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Smart Village Microgrids:
Early Experience in Design & Implementation

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meshpower

Observations

1. Field and laboratory work indicates that little technology development is required for core power system deployment – especially PV-battery systems.
2. Significant differences exist between small subsistence-agriculture villages and larger village microgrids: Same assumptions don't work.
3. A tradeoff between reliability and LCOE may be possible … but human factors have not been properly characterized.

Workers in development call off-grid microgrids "minigrids" to distinguish them from other system types that are not true microgrids.

1: Core Power Technologies Are Available …

Example system by MeshPower and CSU

- AC/DC system, PV-battery-generator

Accomplished using:

- Stock inverter equipped with genset pass-through & charge controller
- Lighting on MeshPower DC circuits
- *Controls from MeshPower customer system*

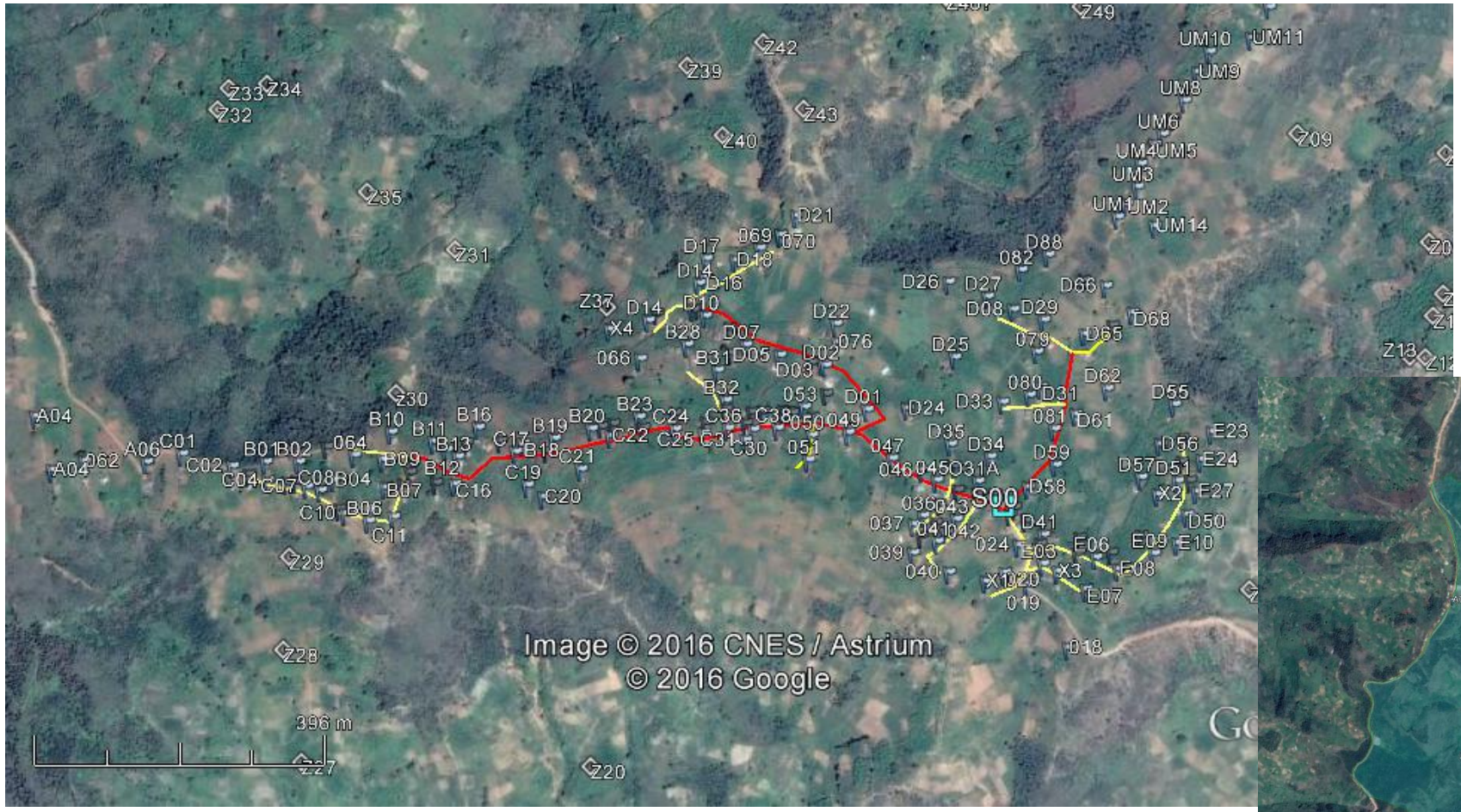
Inverter / Charge Controller

Generator & Auto-Start Control

1 Plenty to do … but not usual EE areas …

- Controls:
  - Power equipment vendors do not utilize standard control interfaces …
  - Locks into single-vendor … or requires code customization
- Cost down:
  - Integration of “normally separate” components reduce cost
  - Protection + metering + power control
  - Safe & simple LV distribution
- Appliances that fit customers’ needs
  - Low-cost, low-voltage (24-60V) DC appliances
  - *Plug standards!*

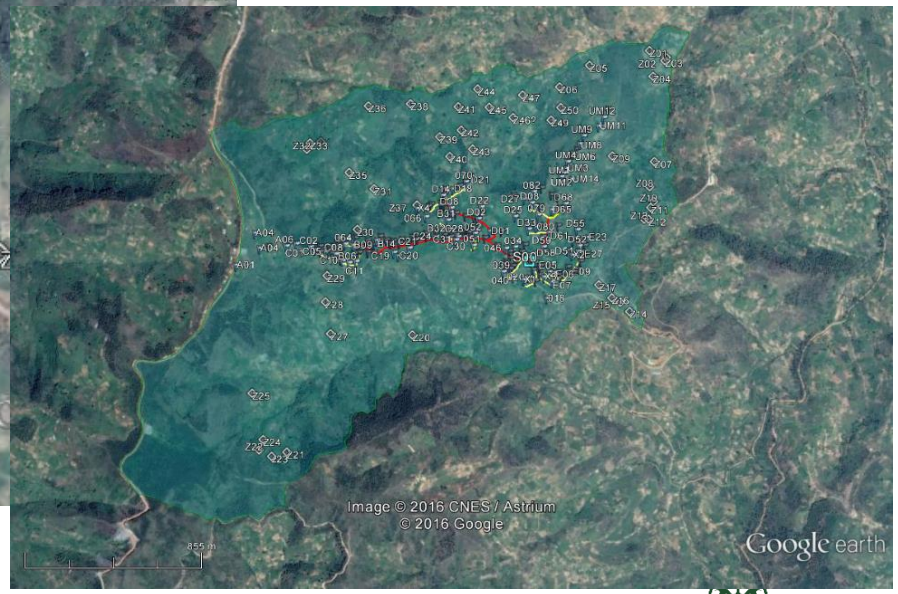
Villages Studied: Typical Example



Two views of one village utilized for design studies

Left: Houses and designed distribution system.

