Identifying Hidden Resources in Solar Home Systems as the Basis for Bottom-Up Grids

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Innovating Energy Access for Remote Areas:
Discovering Untapped Resources

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Session: Community Energy Supply

Outline

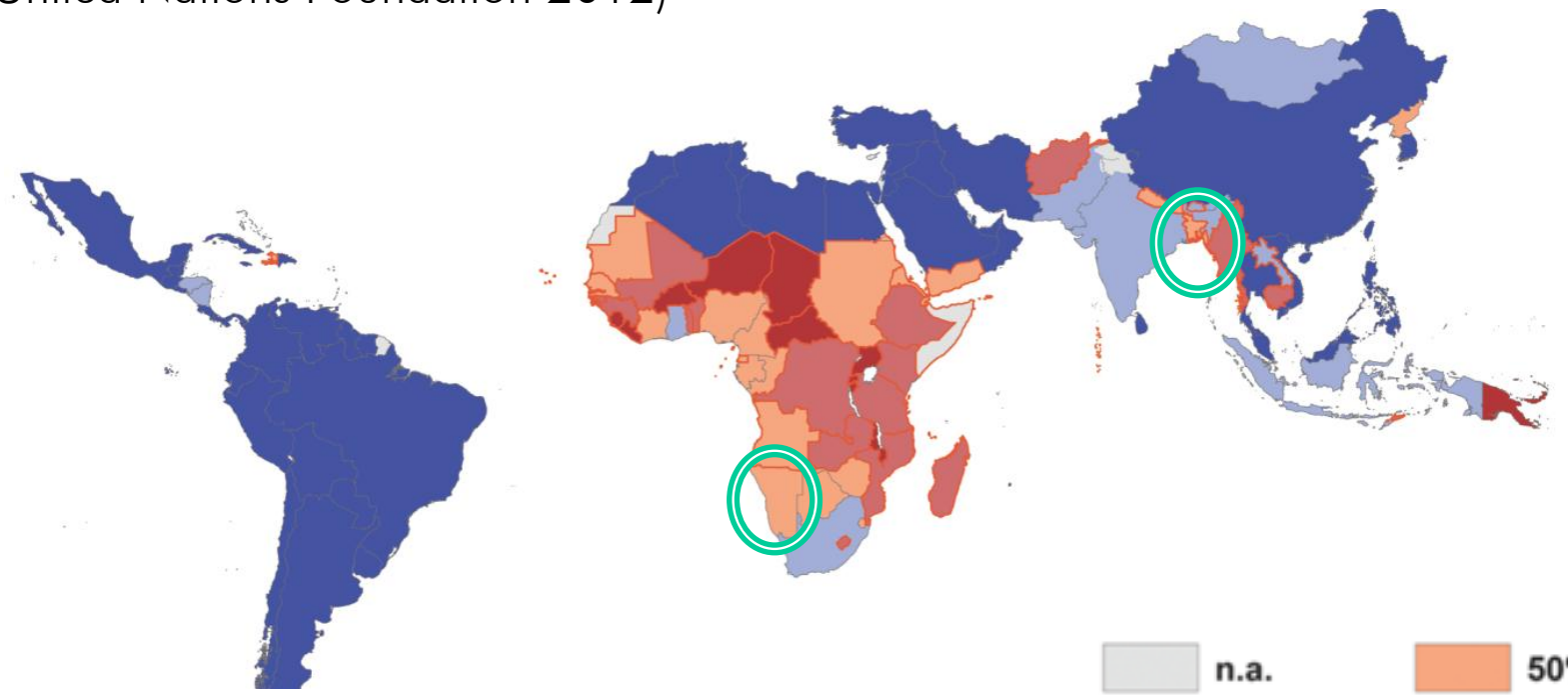
1. Motivation: Bottom-Up Swarm Electrification
2. Model and Simulation
3. Results
4. Summary and Outlook

Global Challenge- Need for Access

1.3 billion people are without access to electricity

1 billion with poor quality access to electricity

(United Nations Foundation 2012)



Share of a country's population without access to electricity
Source: (G. Legros et al. 2009, 11)

