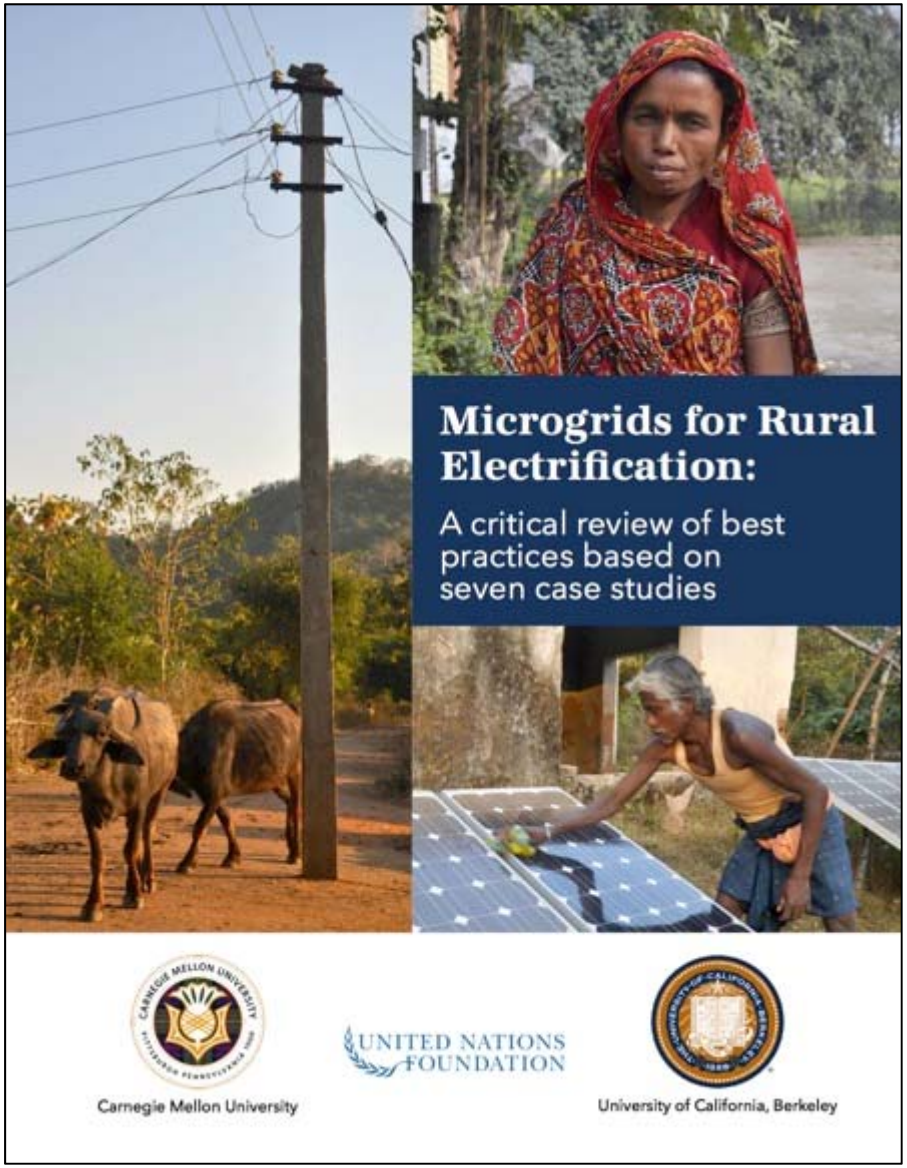

UN Energy Access Practitioner Network Webinar:

The Role of Micro-Grids in Promoting Access to Energy

Dan Schnitzer

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4/22/2014

Motivation for Research

- Recent rapid growth and interest in microgrids
- Dearth of data on tariff structures, microgrid capacity, business models, effect of gov't policies on operations
- What is and isn't working?
  - Strategic planning
  - Operations: Commercial, Technical, Financial
  - Social context
- Are existing best practices valid?

