Challenges in operating solar micro-grids in rural Uttar Pradesh

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Photo: S. Numminen, 2016

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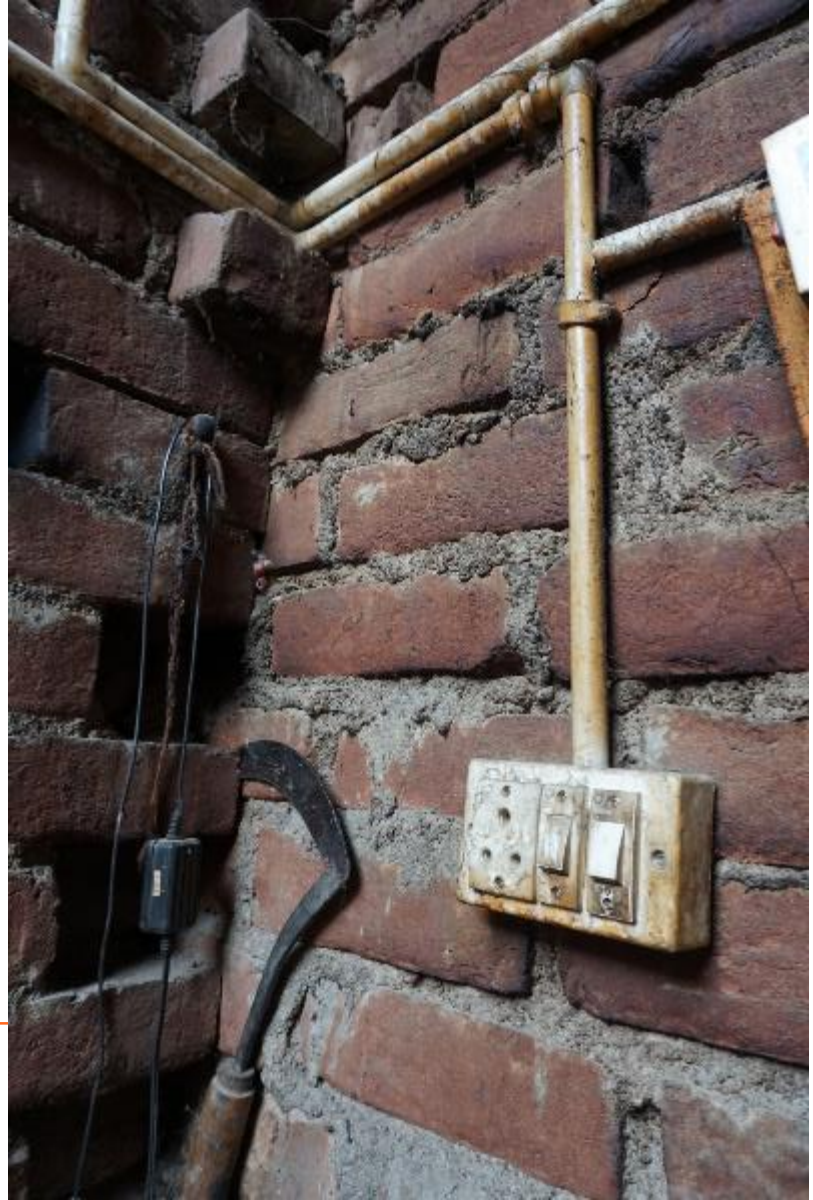


Contents

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)

Photo: S. Numminen, 2015

DISCOM power system, average 16 h supply per day

Micro-grid distribution, average _____ supply per day (measured!)

