From the Bottom Up: How Small Power Producers and Mini-Grids Can Deliver Electrification and Renewable Energy in Africa*

An Implementation Guide for Regulators and Policymakers

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*Forthcoming Book co-authored with Chris Greacen and Tilak Siyambalpitya

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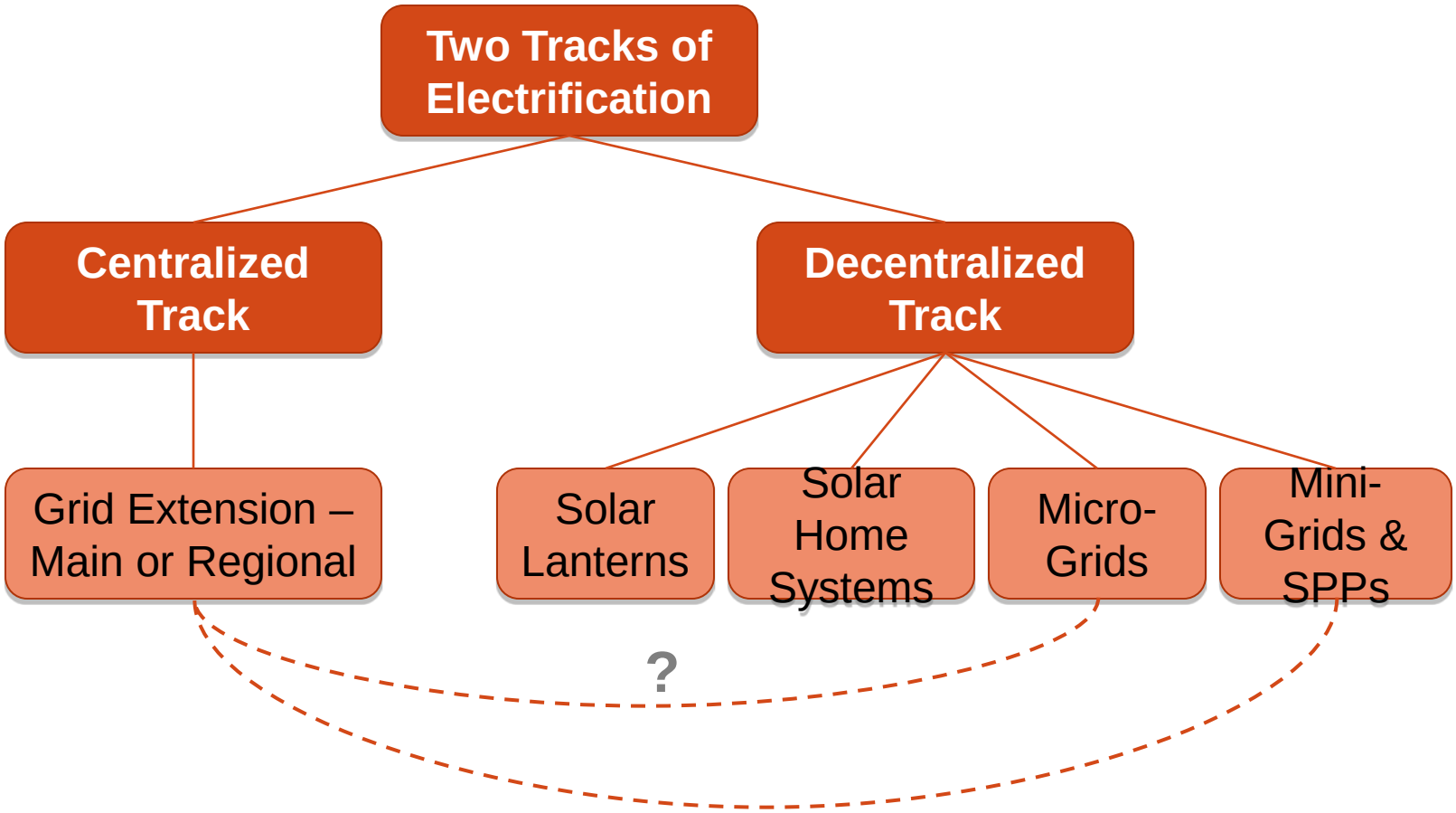
“We need megawatts, not megawords.”