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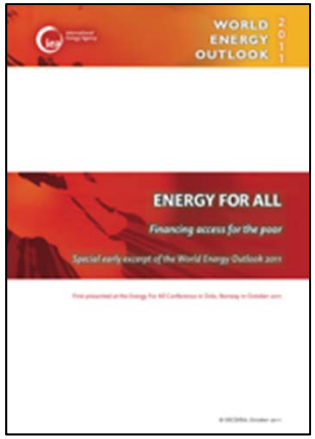
What this report does not address

- Whether microgrids are the "best" approach to rural electrification (see ECA, 2013)

- Whether there is sufficient capital being invested in microgrids to reach SE4All by 2030 (see IEA WEO, 2011)



Generic Model of Microgrid Operations

- Nominal operating schedule:
  - a few days a week; a few hours per day
- Customers charged tariffs
- Volunteers or staff collect tariff payments
- Microgrid operator uses payments to cover O&M
  - Need to pay back capital based on “business model”

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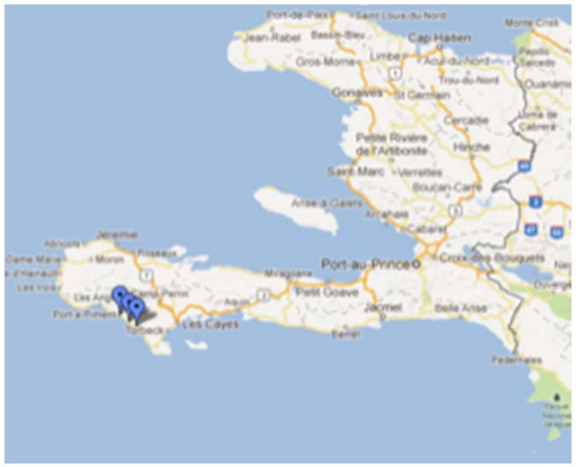
Country Case Studies

India

Malaysian Borneo



Haiti

- Field visits, 2012-2013
- Developer interviews and field visit surveys

Country	# Developers	# Grids Visited
India	4	11
Malaysian Borneo	1	2
Haiti	1	4
Total	**6**	**17**

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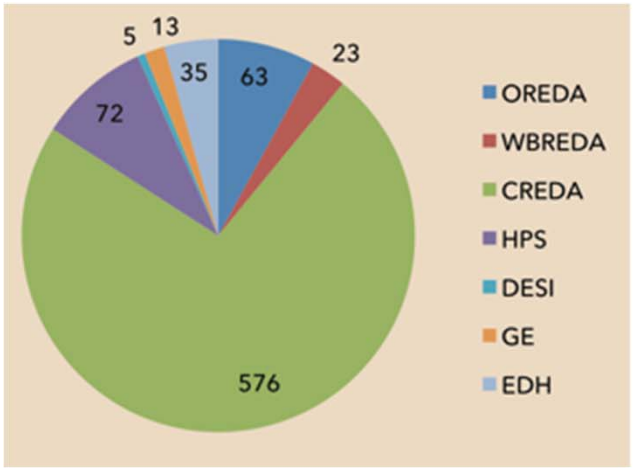
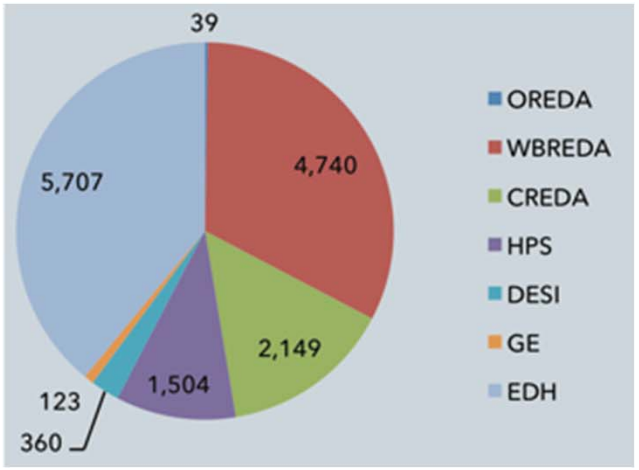
Developer Profiles

