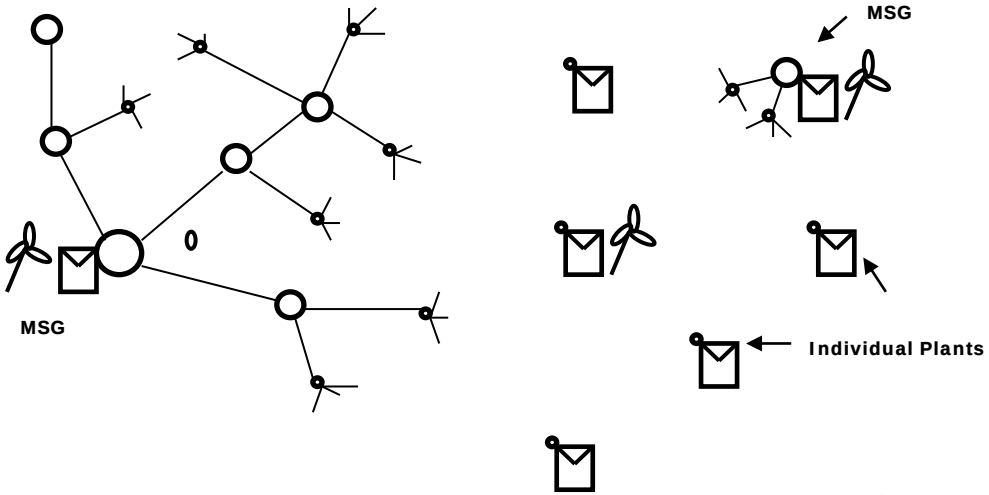






Demand prediction: Example of Ghana – 5 microgrids

VISION: Greenfield microgrids and PV individual plants under the same regulation



ENERGY EFFICIENCY: MANDATORY IN ALL PROJECTS !!

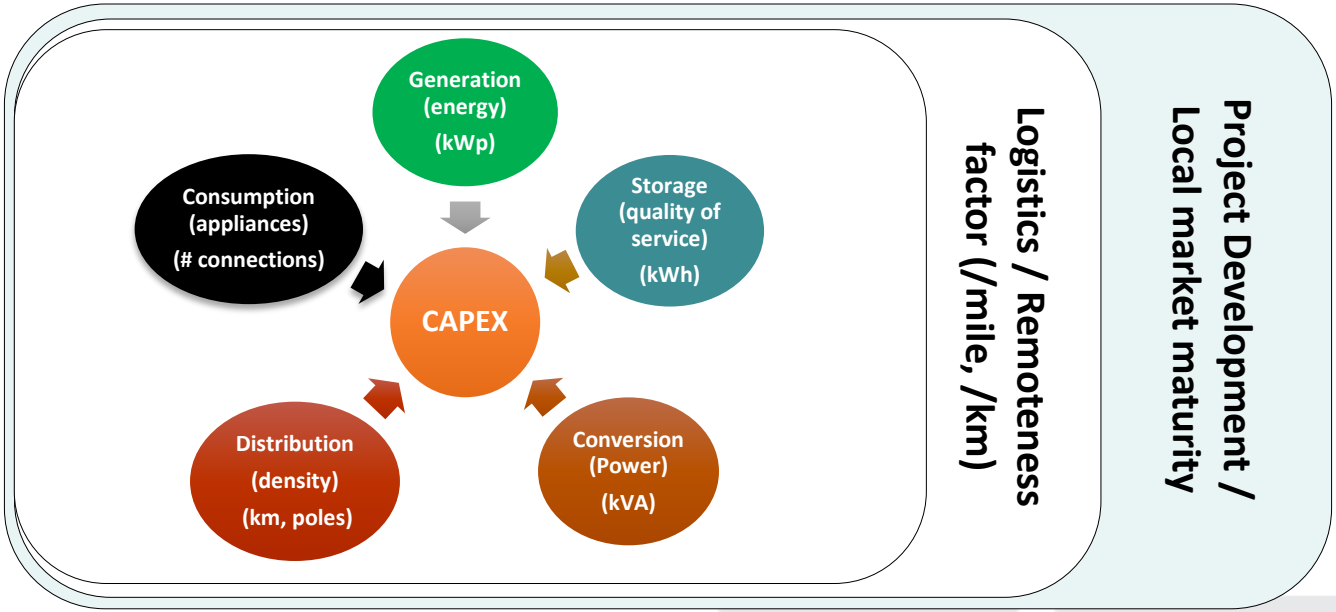
Forfait (fee)			
Code (Txy)	Monthly Fee (CFA)	EDA (Wh/day	Maximum power (kW)
T11	4.100	550	0,5
T21	11.200	1.100	0,5
T41	22.000	2.200	0,5
T72	38.600	3.850	1,0
T82	43.900	4.400	1,0