~Zambian Government Official, 2010

Outline

- Electrification: The Centralized vs. Decentralized Approaches
- SPPs/Mini-Grids and Regulatory Overview
  - What is an SPP?
  - 4 Types of SPPs and Overlap with Mini-Grids
  - Regulation
  - 3 Types of Regulatory Decisions
- Key Regulatory Issues
  - Retail Tariff Setting
  - To Regulate or Deregulate?
  - Selling To and Buying From the Main Grid (Feed-In & Backup Tariffs)
  - “When the Big Grid Connects to a Little Grid”

Electrification: Centralized vs. Decentralized Tracks



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 (i.e., *a connected mini-grid*) or to an existing utility-owned isolated grid
- Usually defined by regulators according to size, fuel and technology (10MW or less?). Should include hybrid generators!
- AKA “distributed generation” (US and Europe) or “decentralized generation” or “decentralized distributed generation” (India) or “mini-grids” (worldwide) or “mini-utilities” (IFC 2012)

4 Types of SPPs / Mini-Grids

		Location of Generation	
		Connected to Isolated Mini-grid	Connected to Main Grid
Nature of Customers	Selling Retail to End Customer	**Case 1** SPP + M-G	**Case 3** SPP + M-G
	Selling Wholesale to Utility	**Case 2** SPP	**Case 4** SPP

4 Types of SPPs (continued)

- **Case 1— SPP selling at retail on an isolated mini-grid**
  - Small generator connected to a few kms of distribution selling to village customers. Best with an anchor customer. Electrification—direct.
  - Cambodia (198, diesel, private), Mali (150, currently diesel, private, sell to about 15% of rural population) and Sri Lanka (250+, micro-hydro, coops).
- **Case 4—Grid-connected SPP selling at wholesale to national utility**
  - A pure SPP (just a generator, *not* a mini-grid). No retail customers. Sells under a "feed-in tariff"(FIT).
  - Sri Lanka (100+, mini-hydro, private), Thailand (264, mostly biomass, private), Tanzania (3, cogeneration or biomass, private). Electrification—indirect or none. "I don't want the headaches of selling to poor households."
- **Case ???—Small power distributors (SPDs)**
  - Buy at wholesale and resell at retail. No generation

Regulation

"The less we have to do with government, the happier we are."

~ Indian micropower developer, November 2012

"Regulation can provide a fertile ground. But regulation does not make a market."

~ IFC Official, World Bank Group Workshop, January 30, 2012

Regulation is just one piece of the puzzle! The case of Tanzania.

1. **SPP regulatory framework developed by EWURA**
   - More complete than anywhere else in Africa. Goal: Light-handed regulation
   - Process as well as prices. (Kenya versus Tanzania)
2. **Grants from donors through REA or directly to M-Gs**
   - Connection grants (US $500 per new connection for mini-grids)
   - Grants for feasibility studies (business plans and environmental assessments)
3. **Availability of financing** (equity, loans from local commercial banks supported by a US $25 million WB line of credit)
4. **Technical assistance** for developers, the REA and

3 Types of Regulatory Decisions (with examples)

Economic	• Retail Tariffs (Cases 1 and 3) • Cost of Interconnection (Cases 2 and 4) • Feed-in Tariffs (Cases 2 and 4) • Price of Backup Power (Case 4)
Technical	• Safety of Connections • Voltage and Frequency Standards • Relay Requirements for Different Generators
Process	• Stakeholder Consultation Requirements • Utility Maximum Response Time to SPP Requests • Provisional License: Exclusive? How Long? Milestones?

Key Issues for Regulators

1. **Retail Tariff Setting**
2. **To Regulate or Deregulate Small Isolated SPPs?**
3. Selling To and Buying From The Main Grid (Feed-In and Backup Tariffs)
4. **When the Big Grid Connects to a**

Issue 1: Retail Tariff Setting: The Revenue-Cost Gap

"Mind the gap."