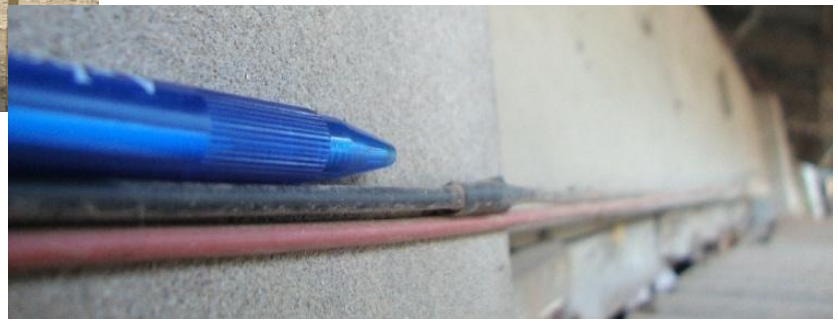
Case1: Close to grid- *illegal wiring* (Namibia)

House in Katutura township (Windhoek), transmission lines

Wire used to connect to a 400 m distanced house
(pen diameter is 9 mm)

Case 2: Mini-Grid – *side connection* (Bangladesh)

Shops powered by 100 kW_p mini-grid and SHS

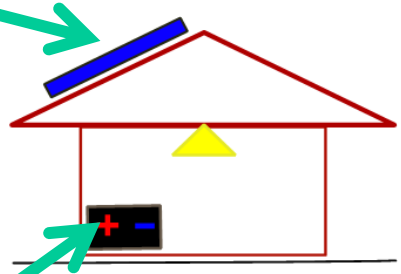


Wire used to connect to a 20 m distanced house (pen diameter is 9 mm)

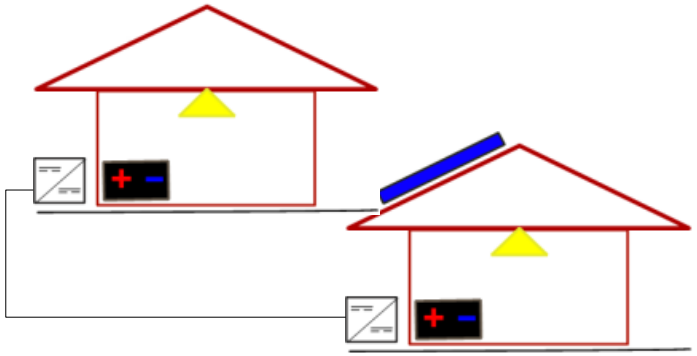
Swarm Electification Concept

10-85 W_p

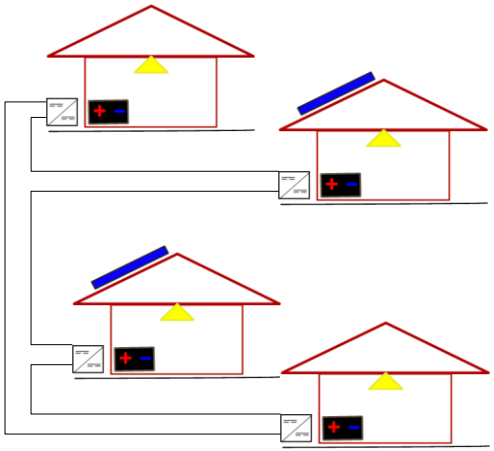
3 days autonomy



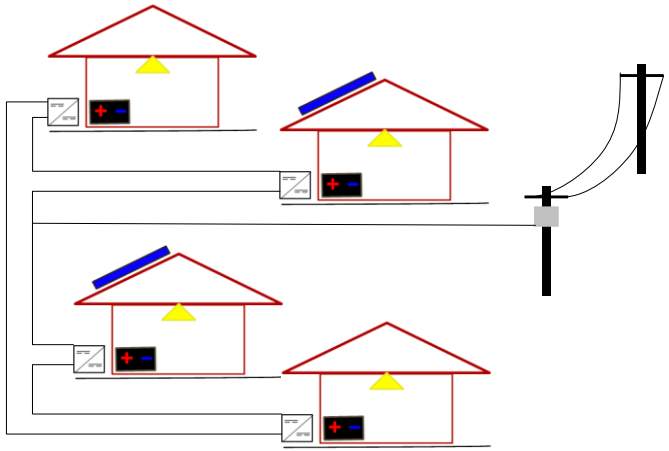
Stage 1



Stage 2



Stage 3



Stage 4

Research Question

What are the **hidden resources** in an **SHS** that could be utilized as the basis for a **bottom-up swarm electrification scheme?**

Modeling I- Solar Module

Scenario:

65 Wp SHS with 100 Ah lead acid battery, synthetic load curve, one year

PV Model:

Flexible single-diode model (Villalva, Gazoli, and Filho 2009)

Losses accounted for:

Irradiation induced temperature degradation

Not considered:

modul ageing, dirt on panel and reflection

Modul II- Battery Modeling

Battery Model : Output parameters: $U_{bat}(I)$ and *SOC* and *SOH*:

Capacity loss due to Corrosion:

High temperature
Partial cycling

Capacity loss due to Degradation:

Time between full charge
Ah-throughput
Low discharge rates

$$C_d(t) = C_d(t=0) - C_{corr}(t) - C_{deg}(t)$$

→ All reflected on in the **state of health (SOH)** (F. Boldt 2012):

$$SOH = \frac{C_d(t)}{C_d(t=0)}$$

Modeling III- Loads

SHS-sizing: 65 W_p, 100 Ah, max 70% DOD (Grameen Shakti 2009)

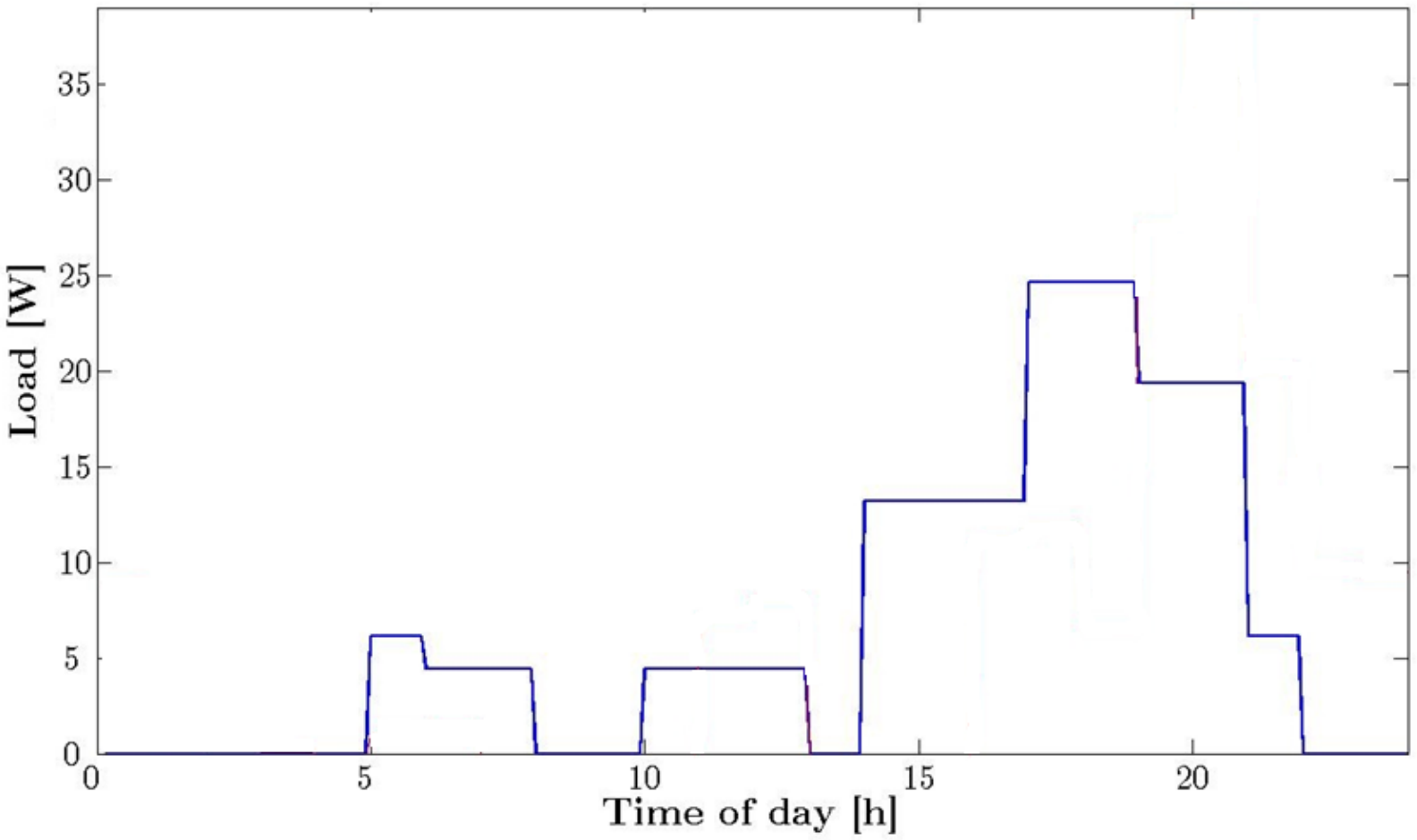
Loads:

Loads for 65 W_p SHS, from (UNFCCC, 2012)

