Demand for off-grid solar electricity – Experimental evidence from Rwanda

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eiflicht

n, als die Männer noch
n, weiß man in aller Re-
als dass sie vorbei sind.
on so. Als vor Jahrtau-
des Jagens und Sam-
Kultur des Ackerbaues
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r jüngeren Vergangen-
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n den Siebzigern durf-
Männer fühlen, wenn
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der Lage waren, mit
g den Deckel zu öff-
so anzuwerfen, dass
te wie im dritten Auf-
er damit heute punk-
gefragt zu werden, ob
Parkplatz für seinen
e.
rmfeuerzeug zu sich
n den Sinn ihres Da-
f anderen Gebieten.
re Augen auf, wenn
ndkerzen ausbauen
ürste wieder funkti-
onnten. Stottern des
Verteilerkappe: was
ch solchen Leistun-
um Bier, öffnete die
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sich vorstellte, dass
geöffnet haben: mit
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ack und plopp. Die
g aller Seligkeiten,

Das Wichtigste

Ihre Kinder, Wasserkrüge und ein Solarmodul zum Kochen – das konnten diese Rohingya auf der Flucht mitnehmen. Staatenlos sind sie, und einige strandeten zwischen Myanmar und Bangladesch. Nun sind auch sie über die Grenze gelangt wie schon 600 000 Menschen, die vor der Gewalt des Militärs nach Bangladesch geflohen sind. Myanmars De-facto-Regierungschefin Aung San Suu Kyi besuchte am Donnerstag erstmals die Region Rakhine, aus der die Minderheit vertrieben wurde. FOTO: SARKAR/AFP

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Research questions and 'bold statement' findings

What is the poor's WTP for off-grid solar technologies?

- Can the poor afford to pay cost-covering prices?

  Finding: They can't.

- On-grid vs. off-grid: What is a cost-effective way for rural electrification in Africa?

  Finding: It's off-grid.

- [Does relaxing liquidity constraints increase WTP?]

  [*Finding: Not much.]*

Some backgrounds

- 1.1 billion people lack access to electricity (~600 million in Africa)
- United Nations initiative **Sustainable Energy for All** intents to connect everybody by 2030
- Paradigm: off-grid households have to pay cost-covering prices for solar

Costs (IEA/OECD estimates)

- Additional costs of 384 billion USD for Africa alone

Costs of on-grid electrification

Lee, Miguel, and Wolfram (2016) in Kenya…

- ‘welfare loss’ from grid intensification of 511-1,100 USD per household.

Lenz et al. (2017) in Rwanda

- Costs per connection: 1,500 USD

Chaplin et al. (2017) in Tanzania

- Costs per connection: 6,600 USD

Lee/Miguel/Wolfram (2016):

„Does Africa’s energy future even lie with the grid?”

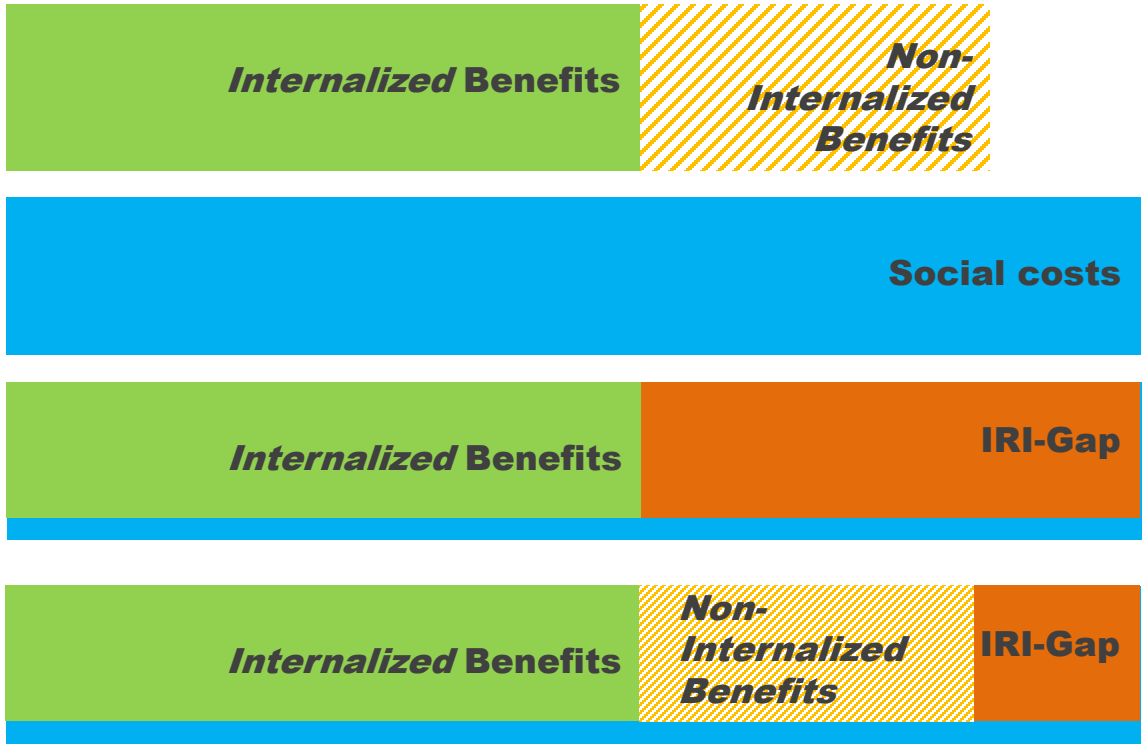
Off-grid solar technologies used in this paper