Developer	Acronym	Location	Short Description
Desi Power	Desi	Bihar, India	Private developer installing biomass gasifier-powered microgrids in communities with anchor business tenants.
Electricité d'Haiti	EDH	Haiti	EDH is the national utility of Haiti. The microgrids it developers are municipally-owned and operated. All of them are powered by diesel generators.
Green Empowerment/Tonibung/ Pacos	GE/T/P	Borneo, Malaysia	Non-profit micro-hydro microgrid developer integrating community empowerment goals into rural electrification.
Husk Power Systems	HPS	Bihar, India	For-profit company installing biomass gasification systems with multiple business models.
Orissa Renewable Energy Development Agency	OREDA	Orissa, India	Government-funded photovoltaic, lighting-only microgrids for the most remote villages in the state.
West Bengal Renewable Energy Development Agency	WBREDA	West Bengal, India	Government funded photovoltaic microgrids interacting with central grid expansion.

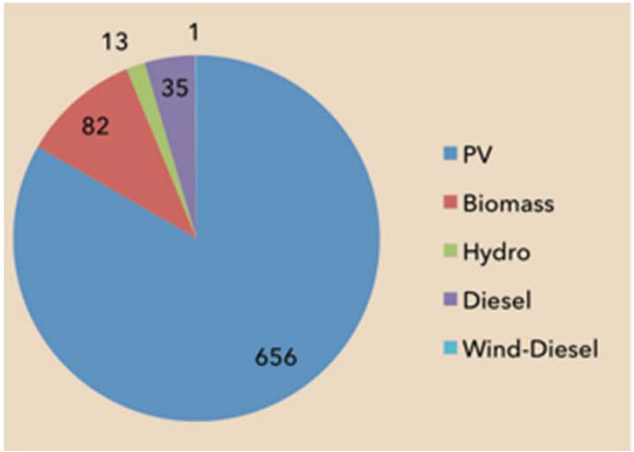
Developer Portfolios



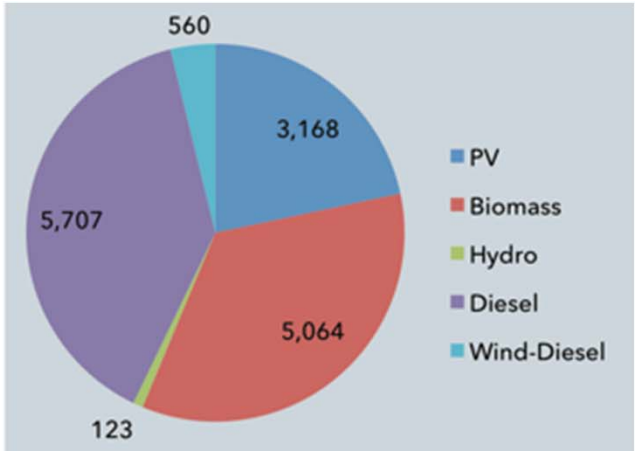
Number of Microgrids, by Developer



Installed Capacity (kW), by Developer



Number of Microgrids, by Generation Type



Installed Capacity (kW), by Generation Type

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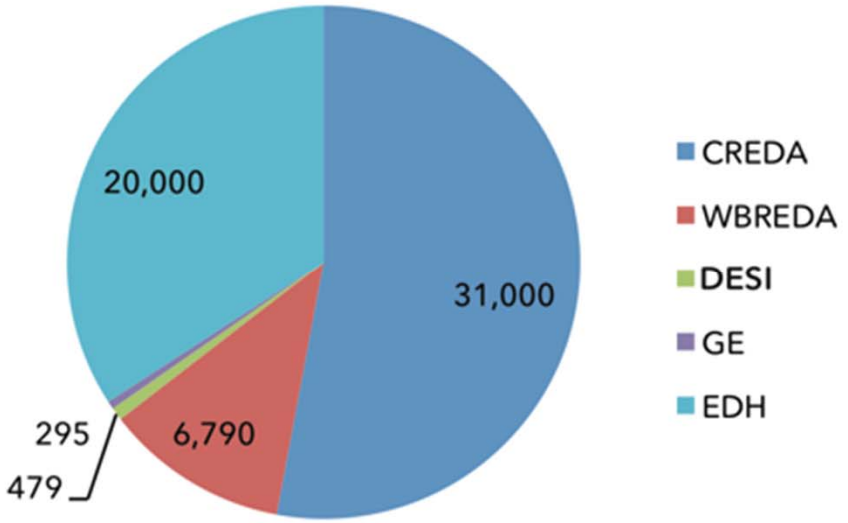
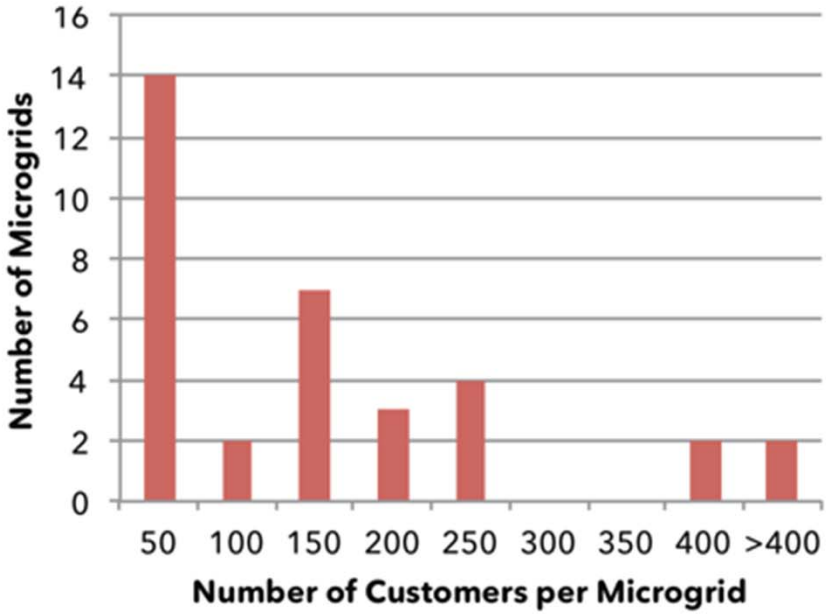
Developer Portfolios



Number of Customers, by Developer



Histogram of Number of Customers per MIcrogrid

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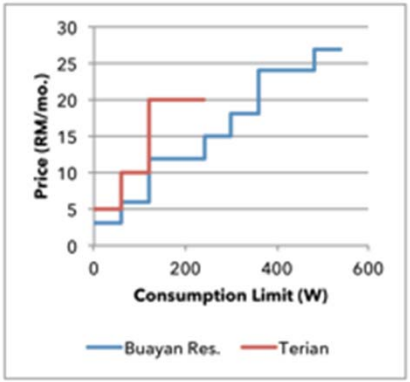
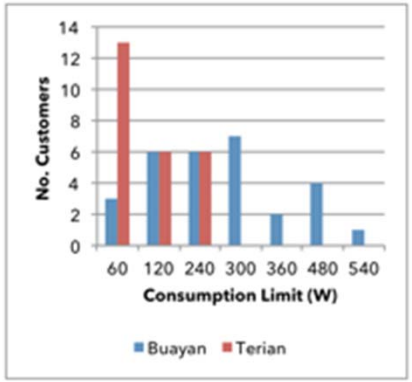
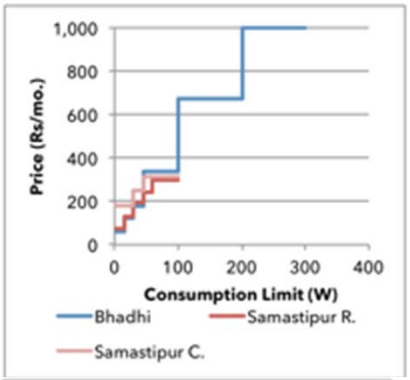
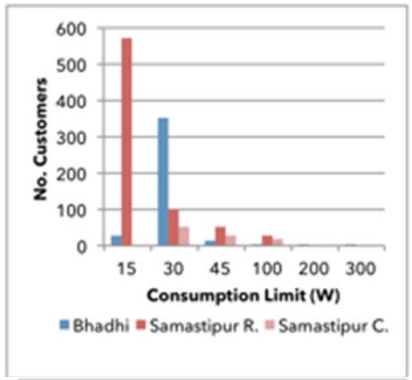
Developer Tiered Tariff Examples