Appliance	Load [W]	Usage [h/d]	Daily Demand [Wh/d]
5 CFL lights	30	4	120
Black and white TV	10	3	30
Mobile Charger	3	4	12
Total			162

Load variation: 6/7 probability for162 Wh load day (UNFCCC,2012)
1/7 probability for 240 Wh load day (Khadem, 2006)
daily noise level (15 %) and hourly noise level (20 %) (Hafez & Bhattacharya, 2012)

Load Profile

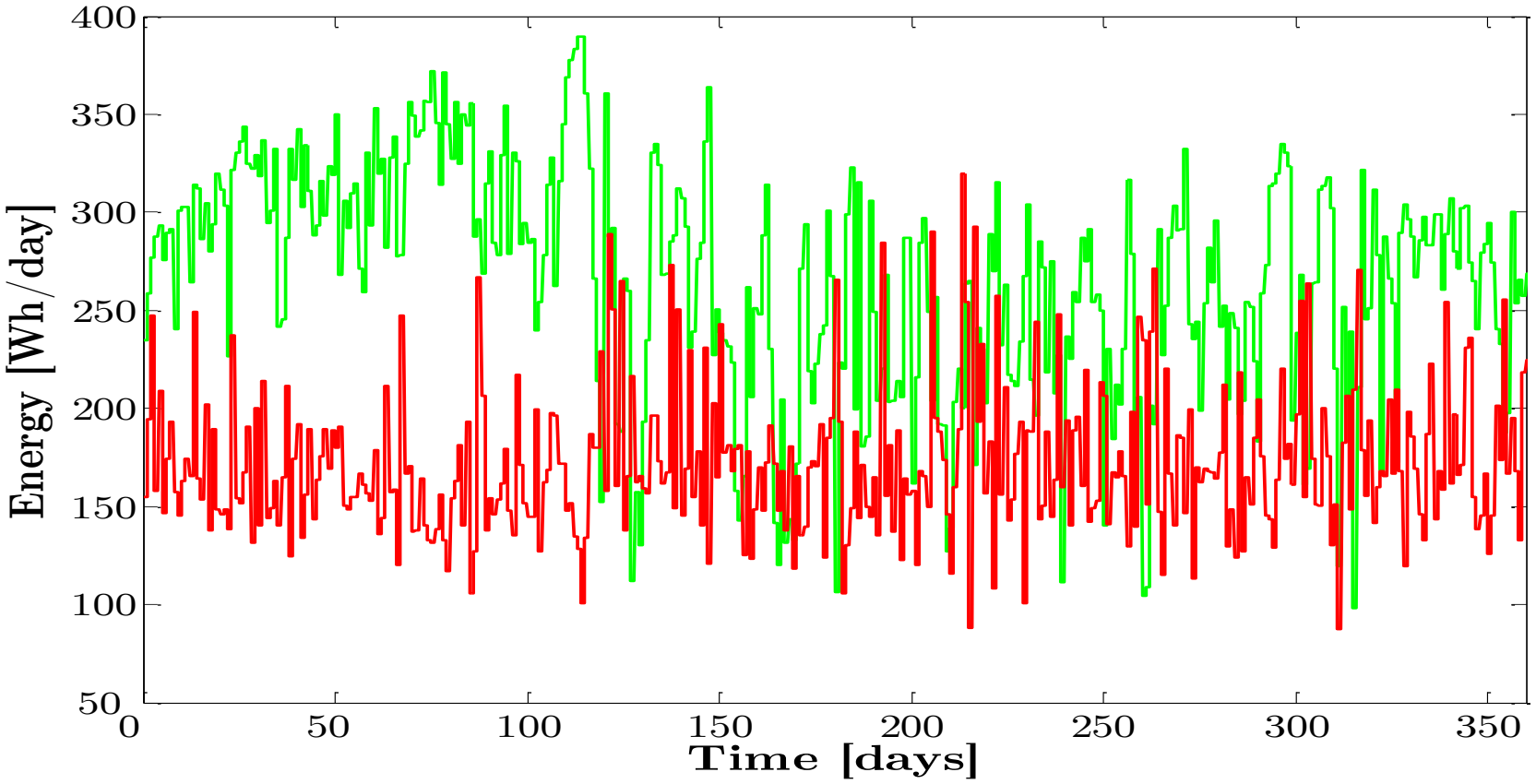


Relative distribution by (Khadem, 2006)