Model:	d.light Design S 2	Greenlight Planet Inc. Sun King Pro 2	ASE Solar – 20W Solar DC Lighting Kit
Run time:	6.5 hours	5.9 - 13.1 hours	4 – 36 hours
Panel size	0.5 Watt	3.3 Watt	20 Watt
Light output	25 lumen	81 – 160 lumen	220 lumen
Features:	1 LED Lamp	1 LED lamp 1 USB Port 3 brightness settings	4 LED bulbs 6 USB Ports Separate battery of 14Ah
Se4All Tier	Tier 0	Tier 1	Tier 1
Market Price	14 USD	40 USD	189 USD

What the present paper does

Stylized cost-benefit analysis for off-grid solar

(adapted from Lee et al. 2016)



How high is revealed WTP ?

Market Price

How big is the Internal Return on Investment-Gap ?

Discussion: Do external effects reduce the IRI-Gap?

Should we subsidize off-grid solar?

What the present paper does

The implicit SE4All- and Lighting Global assumption

***Internalized* Benefits** — Revealed WTP

Social costs — Market price

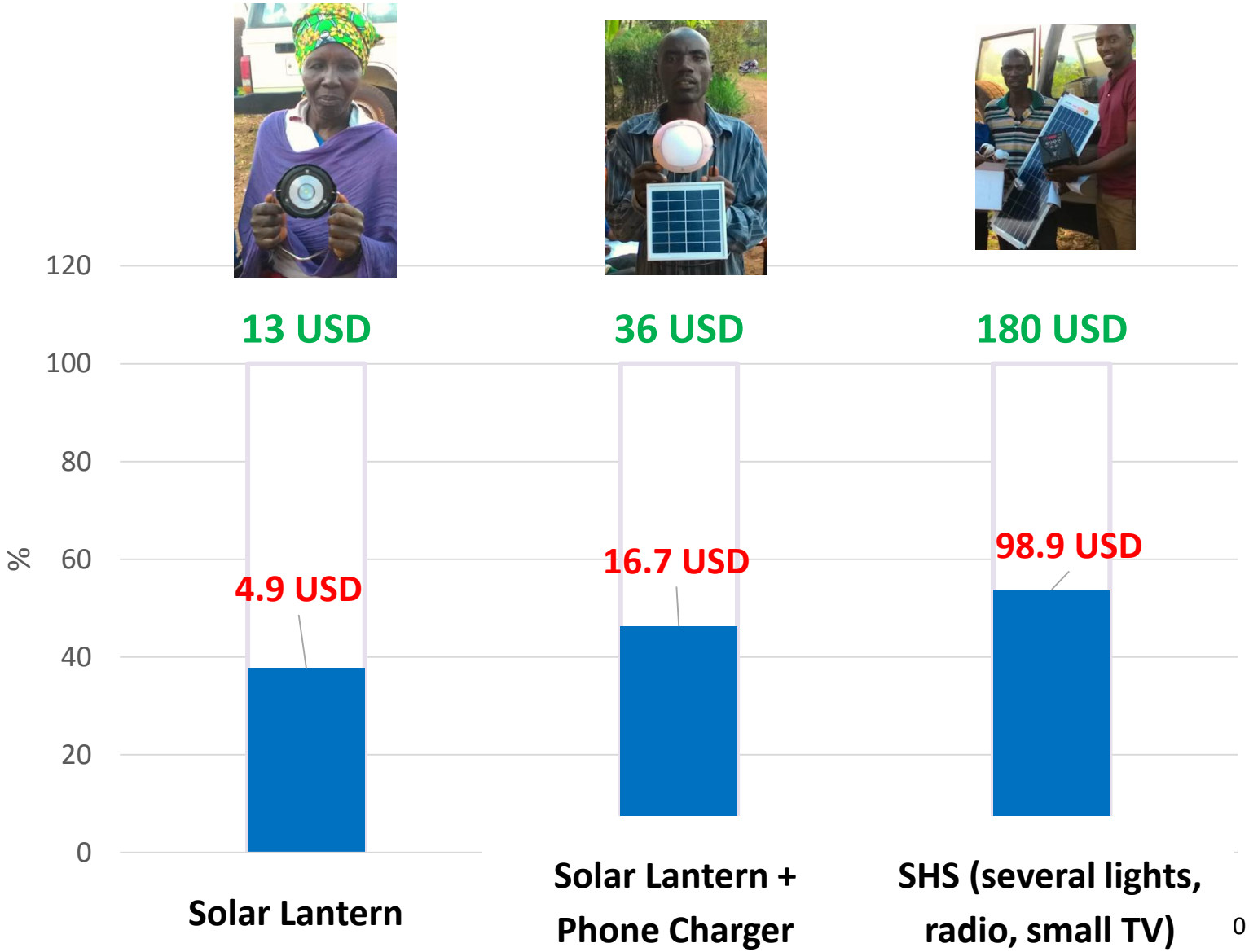
→ **No subsidy needed**

Experimental Design and Implementation

- Sampling: 16 off-grid villages, 324 random households
- Becker-DeGroot-Marschak (BDM, 1964) approach to elicit revealed WTP
- Individual household visits for real-purchase offer
- Additionally, we randomized three payment periods (1 week, 6 weeks, five months) across households

Bidding game results

Bid amount and bid as share of market price



Internal Return on Investment-Gap

8.10 $

19.34 $

83.12 $

511-1,100 $

Solar Lantern

Solar Lantern + Phone Charger

SHS (several lights, radio, small TV)

Grid Connection

(Lee et al.2016)

Impacts of electrification: Literature

Impacts of grid extension:

- Positive evidence on non-African countries (Lipscomb et al. 2012, Barron/Torero 2017, van de Walle et al. 2017), but…
- …evidence on Africa is rather sobering (including Dinkelman 2011):
  - Peters/Sievert (2016): Impacts of Electrification Revisited – The African Context, *Journal of Development Effectiveness*.
  - Lenz/Munyehirwe/Peters/Sievert (2017): Does Large-Scale Infrastructure Investment Alleviate Poverty? Impacts of Rwanda's EARP Program, *World Development*.

Impacts of off-grid solar:

- Evidence is not euphoric, but overall positive (Furukawa 2014, Kudo et al. 2017, Rom et al. 2016, … more is coming)
  - Grimm/Munyehirwe/Peters/Sievert: A First Step up the Energy Ladder? Low Cost Solar Kits and Household's Welfare in Rural Rwanda, *World Bank Economic Review*

Concluding remarks and policy implication

Affordability angle (@SE4All and @LightingGlobal):

- Vast majority of rural poor is not able to make the investment
- subsidies are indispensable to reach the universal access goal