~ London Underground announcement

Retail Tariff Setting: Measuring the Gap

Example: 300 kW hydro at US$4500 per kW (Cases 1)(Africa)

- USD 0.6 million in Rural Electrification Agency grants of USD $500 for each of the 1200 households the project serves

	Additional Donor Grant (USD)	Commercial Tariff (USD/kWh)	Residential Tariff (USD/kWh)
Scenario 1	none	$0.153 National uniform	$0.04 National uniform
Scenario 2	$160,000	$0.153 National uniform	$0.04 National uniform
Scenario 3	$160,000	$0.24	$0.067

Retail Tariff Setting: Measuring the Gap (Scenario 3)

Inputs

Project Inputs		
Plant Capacity	300	KW
Capacity Factor	40%	
Annual Generation	1,051	Mwh
# Connections	1200	

Revenues		Tsh /kwh	US c/kwh
Res. <50kWh/mth	40%	100.0	6.7
Res. >50kWh/mth	10%	273.0	18.2
Business	50%	360.0	24.0
Average Tariff		247.3	16.5
Carbon Revenues		9.0	0.6

Project Returns	
Project IRR	4.8%
Equity IRR	19.7%
Project NPV	($286)
Equity NPV	$73

Generation Costs	USD 000s	TSH Mn	
Generation	600	900	44%
Soft Costs	150	225	11%
Grid Connection	400	600	30%
Grid Extension	200	300	15%
Total Investment Costs	1,350	2,025	100%
REA Grants	600	900	44%
Other Donor Grants	160	240	12%
Total Grants	760	1,140	56%
Investment (excl. grants)	$590	$1,125	44%

Operating Costs	000s	TSH Mn	US c /kwh
Salaries	25	$38	2.38
Maintenance	14	$20	1.28
Fuel Costs	0	$0	0.00
Other	15	$23	1.43
Total	53.5	80.3	5.1

Cost recovery Tariff		
Capital Investments	4.50	$ / W
Operating Costs	5.1	c/ kwh
Output Per Watt	3.50	Kwh / W
Capital Recovery	20.22	c/ kwh
Total	25.3	c/ kwh
	380	TSH / kwh

Other Inputs		
Construction Time	3	Years
Collection Efficiency	90%	
Distribution losses	5%	
Tariff inflation	4.0%	
CPI	6.0%	
Terminal value	0.0	times exit FCF
Exchange Rate	1,500	TSH / USD

Capital Structure			USD 000s	TSH Mn
Equity Share	15%	Equity	203	304
Debt Share	29%	REA grant	600	900
		Other		
Required returns	14%	Grants	160	240
Equity incl. REA	59%	Loan	388	581
Loan Rate	12%			
Loan Grace Period	3			
Loan Term	10			
WACC***	9.2%			

Schedule	1	2	3	4
Construction	33%	33%	33%	0%
Operations	0%	0%	0%	100%

Other Assumptions		
Depreciation period	25	Years
Corporate Tax rate	30%	
Tax holiday	0	Years

