Electricity Access in Emerging and Developing Countries

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Cost/Benefit dynamics of different technologies for electrification

- Differences arise out of many factors
- Geography - settlement patterns, land-locked
- Target energy demand and power levels
- Material cost: transport/customs, scale, imports
- Standards for reticulation
- Costs of transition to smart/prepaid metering.
- First cost to connect: how to spread that
- Benefits of grid-like service
- Can Infrastructure be incremental?
Cost/Benefit dynamics of different technologies for electrification

- Cost differences that arise out of different factors
- Geography - settlement patterns, topography
- Target energy demand and power levels
- Material cost difference due to transport/customs, scale, ad-hoc imports
- Standards for reticulation
- Costs of transition to smart or prepaid metering.
- First cost to connect - how to spread that
- Benefits of grid-like service
a) Bonsaaso, GHANA
b) Tiby, MALI
c) Pampaidia, NIGERIA
d) Potou, SENEGAL
e) Koraro, ETHIOPIA
f) Mwandama, MALAWI
g) Mbola, TANZANIA
h) Mayange, RWANDA
i) Ruhiira, UGANDA
j) Sauri, KENYA

MID:32.7
MID:54.3
MID:99.7
MID:56.9

1 cm = 2 km
The impact of geography on energy infrastructure costs

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Energy Policy

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Myanmar:
National Electrification Plan

Moving Average: MV line per HH
Myanmar - full National Dataset

National MV Grid Rollout
Equal MV Per Phase
- Phase 1
- Phase 2
- Phase 3
- Phase 4
- Phase 5

Connected earlier
Connected later

Phase of Grid Roll-out (quantiles of equal # HH)
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Mean Monthly Energy Expenses per Household in USD

$5/month

Includes Expenses on Kerosene Candles, Fuelwood, and Charcoal

Deciles of Household Total Monthly Expenses on Energy (USD)

n: Bonsaaso 290, Ikaram 258, Mbola 278, Mwandama 300, Ruhiira 300, Tiby 295
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STANDARDS and LEVERAGING LOCAL LABOR

Ready Boards
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Grid-like service?
First costs: for connection + efficient appliances

Situation: >20 ménages par 100 m²

Rayon de 100m
GENERATION
PRIVATE
INVESTMENT

DISTRIBUTION
PUBLIC/CUSTOMER
FINANCED

INSIDE WIRE/APP
TARIFF
FINANCED

ANY SOURCE
eg HYBRID

220V AC
Average Overall Energy Usage Over a Day for 45 Lowest Usage Circuits

Avg Daily Consumption per customer - 101.7Wh
Average Calculated Using Median

(average is bold)

Average Overall Energy Usage Over a Day for 5 Highest Usage Circuits
Moving Average with Regression line for Monthly Energy Usage for Systems in Ruhiiira, Uganda

Sys max cap reached

137% Average Annual Growth

Date

2011-12-01 2012-06-01 2012-12-01 2013-06-01 2013-12-01 2014-06-01
POOR ARE CREDIT WORTHY

UTILITIES NOT ALWAYS

\$2.50/hh pm

\$9/h pm
Modular, incremental with growth. Can lessons apply to grid?
Average Overall Energy Usage Over a Day for 45 Lowest Usage Circuits

Avg Daily Consumption per customer - 101.7Wh
Average Calculated Using Median

(average is bold)

Numerical experiments: performance

- 37% decrease in uncommitted and curtailed demand
- 200% increase in revenue
- Robust control avoids extra 100 W capacity investment

Reliability: utility’s commitment and curtailment

- committed_{it} = \min\{demand_{it}, limit_{it}\}
- Utility possibly loses revenue by setting limits too low
- curtailed_{it} = committed_{it} - supplied_{it}
- Utility pays curtailment cost by setting limits too high
  - Curtailment penalties \( \eta_{it} \propto \text{predictability} \)
Energy and Agriculture (USAID support)

- Understand need, context, constraints of user and constraints of operator, finance
- Constraints: upfront cost, small land holdings, crop & water use varies, no grid power
- How to bring benefits enjoyed by large farms to groups of small farmers?
Cost/O&M/biz model/local/scale in mind

Max Wire Length = 300 meters
Farmers own innovations

Biz Model

Innovation

Co-op+Finance

Roads + transport

Market
Logic/Power Elect/Control/Payment/Pump

- Scheduling logic
- Inverter/VFD
- 415V, 3ph, 50 Hz
- Microprocessor
- Payment app
Innovation
Low maintenance + payment system

Local insight
high utilization
efficient water use

Government/Private Scale, import duty, low-cost finance
Summary: Demand + Prioritization

- Can norms for future demand projections that are generalizable be developed? To what extent dictated by
- Income and/or per kWh tariff
- Tariff structure, any flat monthly fees, and/or tariff stage
- Additional productive demands and other social infrastructure (present or expected).
- Productive demands and when/how/what conditions they emerge?
- Country policies for industry/agriculture
- Settlement size, promotion of appliances, scarcity of biomass, thermal comfort needs and electricity subsidy delivery mechanism.
Grid: costs, losses, subsidies, tariffs, transparent transactions, payment sys

Example: Rajasthan

4.20 + 0.90 + 1.44 = Rs 6.64 = 10 c/kWh
Loss → Rs 6.64 - 3.90 = 2.60 = 4c/kWh
Revenue includes Ag subsidy!

Rs 3.90 is not the tariff but realization
transparent transactions, payment sys