Photo: S. Numminen, 2015

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

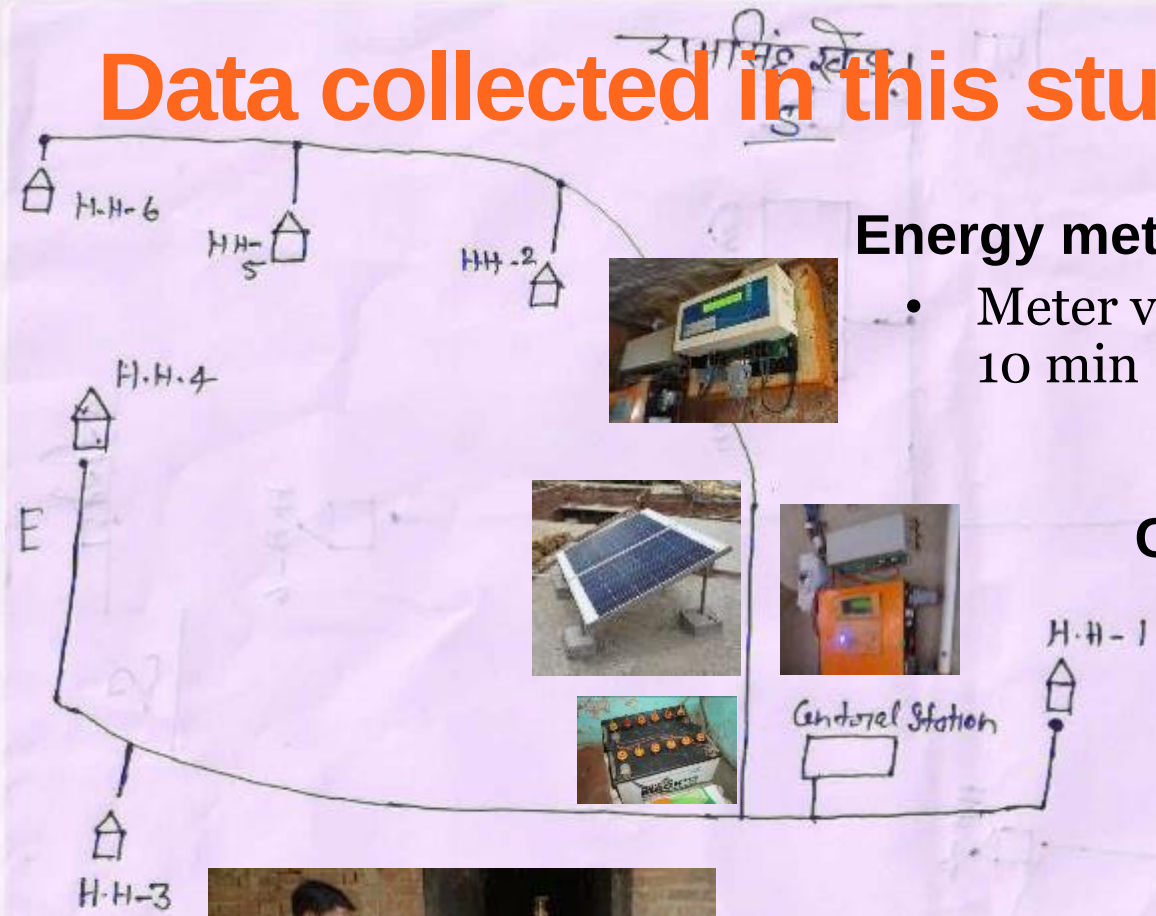
Solar Home System module, nominal 50 Wp

Photo: S. Numminen, 2016

System provider: Indian energy service company Boond

Photo: Boond Engineering \& Development Pvt Ltd

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

Weekly customer interviews

Enumerator's reports

Field observations

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

Photo: S. Numminen, 2016

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Boond Every drop makes a difference

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)

Photo: Simmonds (2018)