Key question #2: Are Microgrid cost well understood?

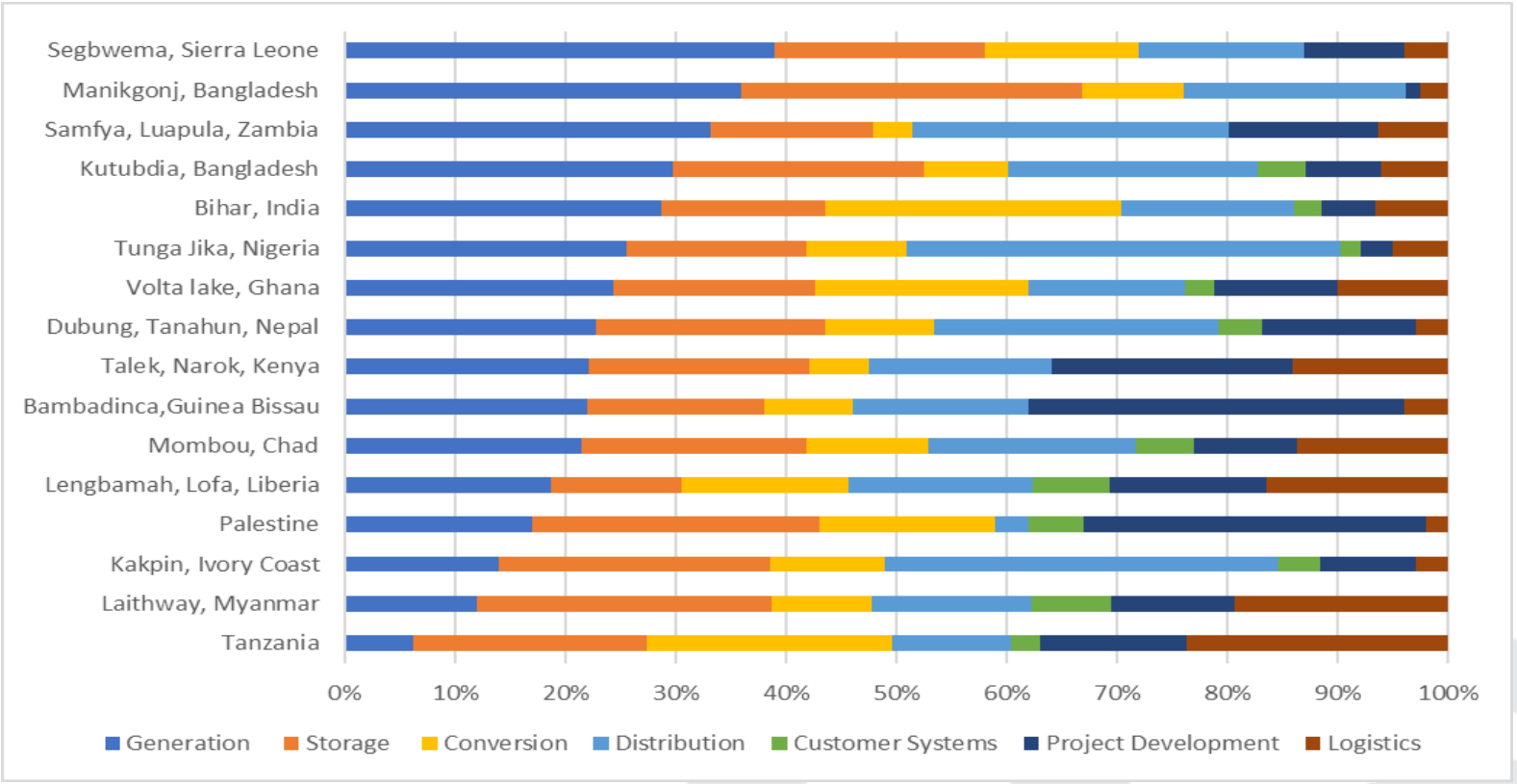
- Type of microgrid: AC vs DC service; central, decentralized or distributed
- Tier of service
- RE sources
- Remoteness
- Market maturity, economies of scale
- RE fraction:

Category	Indicative PV annual energy fraction	Indicative PV rated capacity/load ratio	Characteristics
Low	< 20%	< 50%	No batteries No control Large genset
Medium	20%-50%	> 50%	Batteries 1 d. autonomy Large genset
High	> 50%	> 150%	Batteries >2 d. autonomy Small gensets

Greenfield Microgrids capex



CAPEX study



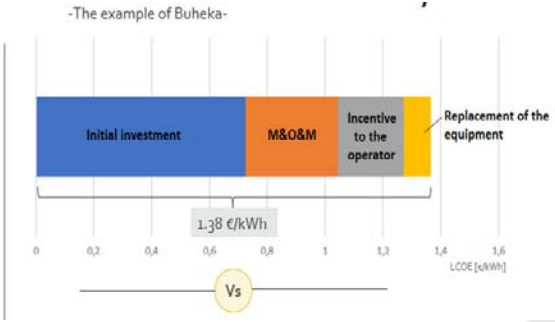
PV hybrid minigrid Cost Benchmark study, TTA-ESMAP 2018

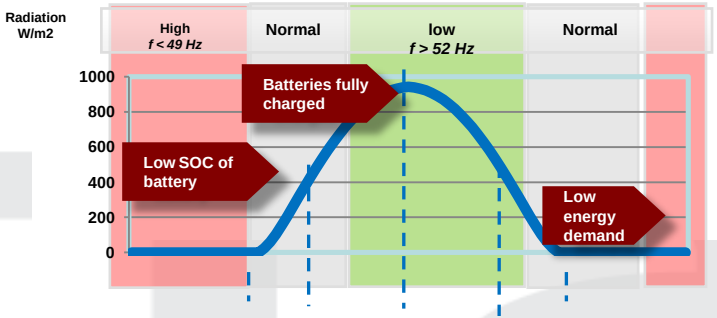
CAPEX per CUSTOMER (Tier of service analysis)

	USD per Customer T1	USD per Customer T2	USD per Customer T3	USD per Customer T4
MINIMUM	$ 318	$ 537	$ 559	$ 2886
MEDIAN	$ 325	$ 1157	$ 2403	$ 5640
MAXIMUM	$ 2336	$ 4929	$ 3779	$ 8279

PV hybrid minigrid Cost Benchmark study, TTA-ESMAP 2018

$$LCOE = \frac{\sum_{t=1}^{20} \frac{C_t}{(1+r)^t}}{\sum_{t=1}^{20} \frac{E_t}{(1+r)^t}}$$

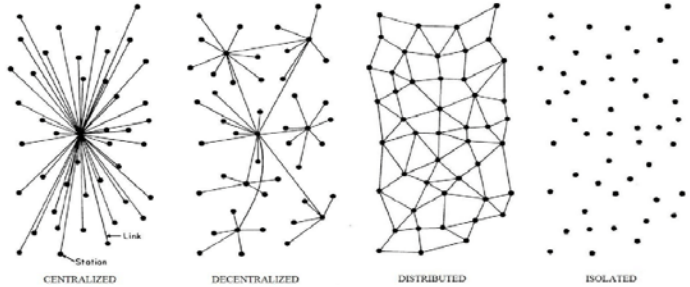


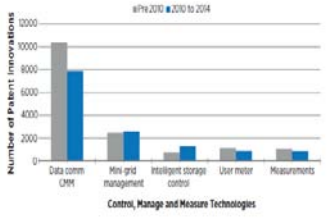


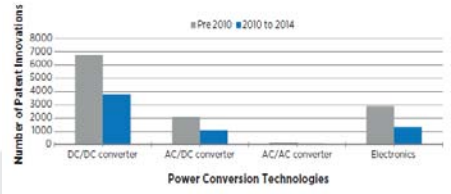
Key question #3: Do we want costs reductions?

