Mini-Grid Planning: Integrated Energy Planning for Rural Electrification

HPNET Webinar

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Reiner Lemoine Institut

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Reiner Lemoine Institut (RLI)

- Non-profit research institute
- 100 % subsidiary of Reiner Lemoine-Foundation (RLS)
- Established 2010 in Berlin
- Managing Director: Dr. Kathrin Goldammer
- Approx. 70 researchers and students
- Member of e.g.: ARE, Eurosolar, SDSN, dena

Reiner Lemoine
Founder of Reiner Lemoine-Foundation

Fields of Research

Transformation of Energy Systems

We analyze and optimize future scenarios with an energy supply largely based on renewable energy sources.

- Scientific monitoring of the energy transition– on national, regional and EU-Scale
- Simulation and optimization of cross-sectoral energy systems
- Analysis of single technology performances in integrated energy systems (energy storage, PtG, PtH, cogeneration)
- Research on transitional energy processes

Mobility with Renewable Energy

We analyze sustainable mobility concepts through sophisticated implementation and optimization of renewable energy systems.

- Battery electric mobility: propulsion of vehicles using electric energy from RE
- Hydrogen-electric mobility: production of hydrogen via electrolysis and Renewable Energies
- Integration of battery-electric and hydrogen-electric mobility: evaluation of mobility needs, analysing of public transportation, car-fleets of municipalities and cooperate firms, planning of charging infrastructure, multi-use of vehicles like car-sharing

Off-Grid Systems

We support the development of sustainable energy supply for remote regions.

- Strategies for rural electrification
- Simulation and optimization of hybrid mini-grids
- Combining GIS-analyses and energy system simulations
- Market potential analyses and business implementation strategies

Off-Grid Systems at RLI – **Mission and Motivation**

Mission

We support the development of sustainable energy supply for remote regions (SDG7)

Motivation

- **Economic:**

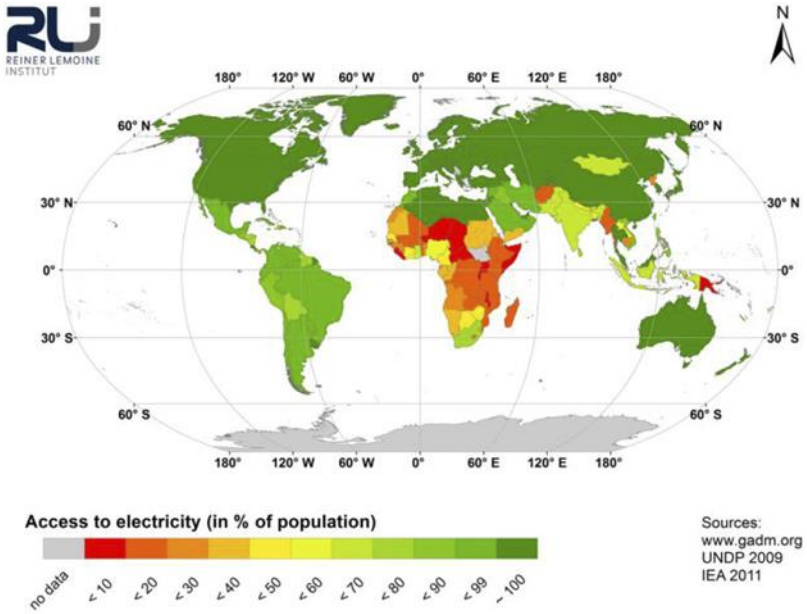
  Decentralized energy supply systems represent an attractive market for renewable energy and battery storage

- **Ecological**

  Fossil fuel substitution by renewable energy reduces harmful emissions locally and globally in off-grid systems

- **Social:**

  Electricity is a prerequisite for improved local development, health care and education.



Off-Grid Systems – Research Fields & Expertise

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Goal 7:

Ensure access to affordable, reliable, sustainable and modern energy for all.