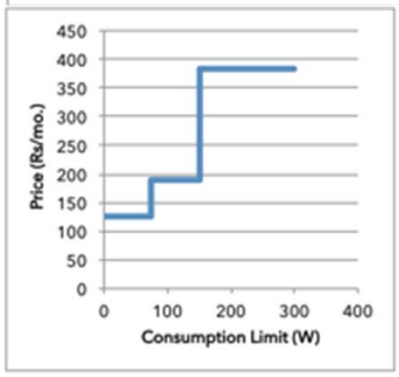


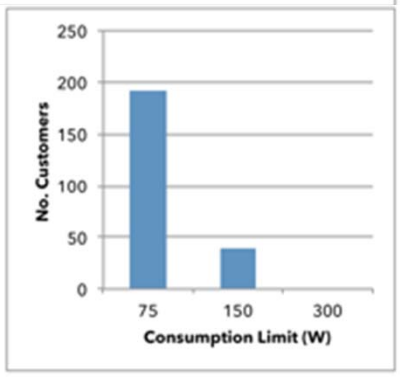
GE/T/P Tariff Structure





HPS Tariff Structure



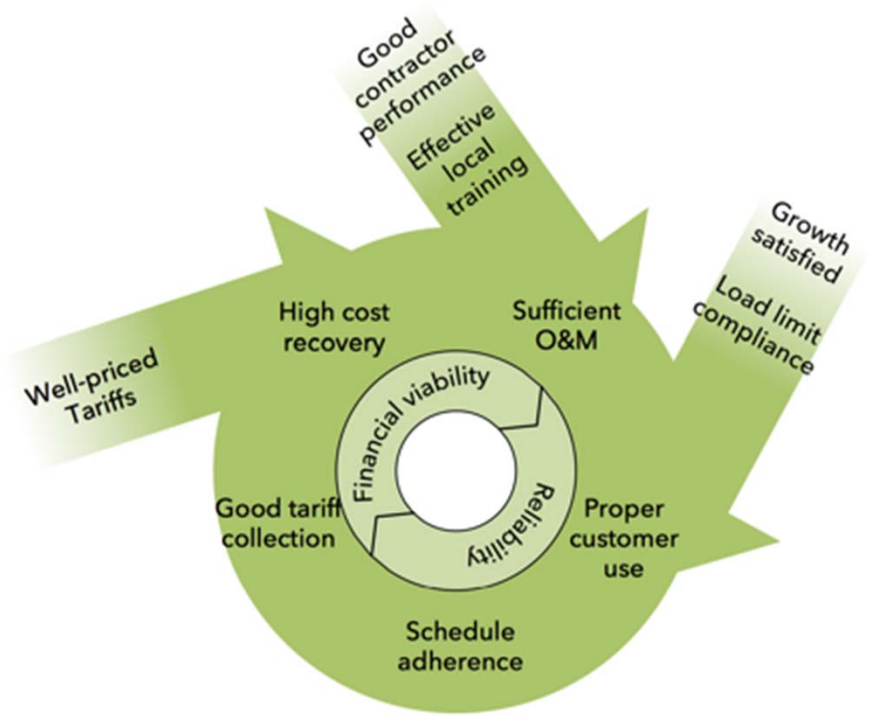


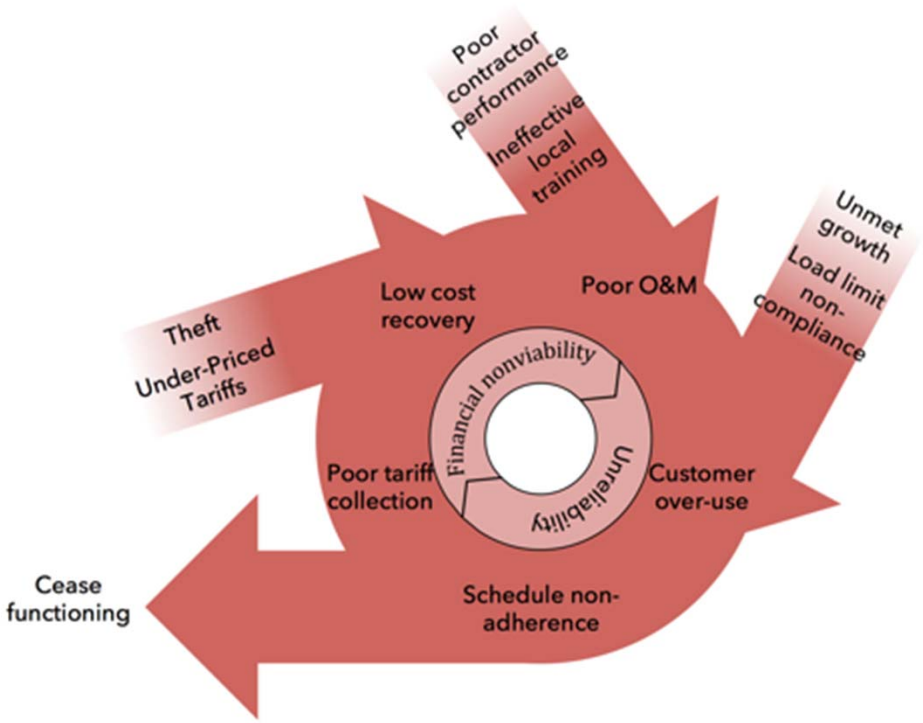
WBREDA Tariff Structure

Framework

- Empirical finding: microgrids follow a “vicious” cycle to failure or a “virtuous” cycle to sustainability
- Common factors in cycles across disparate geographies and demographics imply a theoretical set of “best” (or worst) practices
- Examined factors through lens of strategic planning, operations (technical, commercial & financial), and social context

Findings: Microgrid Operations Flowchart





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Relevance of Factors to Business Model

		For-Profit (FP)	Partly subsidized non-profit (PS)	Fully subsidized non-profit (FS)
	Developer / **Factor**	HPS, Desi (India)	CREDA, WBREDA (India), Haiti, Green Emp. (Malaysia)	CREDA, OREDA (India)
Financial Viability	Tariff-based O&M cost recovery	High	High	Low
	Tariff-based capital cost recovery	High	Low	None
	Theft	High	Medium	Medium
Energy Service Reliability	Contractor performance	Medium	Medium	High
	Local training and institutionalization	Low	Medium	High
