International Scientific Conference
[MES 2015]
Micro Perspectives for Decentralized Energy Supply
April 23 – April 25, 2015
Bangalore, India

Session VIII: Evaluation & Assessment

You are what you measure! But are we measuring it right? An empiric analysis of energy access metrics based on a multi-tier approach in Bangladesh

Authors: Sebastian Groh (MES); Shonali Pachauri (IIASA); Narasimha Rao (IIASA)

contact: sgroh85@gmail.com

SE4ALL: Universal Energy Access by 2030

1. What does it mean?

2. How do we get there?

3. If we don't have an answer for the first question, how will we even know at what point we got there?

Only what gets measured is what gets done ! ! !

ESMAP multi-tier framework

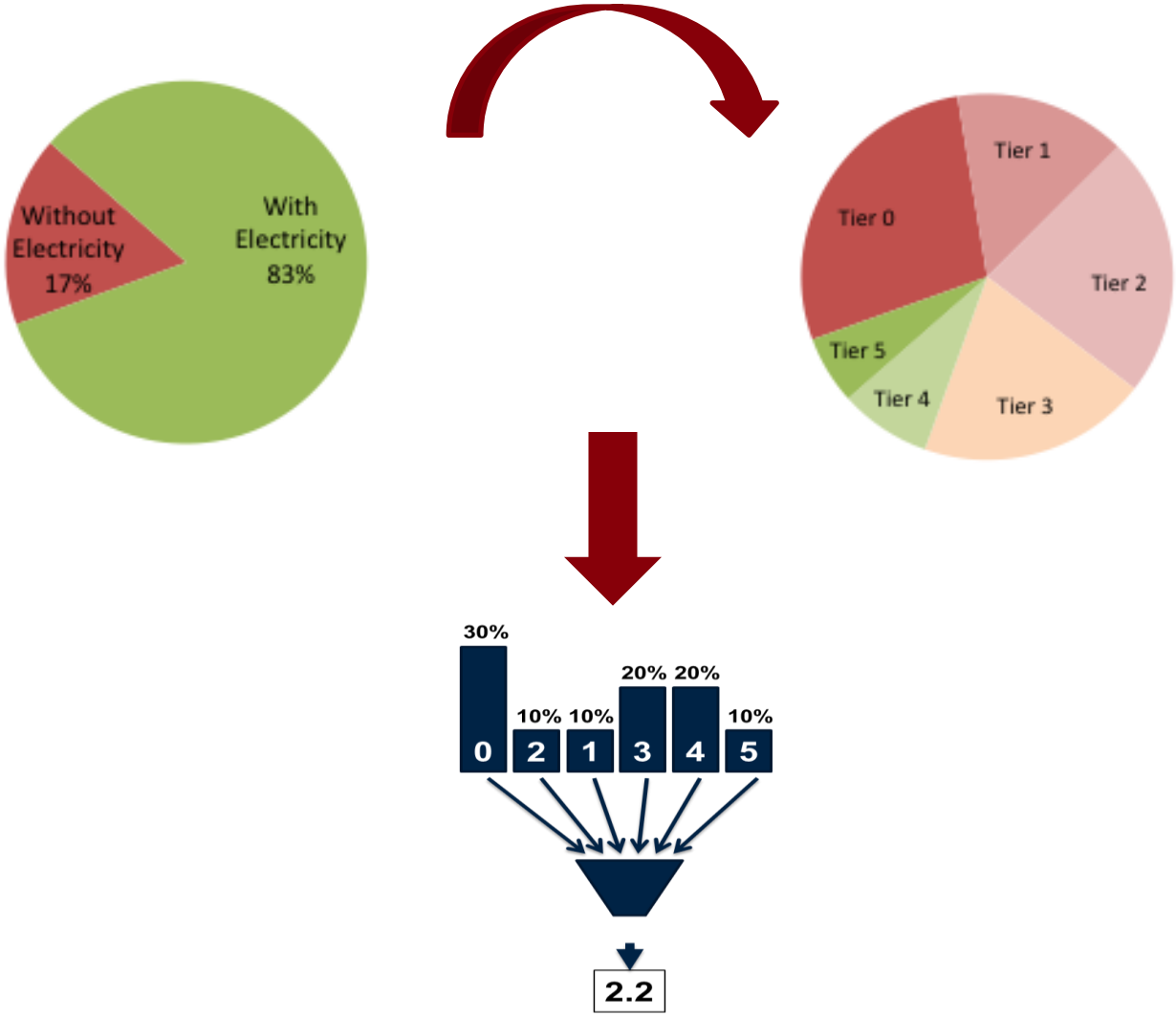
. . . to measure energy service access as a continuum