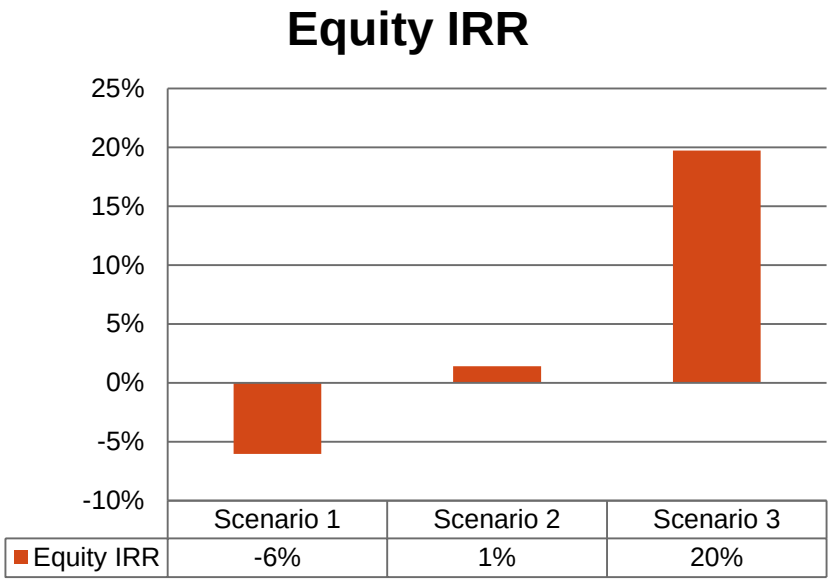
Cash Flow $ '000s	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Residual Value*
Investment	$450	$450	$450	$0	$0											
Increase in WC	$0	$0	$14	$0	$0											
Grants	$253	$253	$253	$0	$0											
Equity	$68	$68	$68	$0	$0											
Debt	$129	$129	$129	$0	$0											
Revenue (c/ kwh)	17.1	17.7	18.4	19.1	19.9	20.7	21.5	22.3	23.2	24.1	25.0	26.0	27.0	28.1	29.1	
Total Revenues	$0	$0	$0	$201	$209	$217	$226	$234	$243	$253	$263	$273	$284	$295	$306	
Operating Costs	$0	$0	$0	$64	$68	$72	$76	$80	$85	$90	$96	$102	$108	$114	$121	
Operating Cash flow	($197)	($197)	($197)	$138	$142	$146	$150	$154	$158	$163	$167	$172	$176	$181	$185	
Cash flow if no grant	($450)	($450)	($450)	$138	$142	$146	$150	$154	$158	$163	$167	$172	$176	$181	$185	
Depreciation	$0	$0	$54	$54	$54	$54	$54	$54	$54	$54	$54	$54	$54	$54	$54	
Loan Payments	$0	$0	$0	$96	$96	$96	$96	$96	$96	$96	$0	$0	$0	$0	$0	$0
Interest	$0	$16	$33	$52	$47	$41	$35	$28	$19	$10	$0	$0	$0	$0	$0	$0
Principal	$0	($16)	($33)	$43	$48	$54	$61	$68	$76	$85	$0	$0	$0	$0	$0	$0
Loan Balance	$129	$274	$436	$393	$344	$290	$229	$161	$85	$0	$0	$0	$0	$0	$0	$0
Effective tax	$0	$0	$0	$9	$12	$15	$18	$22	$25	$30	$34	$35	$37	$38	$39	$0
Tot. Costs Incurred by SPP	$197	$212	$230	$125	$127	$128	$129	$130	$130	$130	$130	$137	$144	$152	$160	
Equity CF	($68)	($68)	($68)	$33	$34	$35	$36	$37	$37	$38	$133	$136	$139	$143	$146	$0
DSCR	0.00	0.00	0.00	1.44	1.48	1.52	1.57	1.61	1.66	1.70	0.00	0.00	0.00	0.00	0.00	0.00

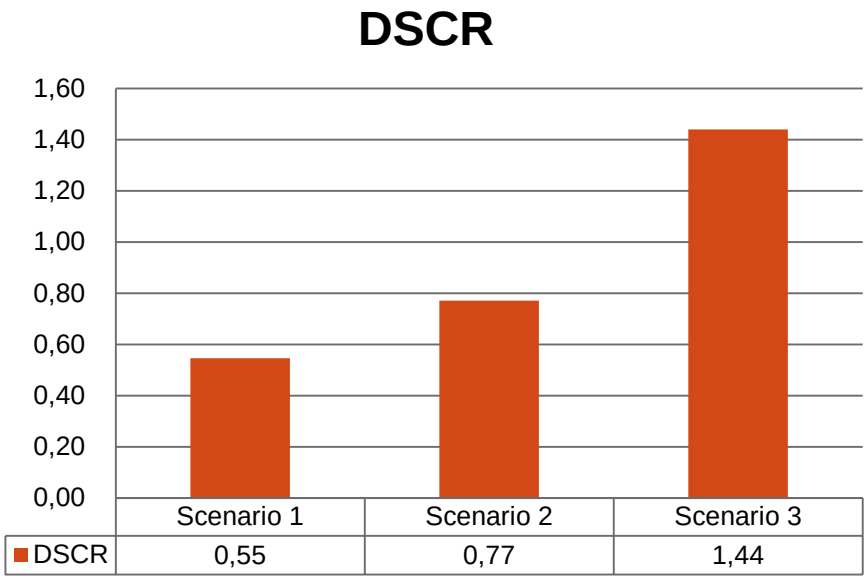
* PV at year 15 for revenues from year 16-25

*** WACC = Equity share * ROE + Debt Share * Loan rate * (1- tax rate)

http://tinyurl.com/rea-spp

Retail Tariff Setting: Measuring the Gap





The project is commercially viable only if it receives a donor capital grant and it can charge retail rates above the "legal" or "political" uniform national tariff and it can cross-subsidize across customer classes (Scenario 3).

