UNIVERSITY OF CAPE TOWN
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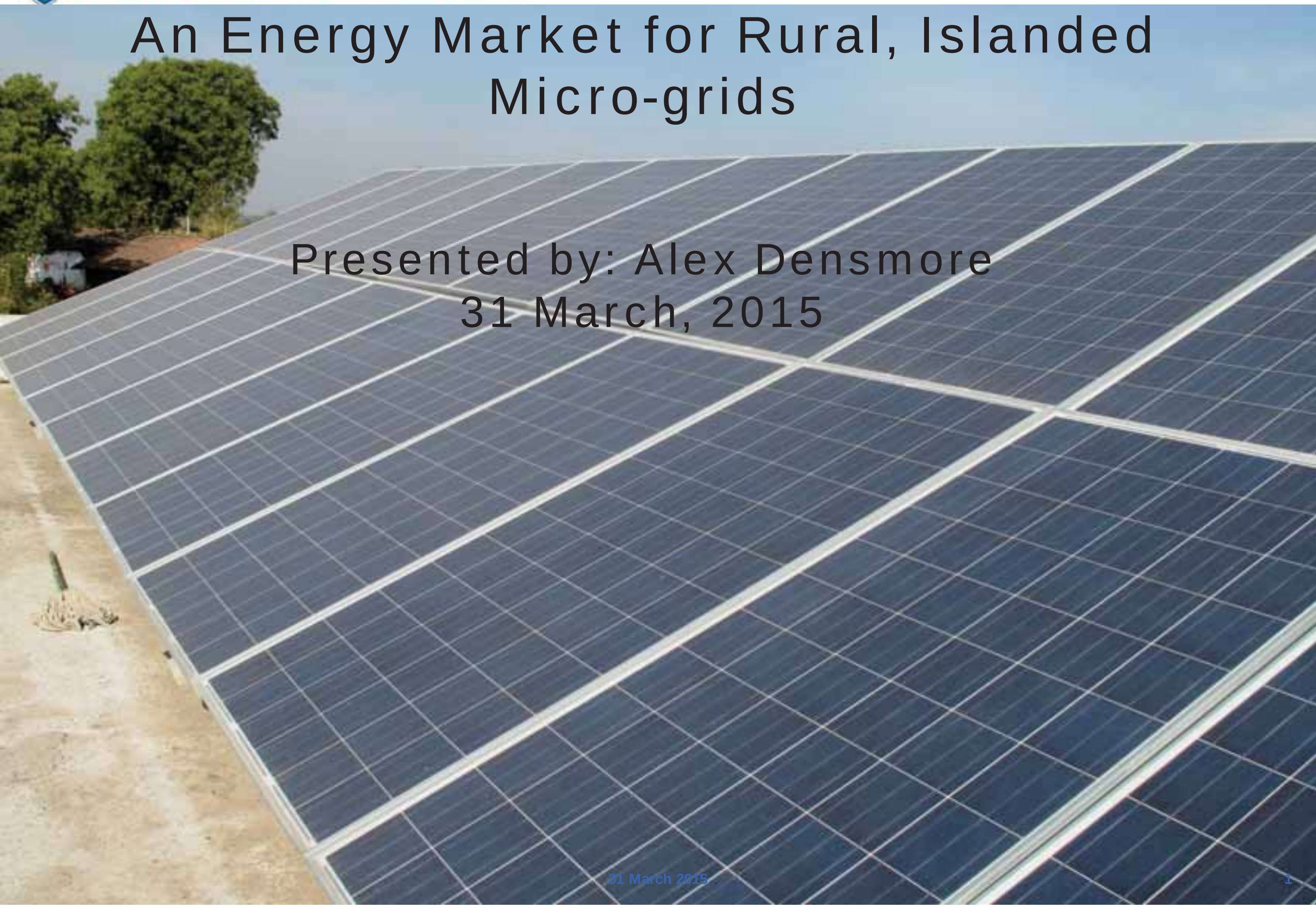
Energy Research Centre
Energy Poverty & Development Group