	Load limits	High	High	High
	Unmet demand growth	High	High	Medium

Strategic Planning: Central grid expansion

- WBREDA microgrid customers ceased payment when central grid arrived
- Raises the question: are microgrids permanent solutions or interim measures?
- CREDA explicitly takes “stopgap” view and even relocates PV assets when central grid arrives
- WBREDA agrees, but central grid did not provide better service

Transmission line connecting Sundarbans Islands to West Bengal central grid

Operations - Commercial: Cost Recovery Requirements Determine Tariff Structure

Developer (Business Model)	Tariff Price (Local Currency)	Tariff Price (USD, January 2014 exchange rate)	Operating Expenses	Major Maintenance	Capital Costs[3]	Profit (for Developer)
CREDA (FS)	5-10 Rs/mo.	0.08 – 0.16/mo.	Partial	No	No	No
DESI Power (PS)	5 – 8 Rs/kWh	0.08 – 0.13/kWh	Yes	Yes	Partial	No
Green Empowerment/ Tonibung/PACOS (PS)	3 – 20 Ringgit/mo.	0.91 – 6.09/mo.	Yes	Partial	No	No
Haiti (PS)	~200 HTG/mo.	4.55/mo.	Yes	No	No	No
Husk Power Systems (FP)	~150 Rs/mo. (average)	2.41/mo.	Yes	Yes	Yes	Yes
OREDA (FS)	10 – 30 Rs/mo.	0.16 – 0.48/mo.	Partial	No	No	No
WBREDA (PS)	80 – 270 Rs/mo.	1.28 – 4.32/mo.	Yes	Partial	No	No