			Tier-0	Tier-1	Tier-2	Tier-3	Tier-4	Tier-5
Attributes	1. Peak capacity	Power	No Electricity	V. Low Power Min 1 W	Low Power Min 50 W	Medium Power Min 200 W	High Power Min 2 kW	
		Daily capacity		Min 4 Wh	Min 200 Wh	Min 1.6 KWh	Min 4 KWh	
	2. Duration	Hours per day	< 4 hrs	Min 4 hrs		Min 8 hrs	Min 16 hrs	Min 23 hrs
		Hours per evening	< 2 hrs	Min 2 hrs		Min 2 hrs	Min 4 hrs	Min 4 hrs
	3. Reliability					Max 3 disruptions **per day**	Max 7 disruptions per week	Max 3 disruptions **per week** of total duration < 2 hours
	4. Quality					Voltage problems do not prevent the use of desired appliances		
	5. Affordability				Cost of a standard consumption package of 365 kWh per annum is less than 10% of household income			
	6. Legality					Bill is paid to the utility / pre-paid card seller / authorized representative		
	7. Health and Safety					Absence of past accidents and perception of high risk in the future		

Tier-rating for the household is calculated by applying the lowest of the tier-ratings across all attributes.

Source: ESMAP, 2014

ESMAP multi-tier framework (ctd)



Source: ESMAP, 2014

Testing Methodology and Sample

- 4 frameworks with differing algorithms are tested, namely electricity

  a) supply,

  b) appliance,

  c) consumption (modified), and

  d) service framework (combination of supply and appliance framework)

- Sample:

Electricity access type	# of households	share of households
National grid	69	30%
SHS	107	46%
Diesel generator	12	5%
No primary access	55	24%

Results

Framework	Algorithm	Sensitivity	Tier Assignment					
			0	1	2	3	4	5
Electricity Supply	Simple	-	31%	28%	40%	1%	0%	0%
		income = 0	31%	49%	20%	0%	0%	0%
		excl. income	31%	2%	65%	3%	0%	0%
	Complex	-	25%	10%	58%	7%	0%	0%
		income = 0	25%	45%	24%	7%	0%	0%
		excl. income	25%	1%	67%	5%	0%	3%
Electricity Appliances	-	-	41%		51%	0	8%	0
Electricity Consumption[#]	-	-	-	59%	-	-	1%	40%
Electricity Services	Combined	-	24%	5%	60%	5%	6%	-

Results (ctd.)

Table 2: Tier based sample distribution

Variable	Obs	Mean	Std. Dev.	Min	Max
supply_simple	231	1.13	.88	0	4
supply_simple_inc0	231	.91	.75	0	4
supply_simple_no_inc	231	1.40	.97	0	4
supply_complex	231	1.48	.95	0	3
supply_complex_inc0	231	1.13	.86	0	3
supply_complex_no_inc	231	1.10	.85	0	3
appliances	166	1.54	1.02	.5	4
consumption	167	2.64	1.96	1	5
services	222	1.62	1.08	0	4

Results (ctd.)