Decentral supply systems (energy system modelling)

Rural electrification planning (GIS and demand modelling)

Climate resilience and transformation (socio-economic research)

International collaborations - knowledge transfer - networking activities - tool development

Off-Grid Systems – Research Fields & Expertise

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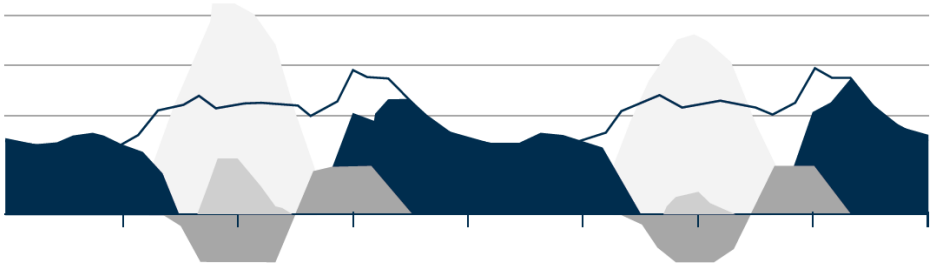
- Simulation of energy systems
- Feasibility studies and business model analyses
- Operation strategies and power flows
- Levelized Cost of Energy (LCOE) calculations



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Off-Grid Systems – Research Fields & Expertise

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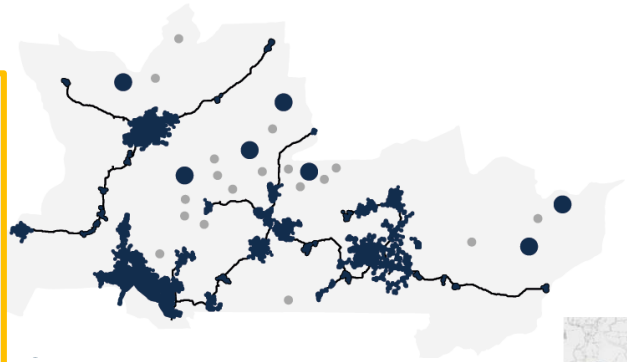
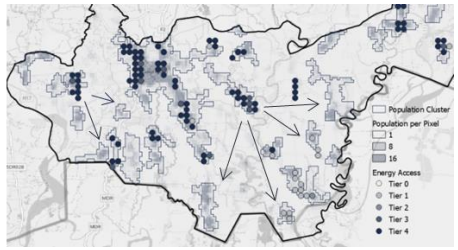
- Renewable resource assessment
- Power supply infrastructure analyses
- Application of database systems
- On-/off-grid electrification modeling
- Energy access baseline
- Ability to pay and energy demand
- Digital survey implementation





Decentral supply systems (energy system modelling)

Rural electrification planning (GIS and demand modelling)

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Off-Grid Systems – Research Fields & Expertise

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- Transformation of energy and transport sectors
- Climate change resilience of energy systems
- Off-grid market potential analysis and climate relevance
- Evaluation of political and social factors

Decentral supply systems (energy system modelling)

Rural electrification planning (GIS and demand modelling)

Climate resilience and transformation (socio-economic research)

International collaborations - knowledge transfer - networking activities - tool development

Guiding (research) questions for RLI's OG Team & Electrification planning

- Where do people without access to electricity live?
- What is the energy access of those people?
- What is the electricity demand of those people?
- What are the least-cost supply options for delivering this demand?
- What is the optimized phase wise electrification plan to implement those options?
- What role play off-grid / island systems?

Definition of the „ideal“ project

What defines a perfect project (location)?

- Brownfield vs greenfield
- Customer type (e. g. IPP, utility, …)
- Size [MW]
- Project volume [USD]
- Duration of project [years]
- Value chain steps