Operations - Technical: Demand Side Management (DSM) Types

Developer	Efficient Appliances	Limiting Business Hours	Restricting Residential Use			
			Customer Agreements	Home-Wiring Restrictions	Over-Use Penalties	Load Limiters
CREDA	✔		✔	✔		✔
DESI				✔	✔	✔
GE/T/P			✔		✔	✔
Haiti						
HPS	✔		✔	✔	✔	✔
OREDA	✔		✔	✔		✔
WBREDA	✔		✔	✔	✔	✔

Operations – Technical – DSM: Efficient Light Bulbs

- Most loads are lighting, therefore most appliances are simply light bulbs
- OREDA, WBREDA, CREDA provided CFLs to customers initially, but only CREDA is providing replacements
- HPS load limits are suitable only for usage of CFL or LED lights, but it is not uncommon to find incandescent bulbs being used by customers on grids without a load limiting device.

HPS employee holding confiscated incandescent bulbs

Operations – Technical: Maintenance

Maintenance implementation

Implementer	Contractor		Developer		Operator		Community	
Maintenance Type	Preventive	Corrective	Preventive	Corrective	Preventive	Corrective	Preventive	Corrective
DESI				✔	✔			
GE/T/P				✔			✔	
Haiti				✔	✔			
HPS				✔	✔			
OREDA	✔	✔						
WBREDA	✔	✔						

Maintenance funding source

Funding Source	External (Government/NGO)		Internal (Tariff-Based)	
Maintenance Type	Preventive	Corrective	Preventive	Corrective
DESI			✔	✔
GE/T/P		✔	✔	
Haiti		✔	✔	
HPS			✔	✔
OREDA	✔	✔		
WBREDA	✔	✔		

Operations – Technical – Maintenance: Preventive

- Typical best practice recommendation is to train local microgrid operator for maintenance tasks
- Expectation that tariffs can cover maintenance expenses
- Case studies show that maintenance is successful when maintenance is left to local operator, as long as sufficient funds
  - Keeping good records seems to help
  - Ambiguity of responsibility (e.g. developer vs. operator) is detrimental
- Model used by OREDA, CREDA, WBREDA is to use 3rd party contractors
  - Sometimes contractors are negligent