Below: Village boundary highlighted

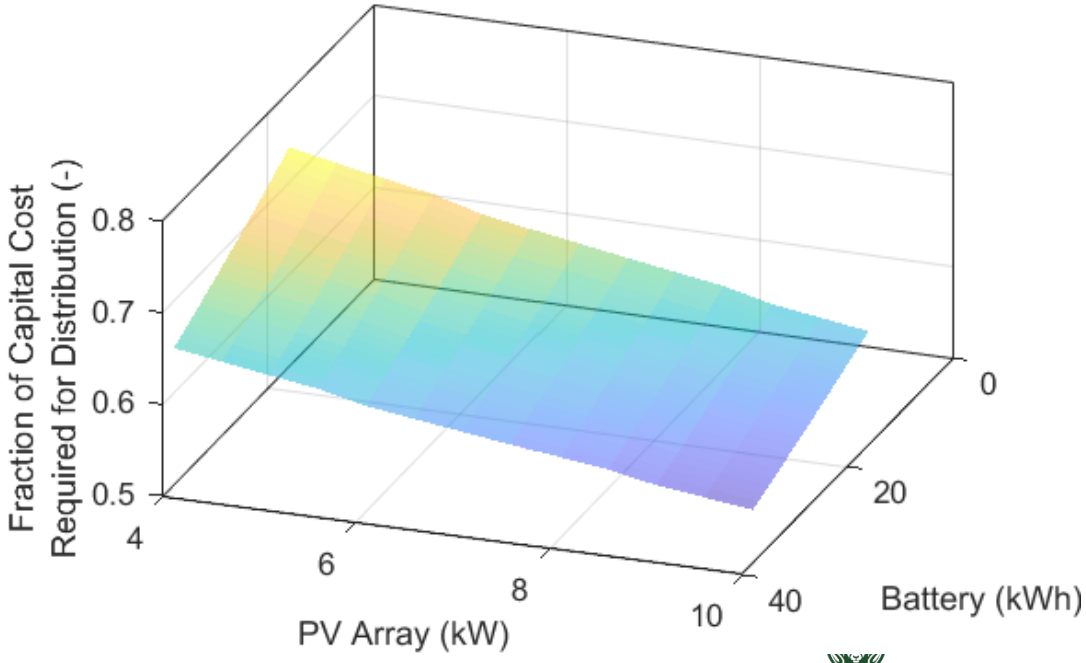


158 connected households / 32 unconnected / 3.5 km distribution

2: Cost Model for Small Villages

- Optimizations commonly state asssume costs as % of total cost
- Reality: Distribution costs are large fraction of total capital and not decreasing while PV and battery costs decrease

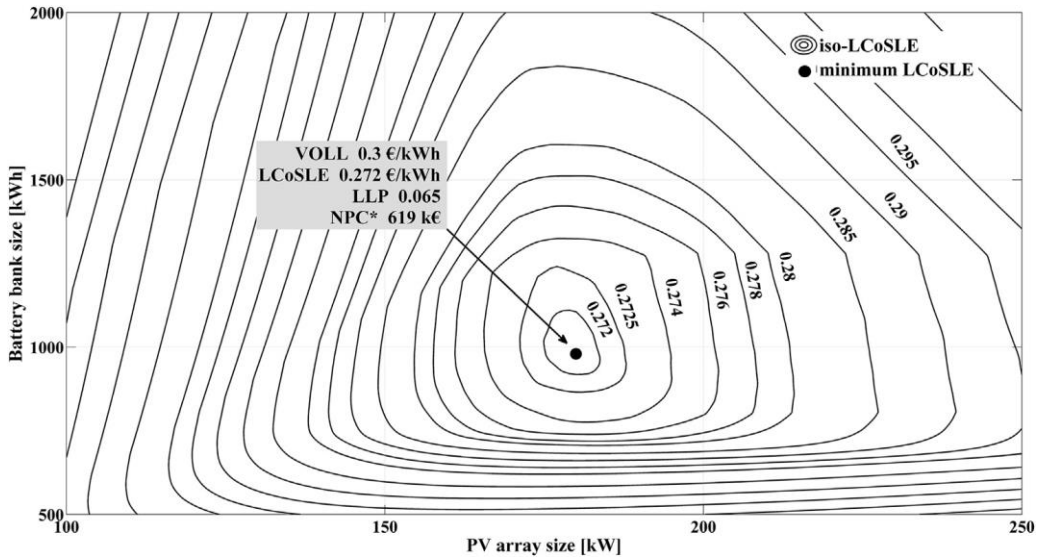
Equipment	Unit Cost	Units	Number of Units	Total Cost
Type A Line	$ 2.51	m	1539	$ 3,863
Type B Line	$ 1.52	m	2055	$ 3,124
HH Connect Line	$ 1.52	m	2788	$ 4,238
Pole & Hardware	$ 66.00	pole	119	$ 7,854
Meters	$ 65.00	connection	158	$ 10,270
HH Service Entry	$ 31.50	connection	158	$ 4,977
HH Wiring	$ 50.00	connection	158	$ 7,900
Meter base stn	$ 1,596	village	1	$ 1,596
Meter totalizer	$ 250	branch line	10	$ 2,500
Total				$ 46,323