An Energy Market for Rural, Islanded Micro-grids



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Overview

- Context
- Problem Statement
- Proposed Solution
- Methods
- Results
- Discussion
- Future Work

Context

- Renewable energy micro-grids are increasingly seen as an important tool in electrifying rural areas while meeting low-carbon goals
- In general, micro-grids fit above lanterns and SHS in terms of the energy access "ladder". They are not appropriate for all situations.
- There is a desire for private-sector investment

Problem Statement

- Little data exist to repeatably estimate rural energy use in a variety of contexts (geography, culture, income sources, etc)
- Uncertainties in estimating user demand lead to great investor risk in providing funding for capital expenditures
- Difficult to acquire private-sector investment
- Once built, grid is inflexible to changing conditions
- Link between electrification and income-generating activities is weak

Proposed Market Framework

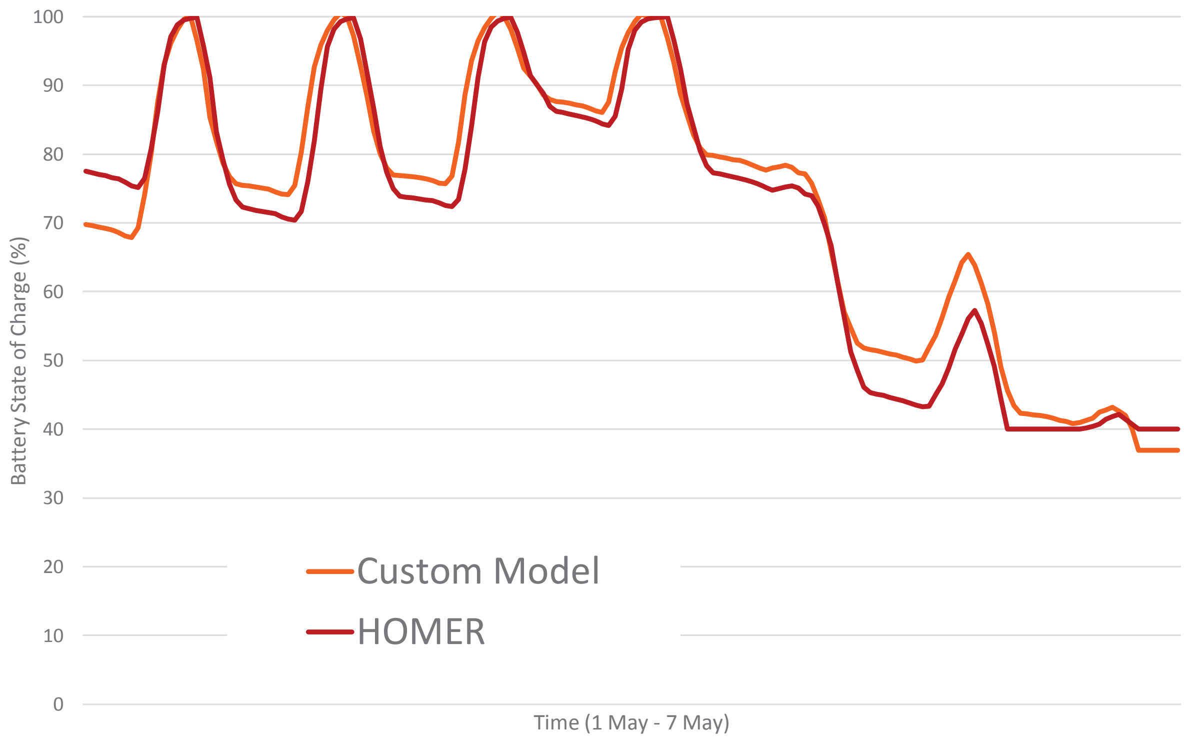
- Goals:
  - Maximize revenue for grid operator (within constraints)
  - Optimize user experience
  - Provide revenue source for local entrepreneurs
- Implementation:
  - Adapt pricing to expressed user demand
  - Allow local entrepreneurs to participate in the buying and selling of electricity