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

Photo: S. Numminen, 2015

Reasons for power outages

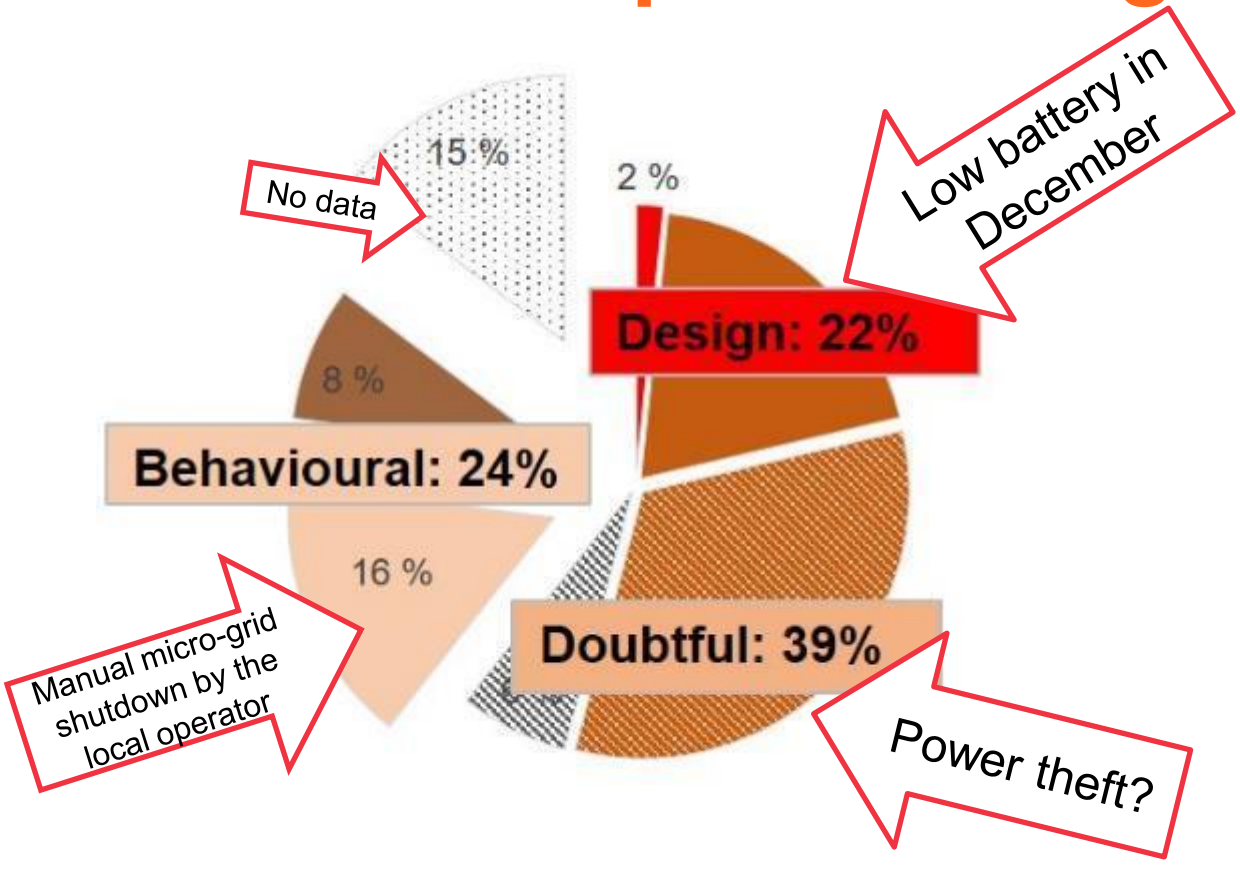


Figure: S. Numminen, Dissertation, Aalto University, School of Science (unpublished results)

Surprising reasons caused lacks in service

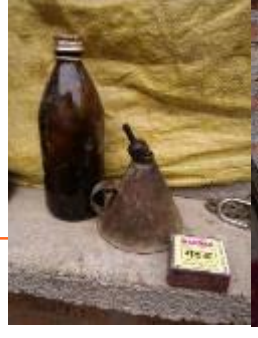
- **Lack of solar energy**
  - Low irradiation in December
- **Behaviour of some local grid operators**
  - Manual shutting down the grid
- **Power theft directly from battery**
- **Components breakups and non-availabilities in data**
  - Only 5 hamlets data out of 7 could be analysed

Photo: S. Numminen, 2016

Numminen, S., Lund, P.D., Yoon, S., Urpelainen, J., 2018b. 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
  - 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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Photo: S. Numminen, 2015