…

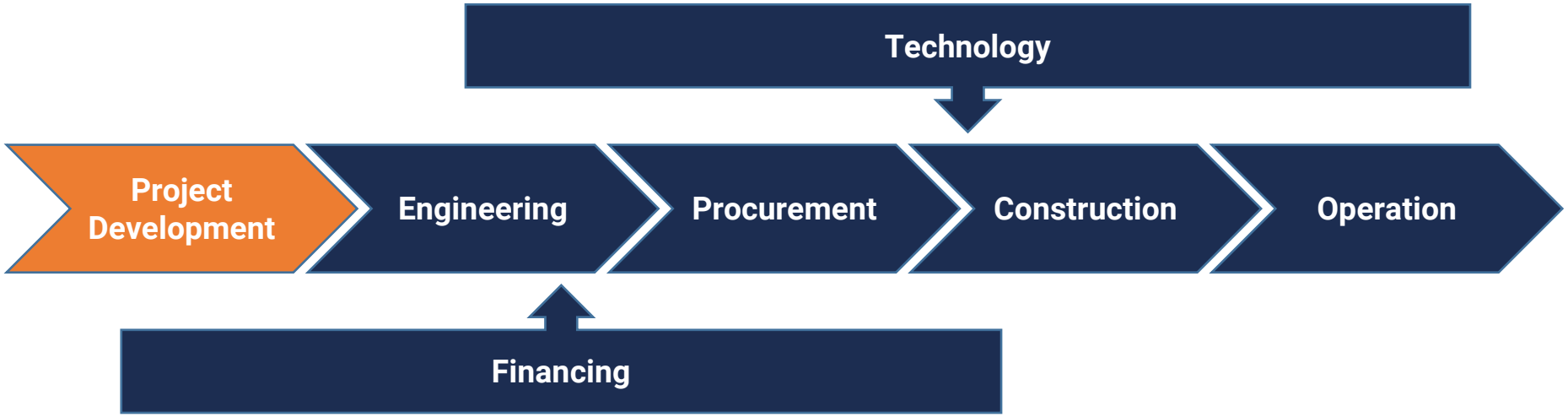
Definition of the „ideal“ market

What makes a perfect market?

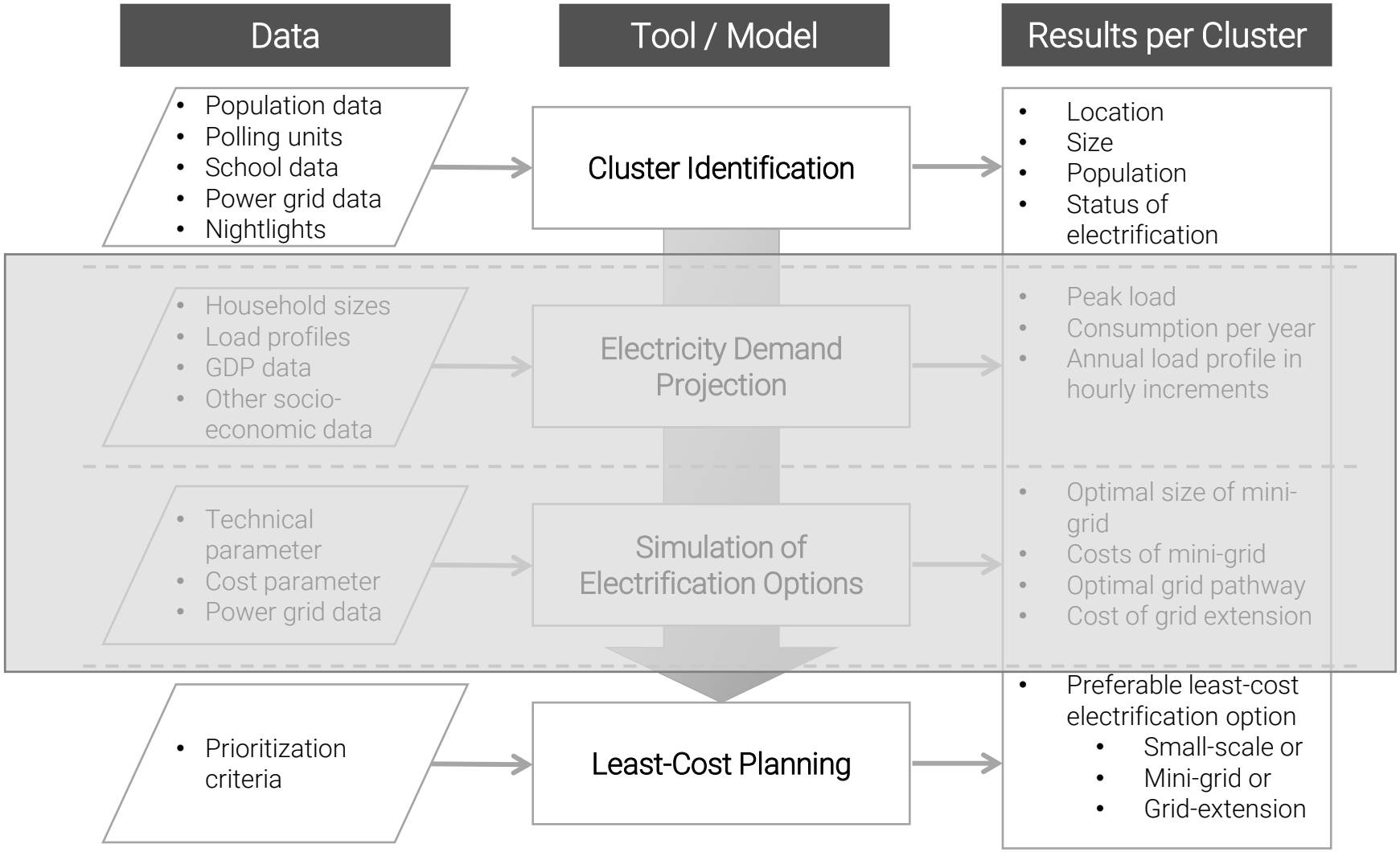
- Size [# of pot. projects] per region
- Exclusion criteria (civil disorder / language,…)
- Sales network
- Accessibility
- Replicability