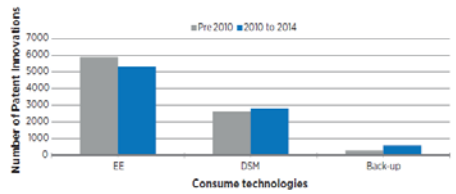
Related to: TECHNOLOGY

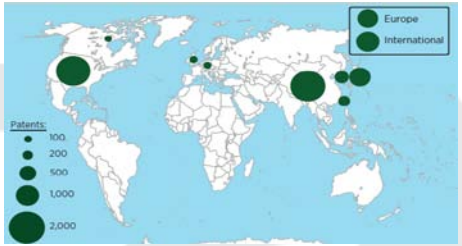
- Innovation
- Storage
- Avoid oversizing / modularity
- Distribution: power or energy? 3-phase AC?, DCLV, DCELV?
- Integrated service with high efficient appliances











IRENA
International Renewable Energy Agency

microgrid technology outlook
patent review

Cost reductions:

Related to: **SOFT COSTS**

- Policy and project planning
- Market regulation
- Customs and taxes
- Local capacity building

Tier (residential)	**EDA (Wh/day)**	**Power (kW)**	**Willingness to Pay fee - O&M and 25%CAPEX (GhS/month)**	**Minimum Cost reflective fee - only O&M (GhS/month)**	**Grid tariff equivalent (GhS/month)**
T01	275	0,5	18	10.0	4.2
T11	550	0,5	30	20.0	6.9
T21	1100	0,5	52	40.2	12.3
T31	1650	0,5	74	60.2	17.7
T42	2200	1	100	8.3	33.6
T53	2750	1,5	120	100.4	44.7

Revenue policy: Example of Ghana – 5 microgrids

Key question #4 Technical standards & level of quality

2013年10月，IEC投票通过由中国主导制定两项IEC微电网国际标准。

OCT. 2013. IEC voted and decided that china lead the development of two IEC international standards about microgrids

2014年1月，IEC/TC8/WG7国内工作组成立，该工作组致力于IEC/TS 62898-1与IEC/TS62898-2两项标准的制定与组组织协调工作。

JAN. 2014. IEC/TC8/WG7 domestic work group, which devote itself to the development and coordinating of IEC/TS 62898-1 and IEC/TS 62898-2, is established.