Method

- Comparison of proposed market to a fixed-price scenario
- Computer simulation – HOMER + custom modeling in Python
- Sensitivity analysis of unknown variables (price elasticity, demand)

HOMER
The Micropower Optimization Model
+ python™

Method


100
90
80
70
60
50
40
30
20
10
0
Battery State of Charge (%)
Custom Model
HOMER
Time (1 May - 7 May)

Method

Households (avg. 220Whr per HH per day)						
Quantity	17	17	17	17	16	16
% of total load	20%	10%	8%	22%	27%	13%
Max. price willing to pay	1.5	1.5	1.5	1.5	1.5	1.5

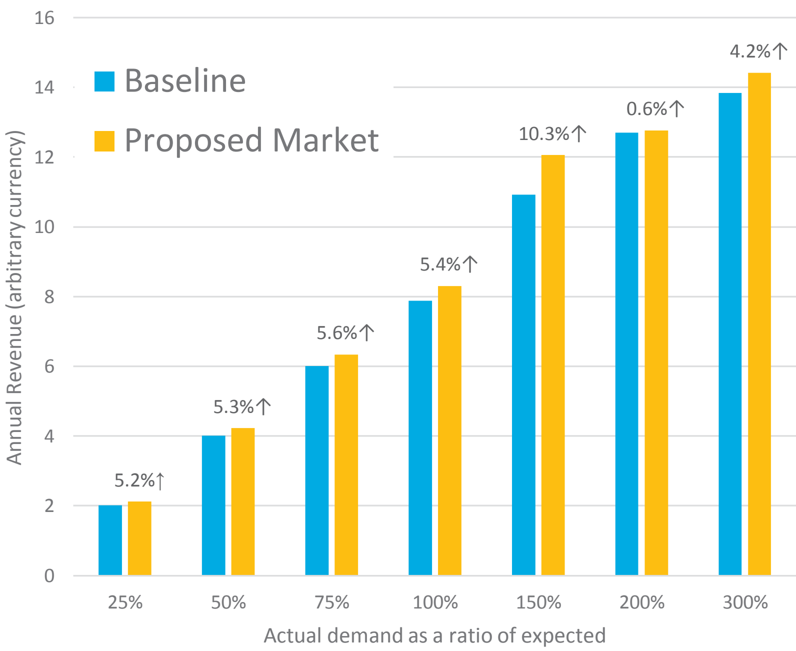
Entrepreneurs		**Operator**	
Quantity	4	PV Peak Output	8kW
Battery Size (ea.)	7kWh	Battery Size	32kWh
Electricity sale price	1.5	Max hourly change in price	+/-0.5%

Method

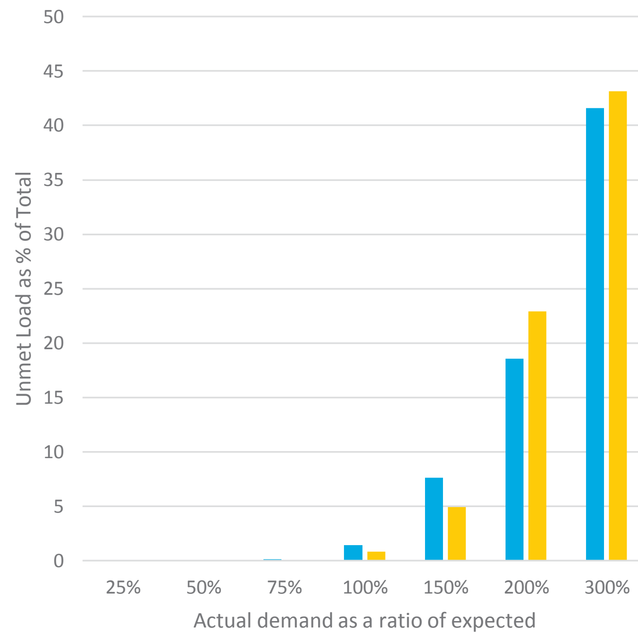
- Change prices based on load-shedding frequency (scarcity):