…

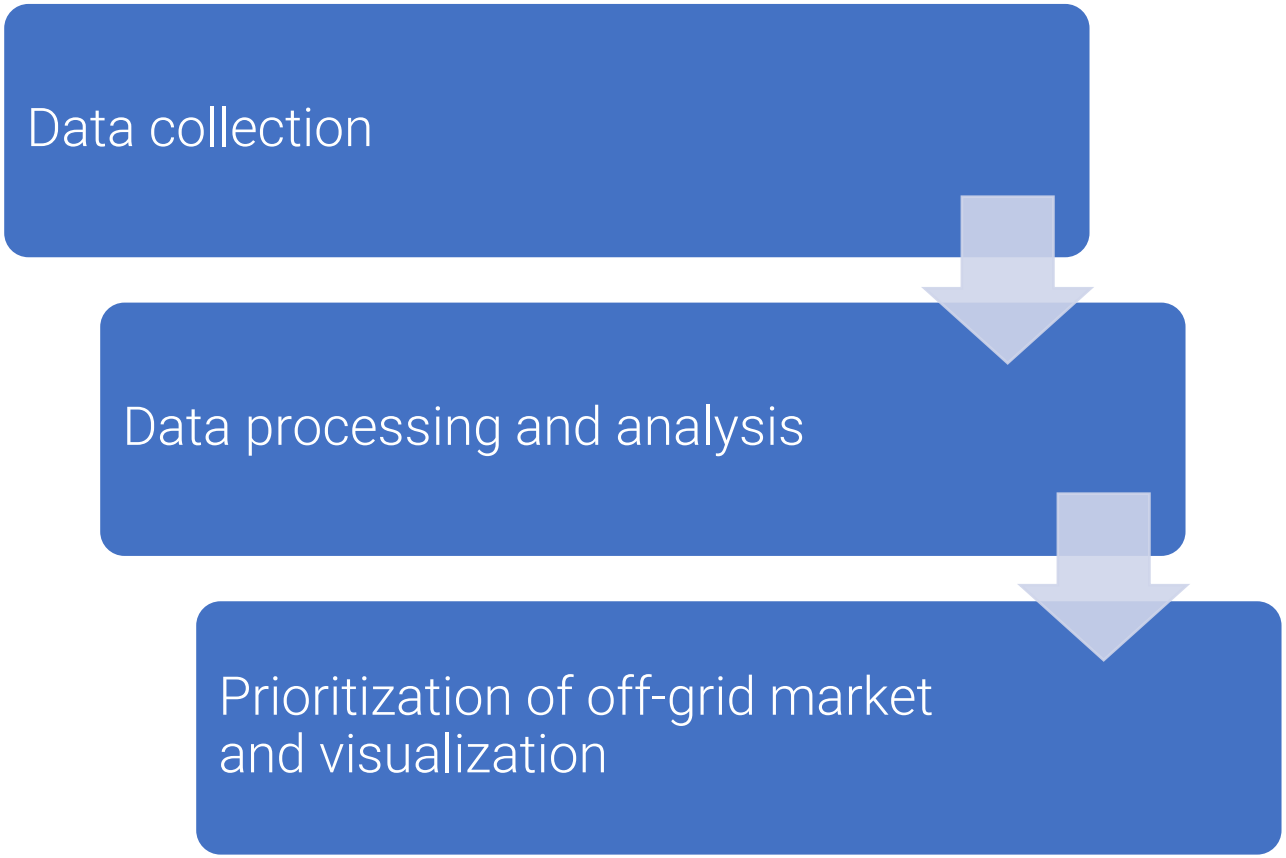
Value chain in the off-grid market



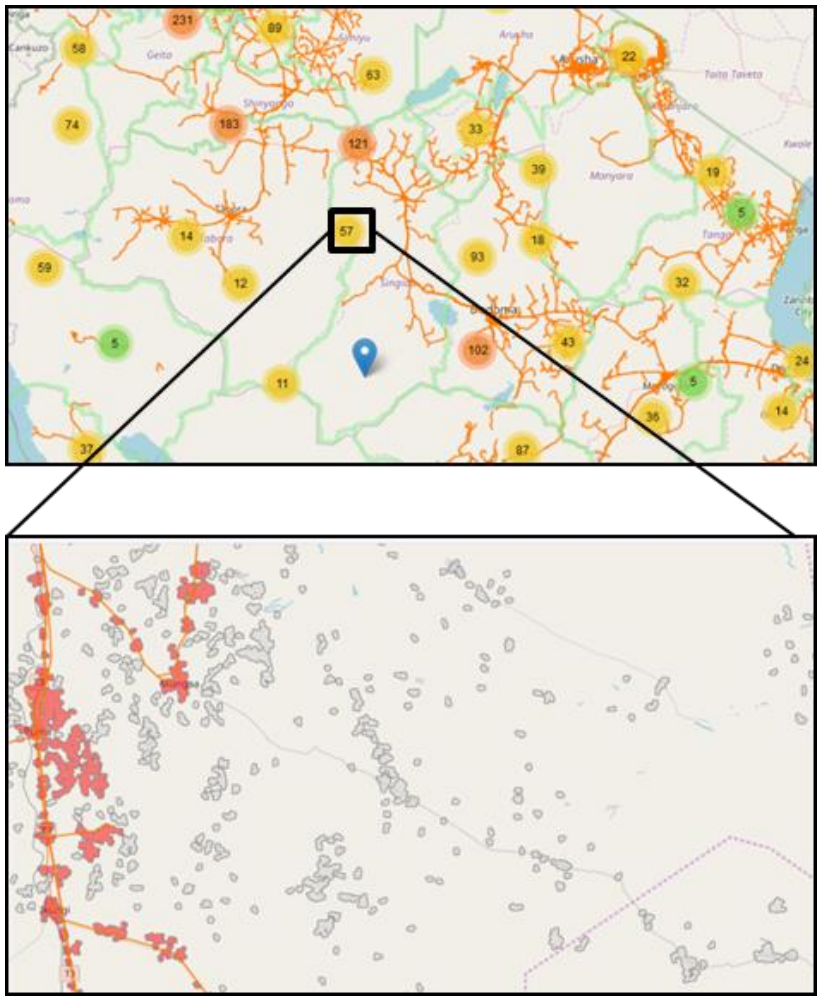
Electrification Planning



Process: GIS-based off-grid assessment

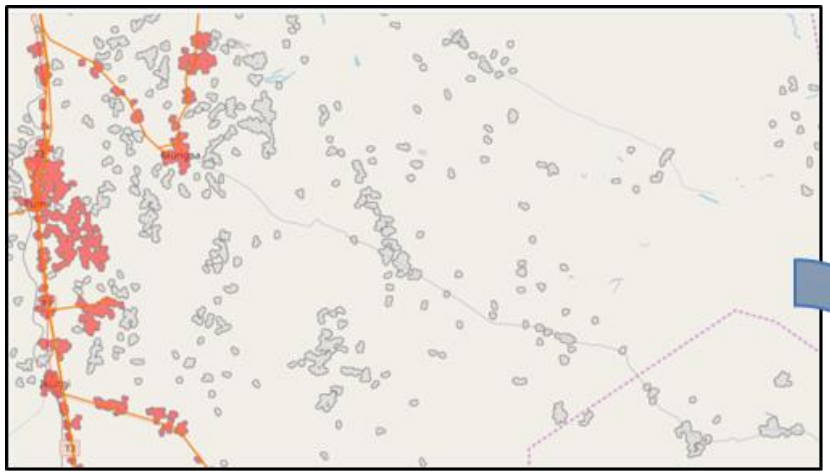


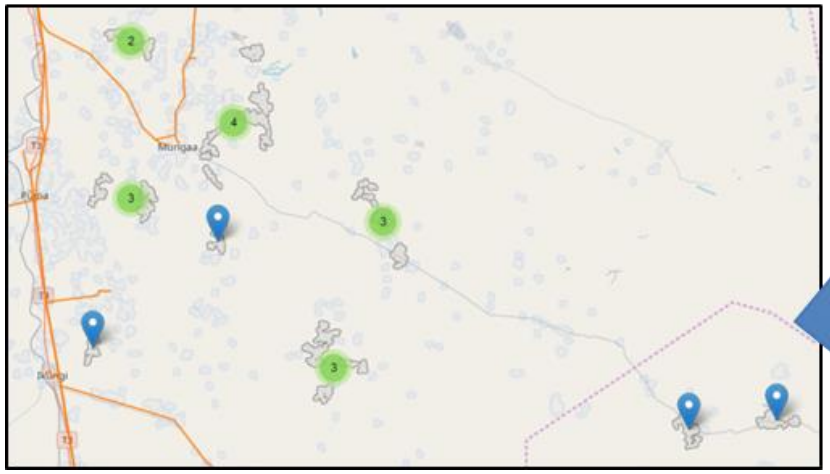
Location-specific site identification and characterization