IEC/TS 62898-1：微电网规划与设计导则

IEC/TS 62898-1:Guidelines for General Planning and Design of Microgrids

IEC/TS 62898-2：微电网运行与控制技术规范

IEC/TS 62898-2:Technical Requirements for Operation and Control of Microgrids

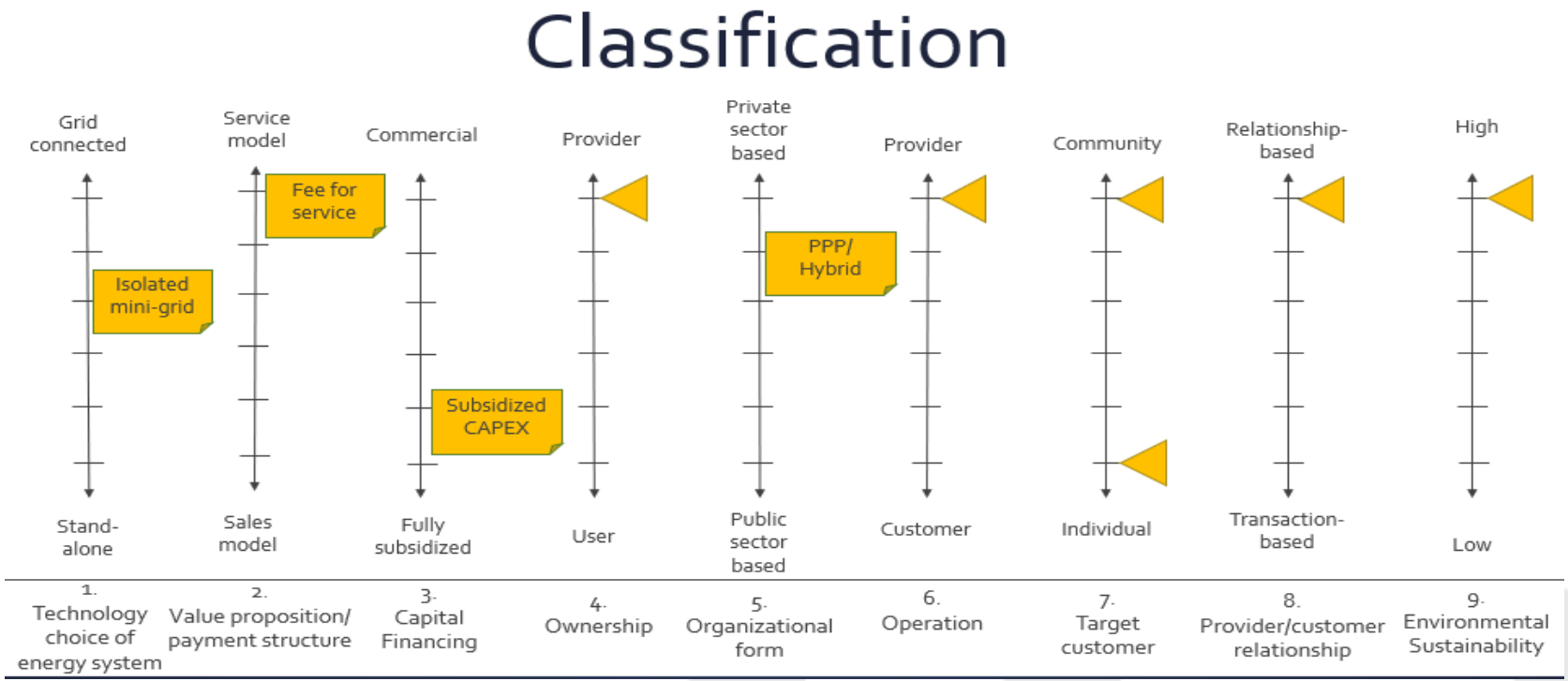
Source: Prof. Zhang Jianhua
North China Electric Power University (presentation given at the Niagara 2016 Symposium on Microgrids)

Source:
Quality Assurance Framework for Mini-Grids (National Renewable Energy Laboratory, U.S. Department of Energy) 2016

Issue	Base Level of Service	Standard Level of Service	High Level of Service
Power Reliability			
Unplanned-SAIFI$_{xx}$[1,3]	<52 per year	<12 per year	<2 per year
Unplanned-SAIDI $_{xx}$[1,3]	<876 hours (90% reliability)	<438 hours (95% reliability)	<1.5 hours (99.99% reliability
Planned-SAIFI$_{xx}$[1,2]	No requirement but should be defined	No requirement but should be defined	<2 per year
Planned-SAIDI$_{xx}$[1,2]	No requirement but should be defined	No requirement but should be defined	<30 minutes - 100% reliability

(1) System Average Interruption Frequency Index (SAIFI) measures the average number of power outages that an average customer experiences in a year and is defined as Total Number of Customer Interruptions/Total Number of Customers Served.
(2) System Average Interruption Duration Index (SAIDI) measures the average number of minutes that an average customer is without power over the defined time period, typically a year.
(3) SAIFI and SAIDI are typically assumed for power systems that are specified to provide full-time energy service 24 hours/day. A subscript is used in this report for systems that provide partial hours/day service since the number of planned and unplanned interruptions and length of any interruptions should be normalized by the percent of hours of service.

Key question #5 Delivery models



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