Example using Cost-Reliability Tradeoff

Assume distribution fraction of system cost

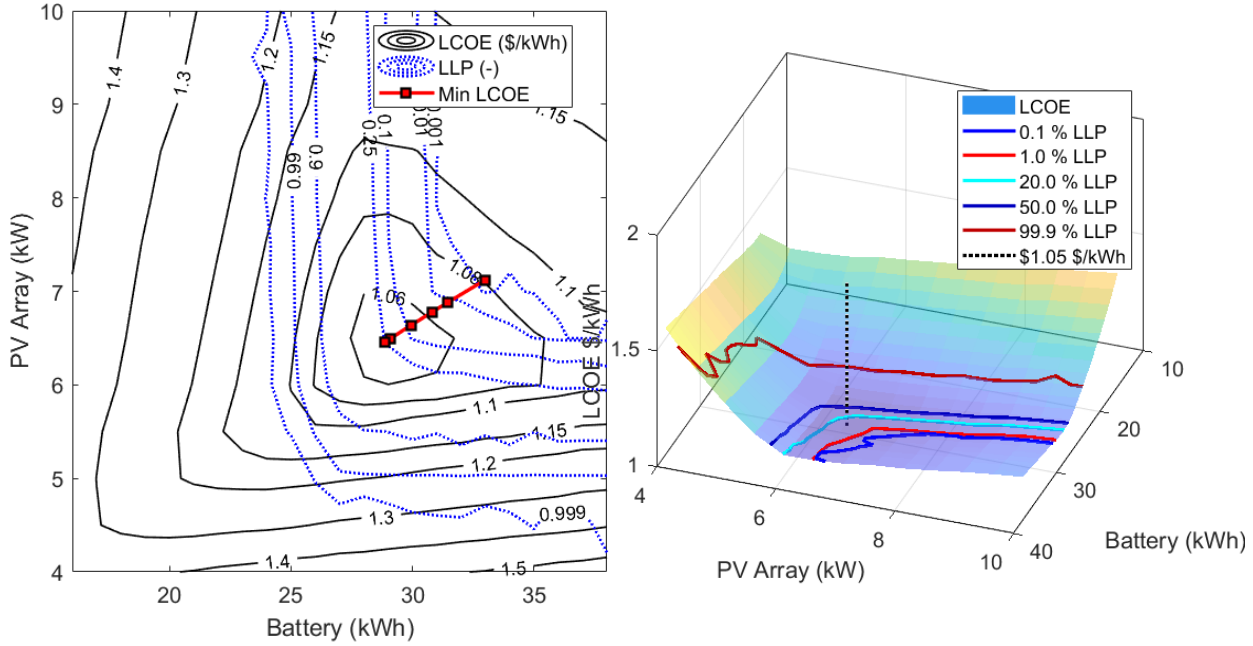
- Centered reliability & LCOE
- Conclusion: Can scale system on reliability + LCOE



[1] S. Mandelli, C. Brivio, E. Colombo, and M. Merlo, "Sizing methodology based on Levelized Cost of Supplied and Lost Energy for off-grid rural electrification systems," *Renewable Energy*, vol. 89, pp. 475–488, Apr. 2016.

Model distribution costs independently

- Reliability curves not aligned with LCOE
- Virtually no cost penalty to be "slightly larger" @ *higher* reliability
- Conclusion: Grow load to reduce cost .. reducing system size @ reasonably reliability has virtually no impact



Zimmerle DJ, Manning DT. 2017. Optimizing Rural Village Microgrids to Provide Affordable and Reliable Renewable Electricity in Developing Countries. 2017 Oct 19. IEEE Global Humanitarian Technology Conference; San Jose, CA.

Focus on “Productive Use”

- Field experience & modeling indicate that:
  1. Costs will not go down without increase in economic activity → drive load growth
     - Productive uses: Milling, refrigeration, welding, etc.
  2. Growing village economy requires “grid-similar” power
     - Solar home systems can’t provide enough concentrated power for productive uses.
     - Individual systems get expensive fast
  3. Need minigrid to provide ‘grid similar’ power where needed
- Next:
  - Focusing on productive uses & information access in villages
  - Human factors!
  - Judicious integration of multiple functions into single components

Thank You

Contact

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