0% of the expected load was shed in the previous period	Lower the price to induce demand
More than 0% of the expected load was shed in the previous period	Raise the price to reduce demand

Results

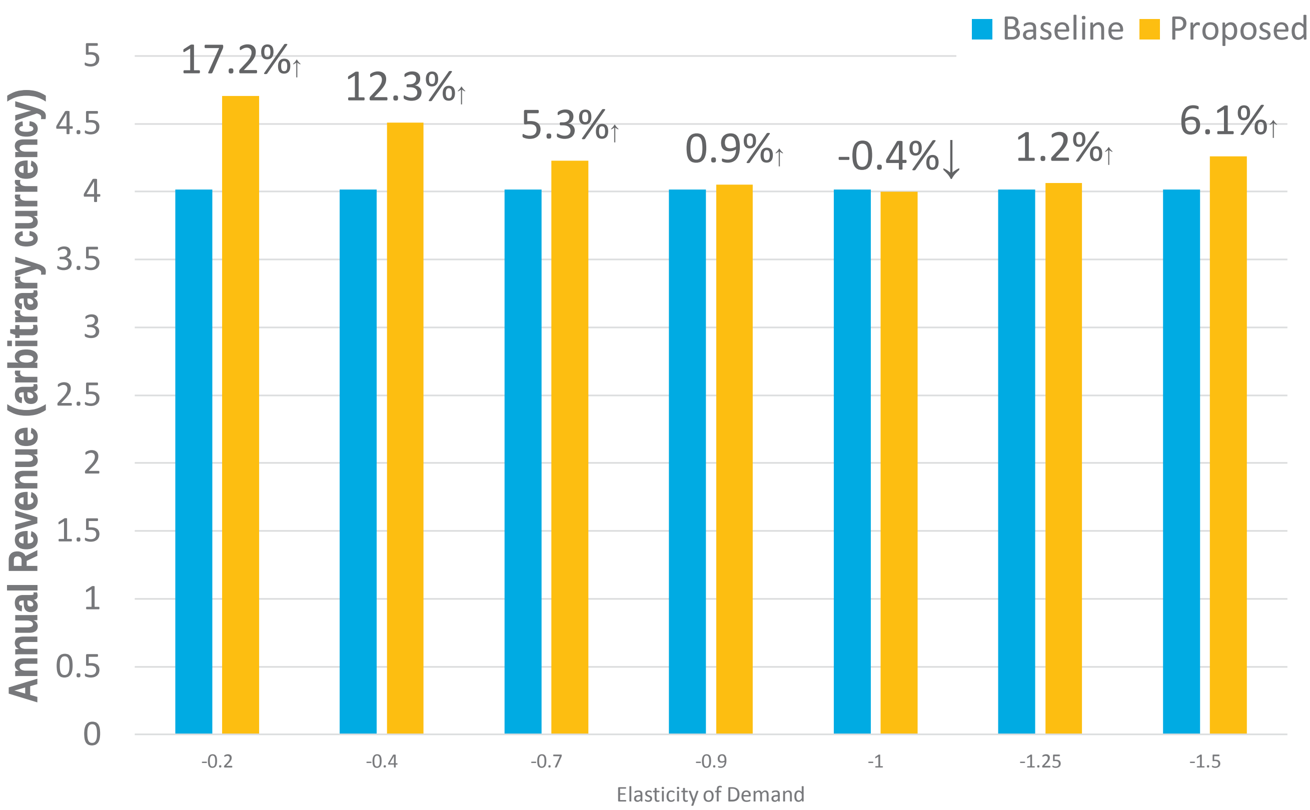


Revenue



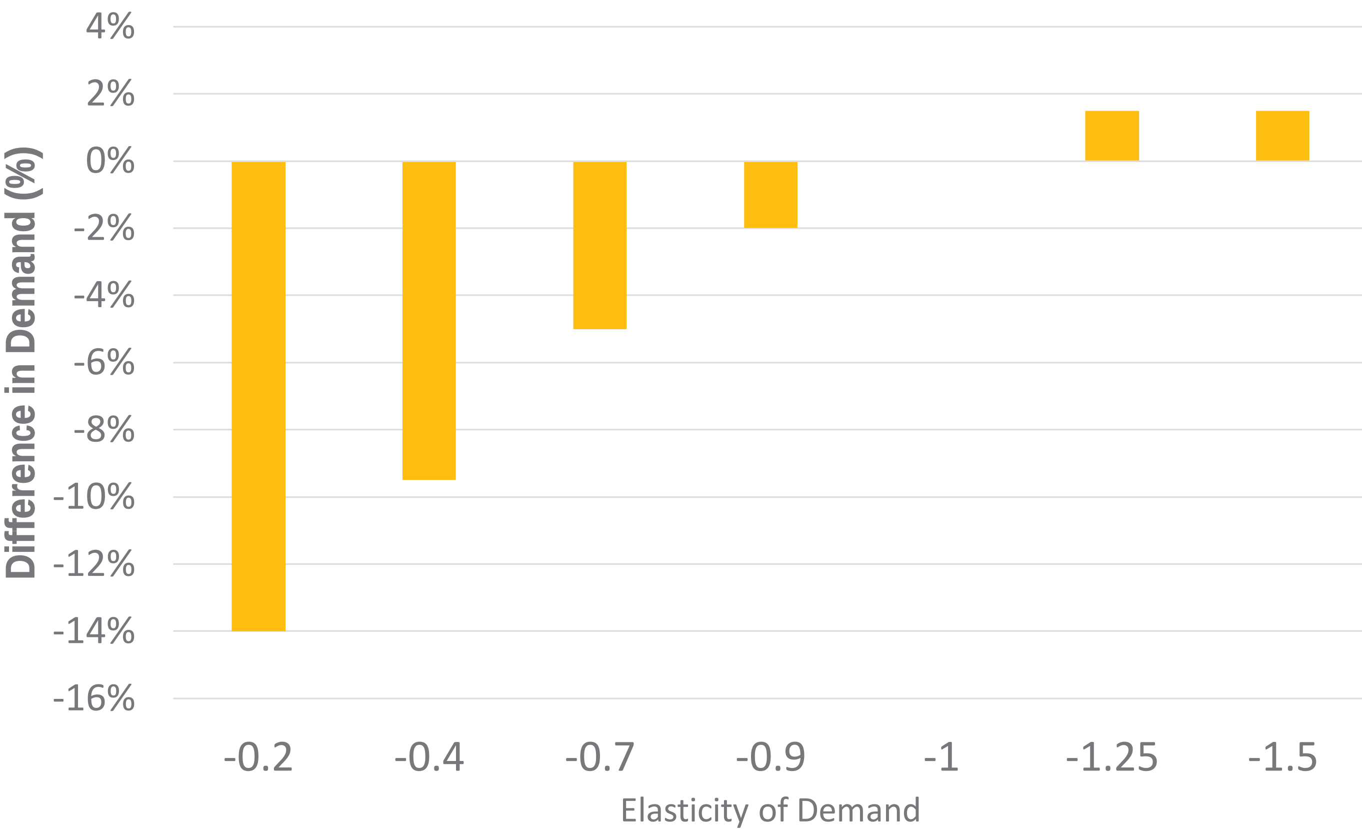
Unmet Load

Change in revenue and unmet load with proposed market, considering several demand scenarios (-0.7 elasticity of demand)



Change in revenue when considering elasticity of demand (50% demand scenario)

Resiliency to low demand



For example: demand can be 5% less than expected (in the -0.7 elasticity case), yet actual revenue will match initial projections

Discussion

- Entrepreneurs
- System aging
- Communicating price signals & billing
- Trust

Future Work

- Case Studies
  - Benchmark with real-world data
  - Add financial indicators (Payback, NPV, etc)
- Pilot implementation
  - Demonstrate feasibility of market
  - User and investor acceptability
  - Demonstrate ICTs

Questions