Table 3: Electricity Source and Tier Assignment

SHS tier perfomance

tier	Obs	Mean	Std. Dev.	Min	Max
simple_access	107	1.56	.54	0	2
complex_access	107	1.80	.40	1	2
services	107	1.91	.29	1	2

on-grid tier perfomance

tier	Obs	Mean	Std. Dev.	Min	Max
simple_access	69	1.28	.89	0	4
complex_access	69	2.04	.53	0	3
services	65	2.49	.83	1	4

Table 4: Sample based relative electricity expenditure

Electricity Expenditure/ Total Income	Sample share
average	6%
nothing	17%
less than 5%	64%
5% - 10%	17%
more than 10%	19%

Incoherence with some off-grid schemes (exemplary)

Multi-tier matrix for access to household electricity consumption

	Tier-0	Tier-1	Tier-2	Tier-3	Tier-4	Tier-5
Annual Consumption levels (KWh)	< 7	≥ 7	≥ 100	≥ 365	≥ 1250	≥ 3000
Daily Consumption levels (Wh)	< 20	≥ 20	≥ 274	≥ 1000	≥ 3425	≥ 8219

Source: ESMAP, 2015

panel size (Wp)	derate	peak sun hrs	peak capacity (Wh)	highest possible tier assignment
2.5	0.63	4.5	7	0
5	0.63	4.5	14	0
10	0.63	4.5	28	1
20	0.63	4.5	57	1
30	0.63	4.5	85	1
40	0.63	4.5	113	1
50	0.63	4.5	142	1
75	0.63	4.5	213	1
100	0.63	4.5	284	2
120	0.63	4.5	340	2
200	0.63	4.5	567	2
375	0.63	4.5	1,063	3

IFC Lighting Global

IDCOL SHS Program

Source: own calculations

Incoherence with some off-grid schemes (exemplary)

Wh consumption does not matter, but the associated service:

- # of lumen hrs
- # of color TV hrs
- # of fan hours
- # of hours a fridge can run
- ...

Key take-aways

1) Multi-tier framework superior to simple binary metrics to measure energy poverty/access

2) Differing frameworks and decision algorithms result in different assessments of the electricity access situation in Bangladesh

Recommendations

Rethinking of capacity attribute in light of new appliance efficiencies evident in the market

Re-designing the affordability attribute

(Ir-) relevance of electricity consumption framework

Further refinement of attributes

Development of an electricity service framework

Conclusions

Metric design

- Negligence of health and safety attribute
- Payment flexibility needs to be evaluated as part of affordability (e.g. PAYG)
- High sensitivities
- Grid extension only partially a solution in terms of tier performance

Policy

- Bangladesh based energy interventions not adaequately relfected (IDCOL program, up-coming IFC Lighting BD program)
- Fast review required in light of up-coming SDGs
- More efficient design of pro-poor policies will become possible

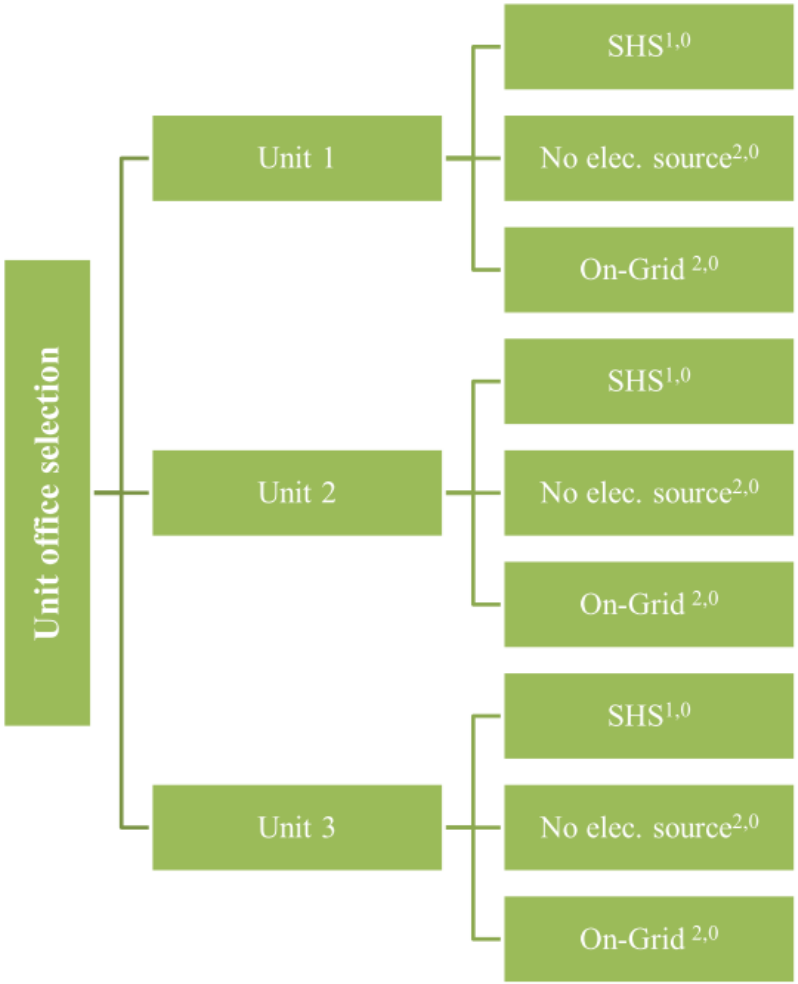
Thank you!