Social planner's angle: what if we subsidized off-grid solar at 100%?

- *internal return on investment-gap* of off-grid is way lower than for on-grid
- Emerging evidence: Non-internalized benefits probably high enough to justify subsidies

Electrification Masterplan:

- Grid extension should focus on certain thriving rural regions only
- Subsidize off-grid solar elsewhere

thank you!

Bidding game results

	Kit 1	Kit 2	Kit 3
Respondent participates in bidding game	94 %	92 %	56 %
Average bid amount (USD)*	4.90	16.66	96.88
	(2.01)	(6.95)	(34.60)
Market price (USD)	13	36	180
Bid as share of total monthly expenditures	19.77	61.38	343.06
	(24.46)	(61.38)	(605.64)
Price drawn (USD)	7.44	22.68	154.60
N Sales in experiment	66	88	10
Number of observations	324	324	324

*Note: Standard deviations in parentheses. *Tobit corrected values.*

Effects of liquidity constraints

Payment periods	Kit 1			Kit 2			Kit 3		
Payment period: 6 weeks	0.012	0.021	**0.023**	0.049	0.044	**0.056**	0.060	0.065	**0.058**
	(0.801)	(0.633)	**(0.627)**	(0.333)	(0.367)	**(0.256)**	(0.240)	(0.203)	**(0.245)**
Payment period: 5 months	0.119	0.106	**0.111**	0.086	0.076	**0.073**	0.085	0.067	**0.080**
	(0.011)**	(0.037)**	**(0.017)****	(0.111)	(0.122)	**(0.137)**	(0.089)*	(0.184)	**(0.111)**
Pseudo R-squared	0.173	0.159	0.203	0.497	0.585	0.693	0.266	0.206	0.284
Observations	323	324	323	323	324	323	323	324	323
Control variables included									
Community and time	YES	YES	YES	YES	YES	YES	YES	YES	YES
Socio-economic characteristics	YES	NO	YES	YES	NO	YES	YES	NO	YES
Baseline lighting consumption	NO	YES	YES	NO	YES	YES	NO	YES	YES

*Note: p-values are displayed in parentheses, where *** p<0.01, ** p<0.05, * p<0.1 denote statistical significance. The dependent variable is log(WTP). We display marginal effects from a Tobit estimation. The base category is a one week payment period. To read the coefficients as percentage change in absolute values of WTP – rather than log(WTP), the coefficients have transformed as follows: 100* [exp(coeff) -1]. Table B.1 in the Appendix B shows the complete regression results including control variables.*

- Modest effects of extended payment schemes on WTP…
- …that vanish when interest rates are accounted for

This paper…

What is the poor's WTP for off-grid solar technologies?

- Can the poor afford to pay cost-covering prices?

Affordability angle

- On-grid vs. off-grid: What is a cost-effective way for rural electrification in Africa?

Social planner's angle

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