Retail Tariff Setting: Closing the Gap

Five Recommended Regulatory Actions

1. Allow M-Gs to charge retail tariffs above the uniform national tariff if required to recover efficient opex & capex costs.
2. Allow M-Gs to cross-subsidize their retail tariffs (usually by charging businesses more than households).
3. Allow M-Gs to enter power sales contracts with businesses without requiring prior regulatory approval of contract terms.
4. Require M-Gs to charge tariffs that include depreciation on equipment financed through grants.
5. Allow M-Gs to recover the costs of on-bill financing for

Issue 2: To Regulate or Deregulate Small Isolated SPPs?

("light-handed regulation to the max")

- **Regulator's safe strategy:** When in doubt, regulators will regulate. But this may not be a good decision.

- Arguments for (some) deregulation ("light-handed regulation to the max"):
  - Successful decentralized rural electrification—little or no price reg (Cambodia & Sri Lanka)
  - Substitutes exist & markets are "contestable" – Gov. of India
  - Need to experiment with different business models (India: Husk Power vs OMC vs Gram Power)
  - Administrative necessity ("too many to regulate")

To Regulate or Deregulate? (continued)

- An example: the OMC Power (India) business model
  - Hybrid generator (solar & diesel) selling to mobile tower owner/operator (anchor customer) under a long-term PPA
  - Renting rechargeable battery boxes to village households & businesses that are delivered daily
  - No deposit; no connection charge; no government subsidies(?)
- Regulation: multi-dimensional, not an "all or nothing" proposition
  - Tariff regulation—No
  - Licensing—Registration (informational) not licensing (approval)
  - Safety regulation—Yes
- General recommendation: 5 year price tariff dereg with backstops for small private isolated mini-grids. Possible backstops: annual reporting, complaints by many customers, registration

Issue 3: Selling To And Buying From the Main Grid

(Feed-In And Backup Tariffs)

Issue 3: Wholesale Sales to the Main Grid: Power Purchase Agreements

Recommended	Not Recommended
Standardized for all SPPs	Performance requirements
A duration long enough to repay project debt, and at least as long as mandated FIT availability	A **deemed generated energy clause** (but utility must provide historical data on frequency and duration of interruptions)
A “must buy” clause that obligates the utility to purchase all of the SPP’s power output	
A 50 percent discount on regular demand charges for backup power to SPP customers with a load factor <15%	
Eliminate demand charges for SPPs connected to unstable transmission systems and charge an energy charge higher than the energy	

Controversy
When the Grid is Unstable

Complaint of a grid-connected African SPP operator:

"This is the ultimate indignity. I have to shut down because of a disturbance or lack of capacity on the national utility's system. Even though he caused the problem, I am the one who gets hurt. And I get hurt in two ways. First, I lose revenues because I am not able to make sales. Second, I have to pay him high demand and energy charges under his backup tariff because I need his electricity to restart my generator each time the shutdown ends."

Selling Wholesale to the Main Grid: Feed-in Tariffs (FITs) (Case 4)

- Tariff support mechanism for renewable energy generators or co-generators or hybrid generators. TZ(2012): Main grid-$0.096; Existing TANESCO Isolated Mini-Grid-$0.303
- Based either on the value to the utility and/or society of the electricity generated (buyer's cost) (Tanzania), or on the cost of electricity generation for each designated renewable or co-generation technology (seller's cost) (Uganda)
- But who pays for the premium if the FIT exceeds the buyer's cost? Donors' proposed "top-up" program in Uganda.
- SPP developer: "The price is fine but how long will it take to get paid."

Selling Wholesale to the Main Grid: Feed-in Tariffs (Case 4)

Phase I

+ FITs are set at or below the buying utility's avoided costs including tx savings (Tanzania) or technology specific levelized costs (Uganda) below the buying utility's avoided costs.

Phase II

+ Some FITs are allowed to exceed the buying utility's avoided costs when funds for these higher tariffs are available.

+ Differences can be made up by outside donor "top up" grants.

This two-phased approach allows a country to

important but don't forget about….

- Guaranteed interconnection & pre-specified rules for sharing interconnection costs
- Guaranteed purchases ("must-take" requirement)
- Physical ability to receive the power
- Guaranteed sale of back-up power
- Pre-specified pricing formula for purchase of SPP's power with adjustment mechanisms (FiTs) for life of PPA
- Standardized interconnection and operation procedures (see Guidelines on EWURA (Tanzania) website)

Selling Wholesale to the Main Grid: Technical Requirements

The following technical requirements are recommended for SPP and main grid interconnections:

Regulators and utilities can incentivize SPPs to produce electricity at certain times of day or in certain seasons.