contact: sgroh85@gmail.com

Additional slides

Geographical sample location

Selection process



[0] randomized selection

[1,0] Sample selection from unit office customer data based on the following criteria, then drawing of random sample from criteria listing:

1st order: payment performance
- based on portfolio at risk:

a) max. payment delay of 3 days
b) payment delay of 4-6 days
c) payment delay > 6 days)

2nd order: system size
- ranges from 20Wp – 85Wp

3rd order: income activity
- home business, laborer, farmer, fisherman, etc

[2,0] randomized selelction of closest no elec sources/ on-grid houses to SHS sample

Complex tier algorithm

Algorithm elelctricity supply II (complex version)

Tier 0: (A01=7) OR (A01=8) OR (A02=1) OR (A06>4) OR A07<2)

Tier 1: (Tier 0=FALSE) AND [(A02=2) OR (B.3=H) OR (B.3=I) OR (A01=6) OR ((A11=NO) AND ((A01=1) OR (A01=2) OR (A01=4) OR (A01=6)) AND (0.8<=10*A13)) OR ((A11=NO) AND (A01=3) AND (0.8<=10*PL)) OR ((A11=YES) AND (0.8<=10*PT))]

Tier 2: (Tier 0=FALSE) AND (Tier 1=FALSE) AND [(A02=3) OR (B.3=K,L,M,N,U,Q,S) OR (A01=4,6) OR (A06<8) OR (A14=4,5,6,7) OR (25=YES)]

Tier 3: (Tier 0=FALSE) AND (Tier 1=FALSE) AND (Tier 2=FALSE) AND [(A02=4) OR (B.3=O,P,V,T,W,X,Y) OR (A01=2,3) OR (A06<16) OR (A07<4) OR ((A11=NO= AND (A01=3) AND (0.8<20*PL)) OR ((A11=NO) AND 0.8<20*(A13)) OR ((A11=YES) AND (0.8<20*PT)) OR (AO8>3) OR (A09>31)]

Tier 4: (Tier 0=FALSE) AND (Tier 1=FALSE) AND (Tier 2=FALSE) AND (Tier 3=FALSE) AND (A08<=3) AND (A09<31) AND (A06<=22)

Tier 5: (Tier 0=FALSE) AND (Tier 1=FALSE) AND (Tier 2=FALSE) AND (Tier 3=FALSE) AND (Tier 4=FALSE) AND (A08<3) AND (A09<31) AND (A06>22)

National grid tier performance

lsupply_simple	supply_complex 0	1	2	3	Total
0	2	0	12	2	16
1	0	2	14	5	21
2	0	0	30	0	30
3	0	0	0	1	1
4	0	0	0	1	1
Total	2	2	56	9	69