- Geospatial analysis enables a rapid analysis of the potential sites for hybrid and renewable supply using readily available data.
- Village clusters were identified based on available satellite imagery based population datasets.
- These can then be characterised using available datasets such as electricity transmission grids, local infrastructure and others.

Prioritization of electrification options



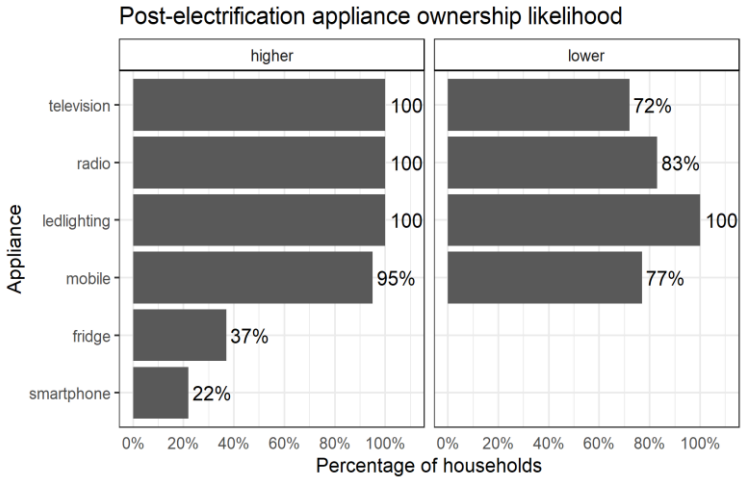


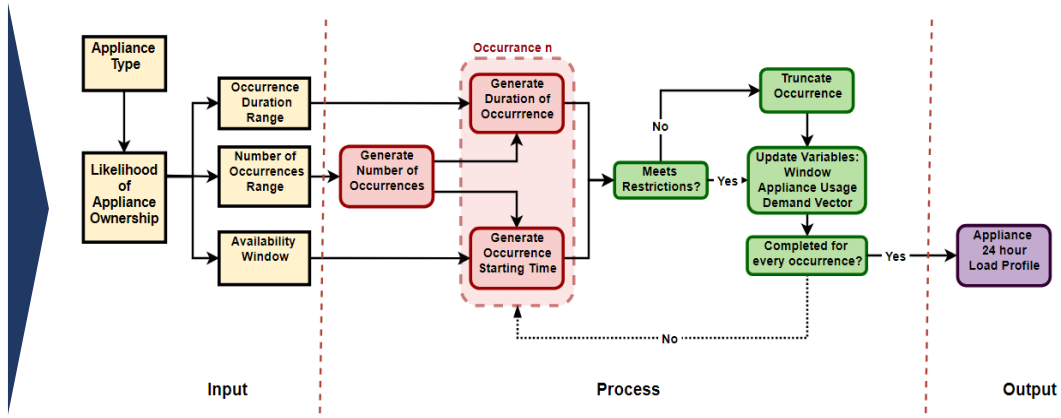
- A range of criteria are then weighted and used to identify which of these sites may be specifically interesting for hybrid and renewable energy supply.