Results-I: Daily Energy Generaration and Demand

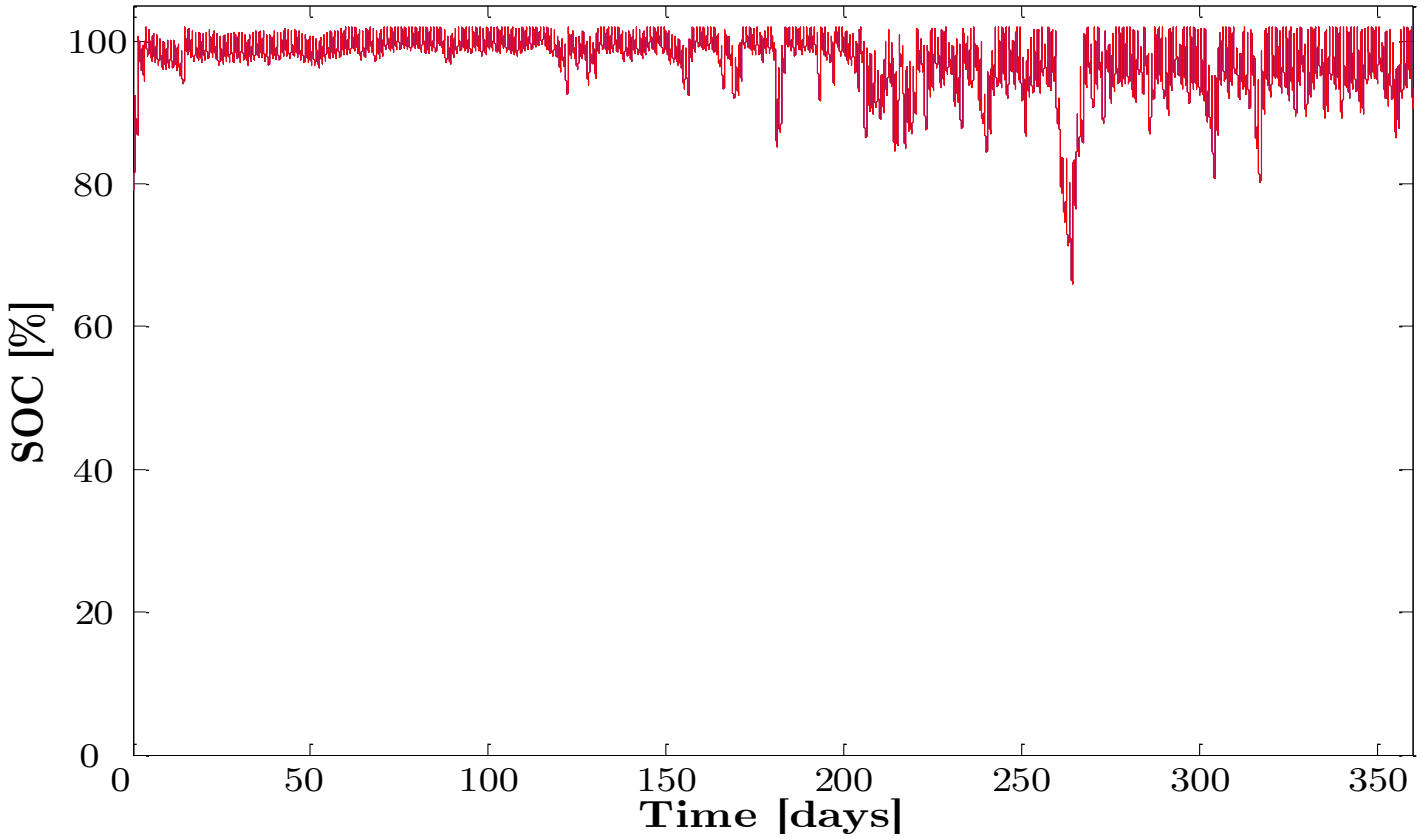
Generation Potential: 97.5 kWh/a
Excess: 31.9 %

Demand: 62.0 kWh/a
Cut-off load: 0 %



Results II: State of Health and State of Charge

State of Health after one year: **96.8 %** 2.5 % due to corrosion
0.7 % due to degradation



Summary and Discussion

Motivation:

- Around the globe, end-users take initiative to electrify themselves
- Swarm Electrification: Bottom up-electrification based on SHS

Modeling and simulation

- One year simulation for 65 Wp, 100 Ah SHS
- Synthetic load curves, sophisticated battery model

Results

- Hidden resource identified: >30 % of potential generation
- State of health of battery is very high after one year, 96.8 %

Outlook

- Agent-based control for safe DC microgrids
- Study of behavior in sharing-based infrastructure, real load curves

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Thank you very much!
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