Challenges in operating solar micro-grids in rural Uttar Pradesh

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Contents

Learning outcomes from a research experiment in rural India

- Unique study: Electrical measurements for one year (2016)
- Reliability of supply
 - Reasons for technical problems
- Seven hamlets

Research team:

- Prof. Johannes Urpelainen (Johns Hopkins SAIS, US)
- Sini Numminen (Aalto University)
- Prof. Semee Yoon (Yonsei University, South Korea)
- Prof. Peter D. Lund (Aalto University)







Reseach question and motivation

- Are the micro-grids able to deliver power for the customers in the desired manner (24/7 and 365 days per year?)
 - As the market is penetrated with solar power system components (electronic components, batteries, BOS) with inconsistent quality and short lifetimes

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System provider: Indian energy service company Boond

Frugal innovation: pre-paid meter (DC) with dynamic pricing for solar micro-grids

Photo: Boond Engineering \& Development Pvt Ltd



DC ^{socket, e.}9 for a ^{mobile} phone charger

Data collected in this study

Energy meters in each household

Meter voltage, Output current every 10 min

Central charging station

• PV panel voltage, Charging and discharging current, Load current, Battery voltage every 5 min



1+1+ -2

A H-H-6

HH-

H.H.4

H-H-3

Weekly customer interviews Enumerator's reports Field observations

H.H-1

Centoral Station

Sini Numminen, 16.10.2018

Pico-grid installations

- Provider: Indian social enterprise Boond Research and Development Pvd Ltd
 - System design, installation, O&M
 - Contracted a local villager as grid operator
- Technology
 - DC distribution, photovoltaic (PV) with lead-acid battery storage
 - Pre-paid energy meters in each household
- Seven hamlets, 5 7 households connected to each pico-grid
- Electricity service: 30 Wp/household
 - Three LED lamps à 3W, socket for mobile phone charger and a fan à 18W provided
 - Price: INR 10 for 100 Wh

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- Customers low-income, mainly farmers
 - Typical monthly expenditure per household: 46 dollars (INR 3,000)









Villagers use a variety of energy sources

- *"We switch on Boond, do some work, then switch it off and burn a kerosene lamp." (Simmonds, 2018)*
- "My second option is, that if our solar panel is not working, in that case we can use Boond by doing a recharge." (Simmonds, 2018)
- Low micro-grid electricity consumption levels: ~17 Wh/household/day (Numminen et. al, 2018b)





Results: reliability in supply

- Micro-grid power was available 87% of the time
 - Households experienced two power outages per week
 - Variation among hamlets (between 5 and 11) – different cultures











Figure: S. Numminen, Dissertation, Aalto University, School of Science (unpublished results)

Surprising reasons caused lacks in service

Lack of solar energy

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- Low irradiation in December
- Behaviour of some local grid operators
 - Manual shutting down the grid
- Power theft directly from battery
- **Components breakups and non**availabilities in data
 - Only 5 hamlets data out of 7 could be analysed

Numminen, S., Lund, P.D., Yoon, S., Urpelainen, J., 2018b. **School of Science** Power availability and reliability of solar pico-grids in rural areas: A case study from northern India. Sustainable Energy Technologies and Assessments 29, 147-154. https://doi.org/10.1016/j.seta.2018.08.005



Conclusions

- Pico-scale energy reduced kerosene use and saved money spent on energy in low-income communities
 - Energy poverty reduction to a certain extent
- Pico-grids delivered more reliable power service (21 hours) than the DISCOM power system (16 hours)
 - Overall good customer satisfaction
- Advice: Size the system according to energy needs
 - Sometimes PV-only is not sufficient for 365 days supply. However, hybrid systems may become too expensive
- Protective measures are important
 - Store batteries in locked cases

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- Use theft-proof electronic components
- Ensure proper customer education and satisfaction
- Create a culture of respect towards the system



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Thank you!

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