SPP power output quality must meet or exceed the main grid's requirements, and protective relays should be in place to disconnect the SPP in the event of faults or unacceptable power quality.

Main grid operators should be able to know SPP operating status.

Issue 4: When the Big Grid Connects to a Little Grid

"Companies may fear that their investment in off-grid solutions may prove worthless if the grid is indeed extended."

~ Alliance for Rural Electrification, *Hybrid Mini-Grids for Rural Electrification: Lessons Learned.* 2011, p. 10.

Little Grid: Business Model Options

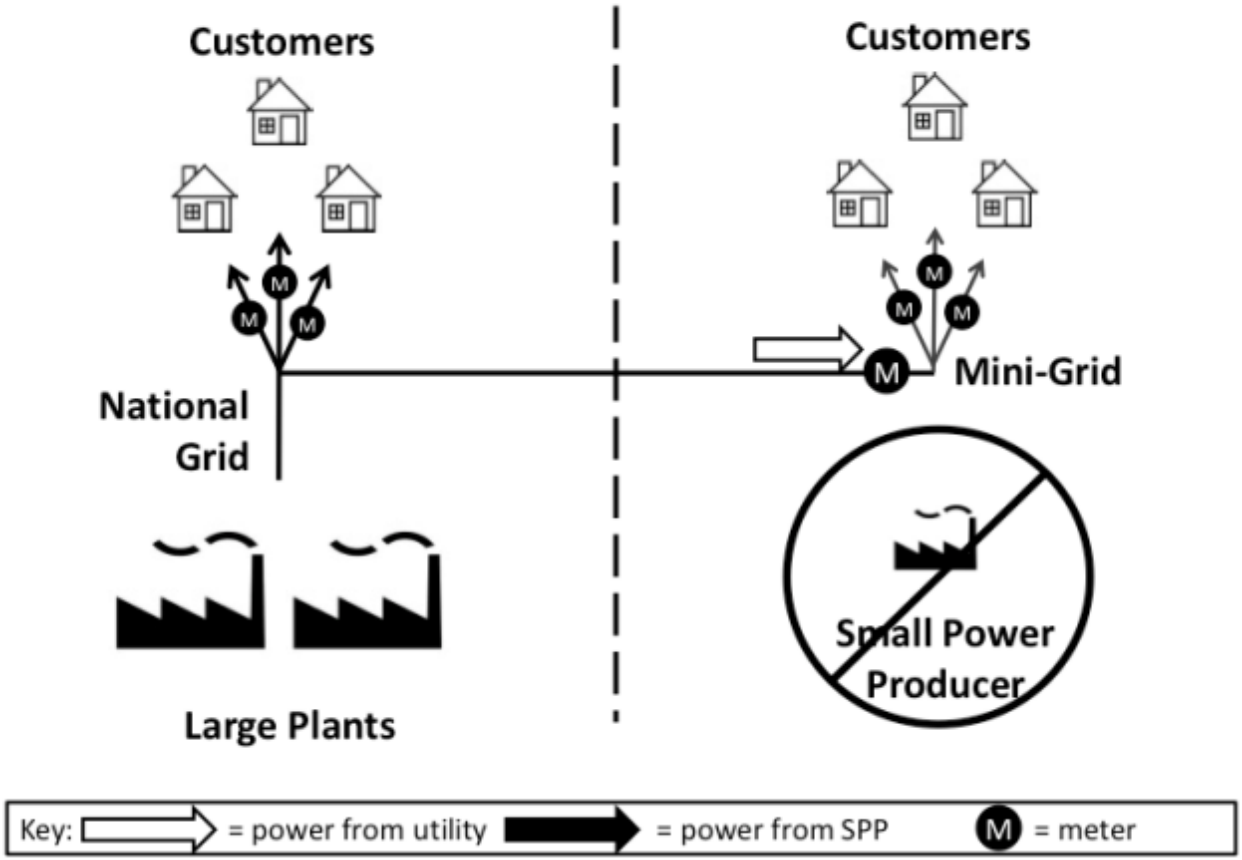
Business Model	Generator	Minigrid
1. SPD	Scrapped or Relocated	Used by SPD to resell electricity purchased at wholesale
2. SPP	Used to sell electricity to main grid	No longer used, sold or leased to the utility to sell electricity to retail customers
3. SPP & SPD Combination	Produces electricity for retail sales and sales to main grid and/or used as backup supply source	Used to supply electricity to the SPP-SPD's retail customers
4. Buyout	No longer used or sold to utility	No longer used or sold to utility