- Common examples include:
  - Distance to grid
  - Population
  - Population density
  - Proximity of health clinics
  - Proximity of schools
  - Mobile phone coverage

Modelling electricity demands

- Household electricity demands are heterogenous across cultures and climates
- Surveys and secondary datasets help gain an understanding of the local context
- Stochastic modelling is a step towards better representation of uncertainties

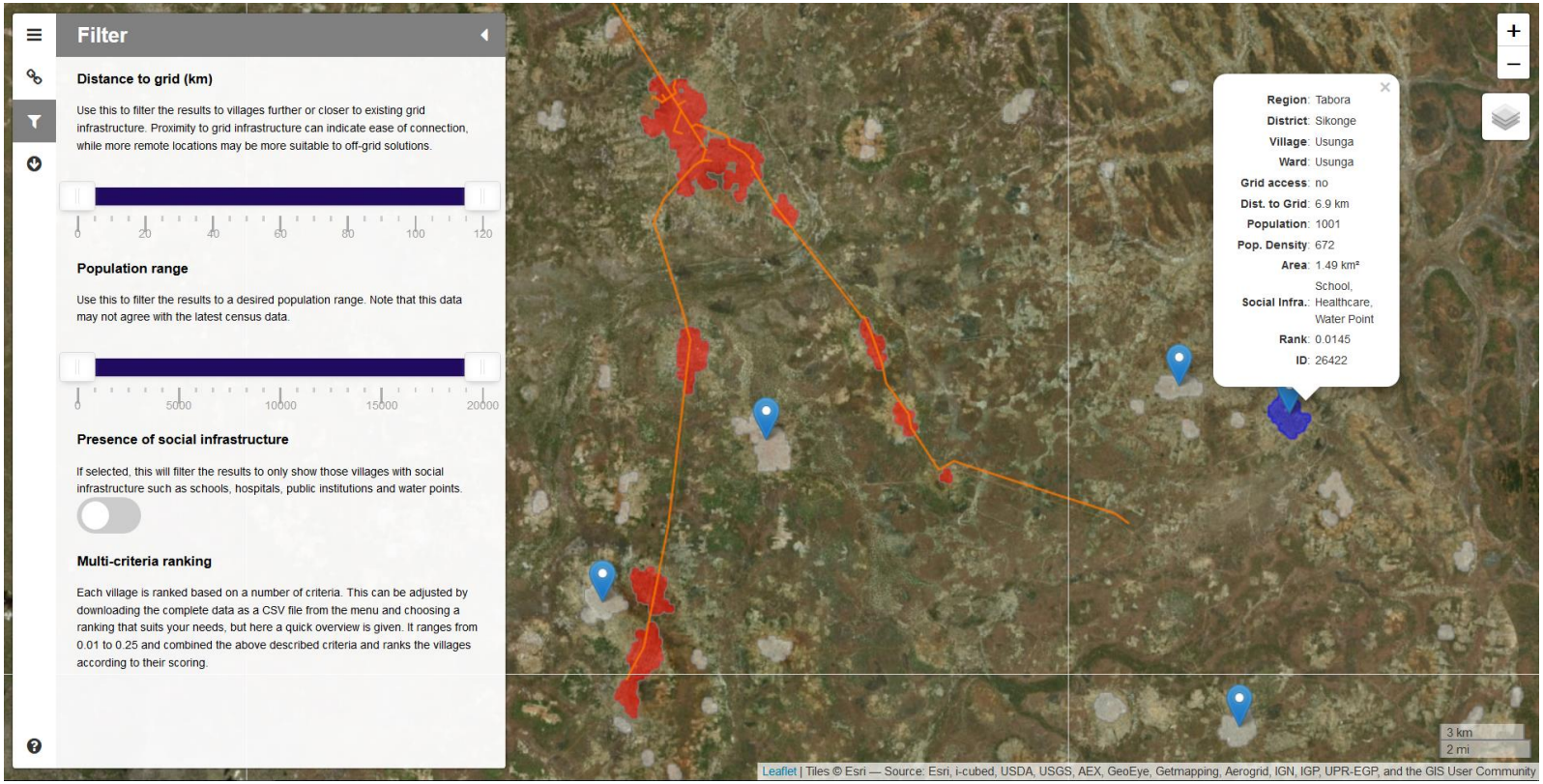




Pelz, S, (Forthcoming) Understanding the energy demands of households in rural Nepal

