Smart Village Microgrids: Early Experience in Design & Implementation

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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.
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
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 assume costs as % of total cost
- Reality: Distribution costs are large fraction of total capital and not decreasing while PV and battery costs decrease

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<th>Equipment</th>
<th>Unit Cost</th>
<th>Units</th>
<th>Number of Units</th>
<th>Total Cost</th>
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Example using Cost-Reliability Tradeoff

Assume distribution fraction of system cost
- Centered reliability & LCOE
- Conclusion: Can scale system on reliability + LCOE

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


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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