When the Big Grid Connects to a Little Grid: SPD Option

“Small Power Distributor”

- Buys power at wholesale rates from the national utility and then sells it at retail rates to households and businesses in one or more localities. (Model #1 on the table.)
- SPDs are common in Asia (Nepal, Cambodia, Bangladesh and Vietnam). Under consideration in Mali, Cameroon and Tanzania.
- Special case: SPPs who convert to SPDs but maintain their own power supply as a backup supply source, for local voltage support and for possible wholesale sales to the national or regional utility. (Model #3 the table)

When the Big Grid Connects to a Little Grid: SPD Option



When the Big Grid Connects to a Little Grid: Distribution Margins

Country	Bulk Supply Tariff (US cents / kWh)	Retail Sale Price (US cents / kWh)	Distribution Margin (US cents / kWh)	SPD Ownership
Bangladesh	3.70 (0-100 kWh)	3.94	0.24	Rural Cooperatives
Vietnam	2.40 (0-50 kWh) 6.40 (51-200 kWh)	3.40 8.50	1.00 2.10	Cooperatives or Private Companies
Nepal	4.90	5.50	0.60	Community Associations
Cambod	13.55	28.00	14.40	Private

Seven “Hot” Issues

1. Design of backup tariffs (Cases 3 and 4)
2. Inclusion of “deemed energy” clauses (Cases 3 and 4)
3. Temporary or permanent deregulation of small isolated mini-grids (Case 1)
4. Who should regulate: the national regulator or the REA?
5. Uniform national tariffs for retail sales: a legal or political necessity? (Several cases)
6. On-bill financing for connections, appliances and machinery?
7. The decentralized option—top-down (Senegal PERACOD) or bottom-up (Tanzania TEDAP)?

Next Steps:
Possible Donor Assistance

Regulation

- Promote national regulatory and policy systems covering all major SPP cases (including hybrid cases) (National regulator or REA/REF?)
- Benchmark regulatory processes for SPPs /M-Gs (e.g., World Bank's *Doing Business)*

Financial

- Guaranteed line of credit (Tanzania) (duration, interest rate, collateral) (All cases)
- Targeted and varying "buy downs" of initial capital costs
- Revolving fund for "on-bill financing" of electricity powered equipment (and roof?)
- FIT top-ups and payment guarantees (case 4)

Technical Assistance

- Public sector: develop SPP rules, policies and regulations

Thank you

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SPPs In Operation in TZ (July 2013)

Project	MW	Type of Resource	Grid type	Status
ACRA - LUMAMA	0.3	Hydro	New Isolated (Case 1)	In operation / community based
TANWAT	2.34	Biomass –wood	Main (Case 4)	Selling 1 MW (2010)
TPC Co-Generation	15	Bagasse	Main (Case 4)	In operation. Contracted to Sell up to 9 MWe to TANESCO
Katani Power Plant	0.3	Biomass – Waste	New Isolated (Case 4)	In Operation – Pilot, not connected to network
Mwenga – Mufindi Tea	4	Hydro	Cases 3 & 4	In operation

SPPs with signed PPAs (July 2013)

Project	MW	Resource	Grid type	Expected COD
Ngombeni Mafia	1.4	Biomass	TANESCO Isolated	June 2013
Sao Hill Energy	15	Biomass –wood (CHP)	Main	Delayed. COD ???
Symbion – KMRI Tunduru	0.3	Biomass	TANESCO isolated	July 2014
Symbion – KMRI Tunduru	3.3	Biomass	TANESCO isolated	Mar 2014
St. Agnes Chipole – Songea	7.5	Hydro	TANESCO isolated	Mar 2014
NextGen Solawazi	2.0	PV	TANESCO isolated	Nov 2013
Andoya Hydro Electric Co.	1.0	Hydro	TANESCO Isolated	Feb 2015
EA Power – Tukuyu	10	Hydro	TANESCO Isolated	Feb 2015

Good News

- SPP program works…

Bad News

- TANESCO is insolvent