Market Evaluation & Portfolio Development

An example from Tanzania: https://tzmapping.github.io/



Challenge: Old satellite imagery / fast development

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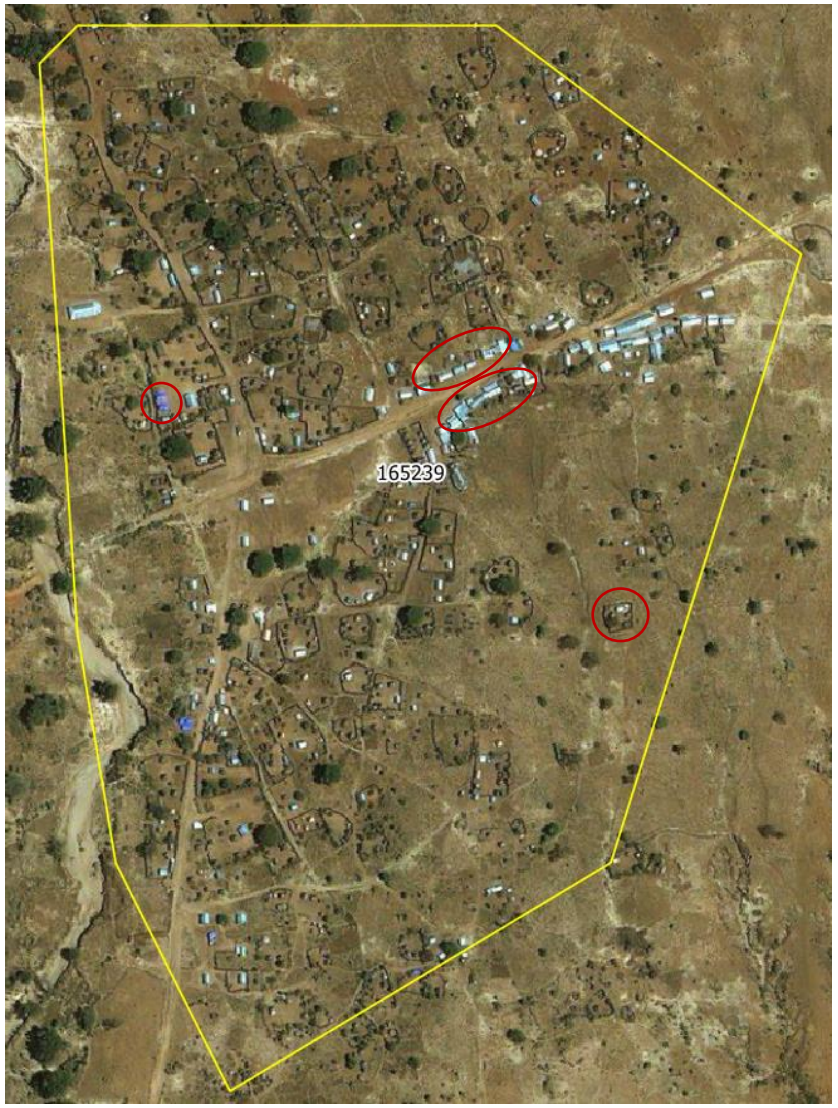
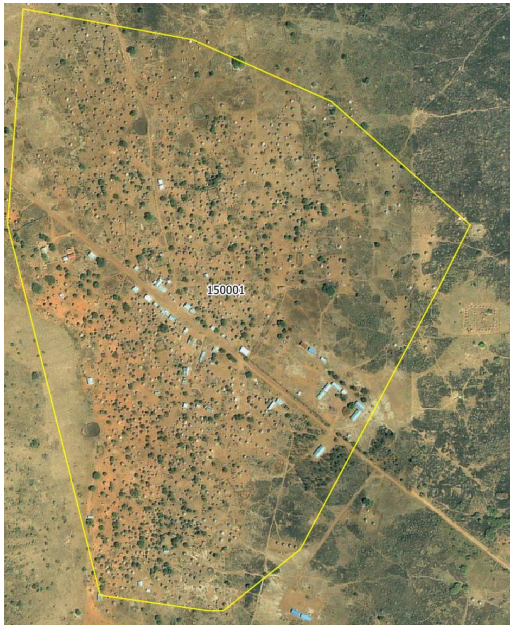


Challenge: Local variation

- Various settlement structures
  - Varying settlement density and shape
  - Settlements along roads



Challenge: Local variation

- Various settlement structures
  - Different house materials
  - Nearby residential areas detected in separate clusters

Thank you very much.

Your ideas?

… Partnerships
… Research cooperation
… Joint project proposals

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