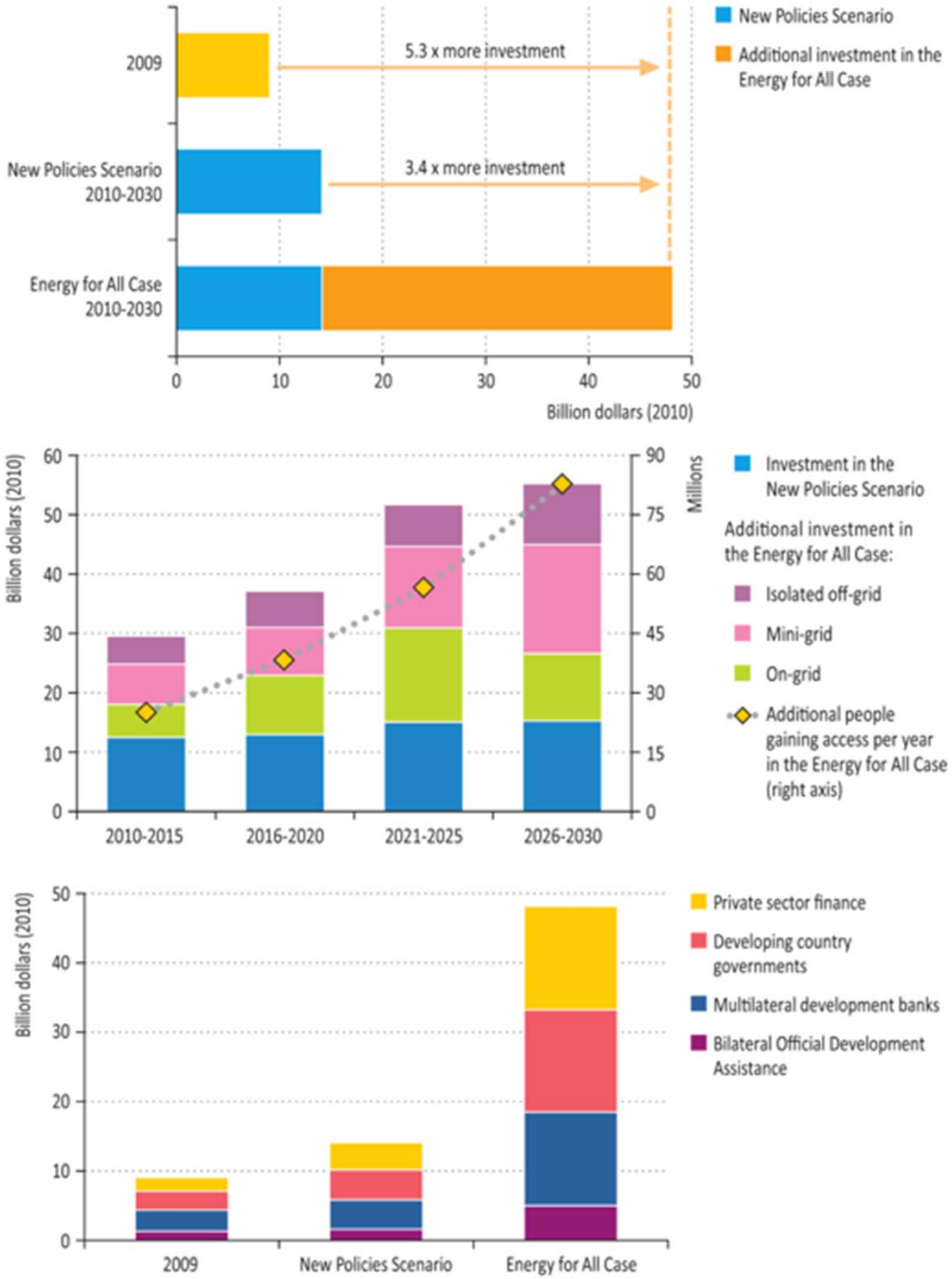
On-site distillation tables at WBREDA PV microgrid

Social Context: Community Involvement

Categories (of Voluntary/ Paid Village Participation)	DESI Power	GE/T/P	EDH	HPS (BM Model)	OREDA	CREDA	WBREDA
Daily Operations	✔	✔	✔	✔	✔ ✔	✔	✔
Major Maintenance							
Collect Tariffs	✔	✔	✔ ✔	✔	✔	✔	
Enforce Penalties			✔ ✔				✔
Initiation/ Planning Strategy Help		✔		✔		✔	✔
Construction Labor		✔				✔	
Village Energy Committee Existence	✔	✔	✔ ✔		✔	✔	✔
VEC Bank Account Existence		✔	✔		✔	✔	
Contribute Land	✔	✔		✔	✔	✔	✔
Initial Community Ownership		✔					
Community Eventually Owns					✔		

Thank You

Additional Slides


2009
New Policies Scenario 2010-2030
Energy for All Case 2010-2030
5.3 x more investment
3.4 x more investment
0
10
20
30
40
50
Billion dollars (2010)
New Policies Scenario
Additional investment in the Energy for All Case
Billion dollars (2010)
Millions
2010-2015
2016-2020
2021-2025
2026-2030
Investment in the New Policies Scenario
Additional investment in the Energy for All Case:
Isolated off-grid
Mini-grid
On-grid
Additional people gaining access per year in the Energy for All Case (right axis)
Billion dollars (2010)
2009
New Policies Scenario
Energy for All Case
Private sector finance
Developing country governments
Multilateral development banks
Bilateral Official Development Assistance