# Energy Access Team


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# Process Overview

## South Africa's Energy needs

- Location
- Resources

## Community Profiles

- Energy Load
- Cattle Waste
- Income

## Technology Choices

- Availability
- Suitable for community size and needs

## Model Testing and Refinement

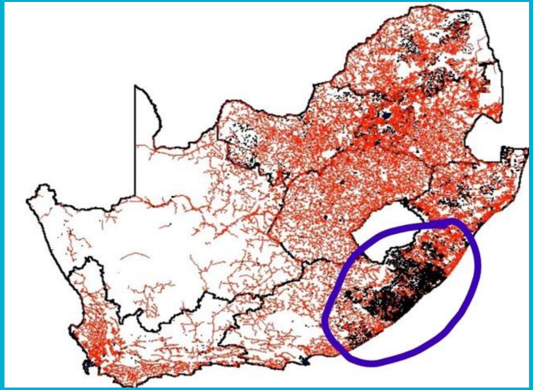
- Storage Technology
- Electric Load Increase
- Biomass Gasification and Reclamation

## Model Verification

- Lifetime Analysis
- Financing
- Government priorities
- Social Impact

# Problem Background

- 1.1 billion people around the world lack energy access
- 86% of South African households have electricity access



# Benefits and Costs of Microgrids

| Benefits | Costs |
| --- | --- |
| Less investment needed per project | Amount of Systems Needed to Supply the Overall Energy Demand |
| Can use energy sources already in the community | Less profit per project - Fewer incentives for Investors |
| Generation close to use | |
| Lower environmental costs | |
| Easier (Local) maintenance | |
| Greater Energy Security | |
| Faster project completion | |

# Past Research

## Techno-economic analysis of microgrid for universal electricity access in Eastern Cape, South Africa

**Omowunmi Mary Longe finds that a standalone microgrid can be used to achieve electricity access in rural off-grid areas of developing countries.**

## Renewable Energy Sources Microgrid Design for Rural Area in South Africa

O. M. Longe, K. Ouahada, H. C. Ferreira, S. Chinnappen
Dept. of Electrical & Electronics Engineering Science,
University of Johannesburg,
Johannesburg, South Africa.
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## Modelling an off-grid integrated renewable energy system for rural electrification in India using photovoltaics and anaerobic digestion

J.G. Castellanos, M. Walker, D. Poggio, M. Pourkashanian, W. Nimmo*
*Energy Technology Innovation Initiative (ETII), Faculty of Engineering, University of Leeds, Leeds LS2 9JT, UK*

# Current Market

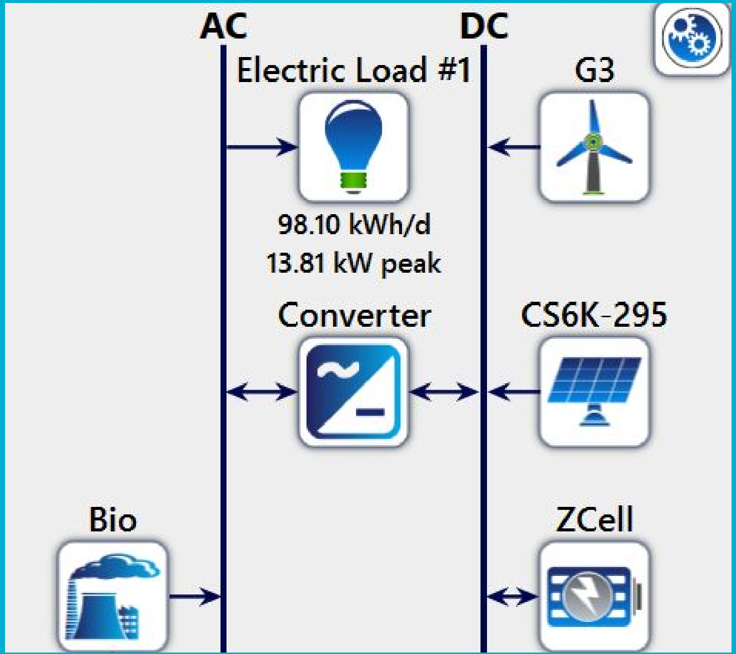
Private

- ABB
- SPECIALIZED SOLAR SYSTEMS
  National Alternative Energy Supply Company
- accenture
  High performance. Delivered.

NGOS

- EEP
  ENERGY AND ENVIRONMENT PARTNERSHIP / SOUTHERN AND EAST AFRICA
- Solar Electric Light Fund

# What is HOMER?



# Assumptions

- Electric Load
  - Linear increase with community size
  - 1.5% annual increase
- Cattle Waste
  - Linear increase with community size
  - 2.5 cattle/household
  - 15 kg waste/cattle/day
  - 25% waste reclaimed
- Financial
  - Inflation = 6.5%
  - Nominal Discount Rate = 8%
  - Average household income: USD $1080.40/yr
  - Conversation rate: 1 USD: 0.07 ZAR
- Not considered: cost of transmission infrastructure, controller

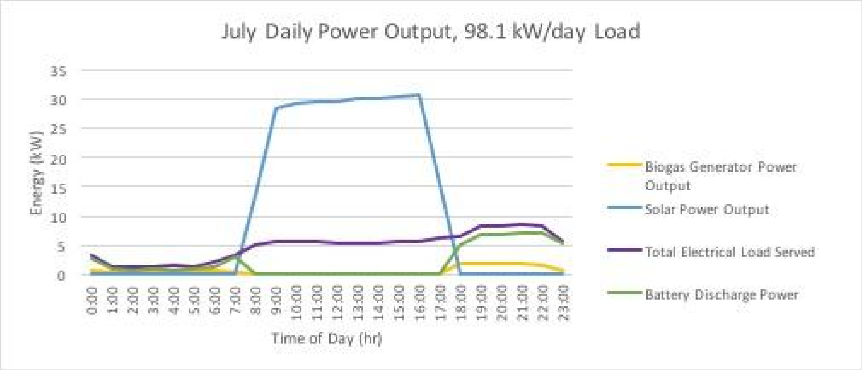
# Component Selection

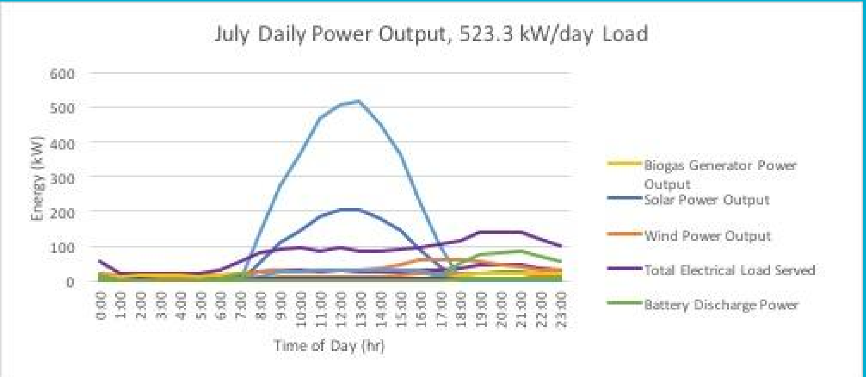


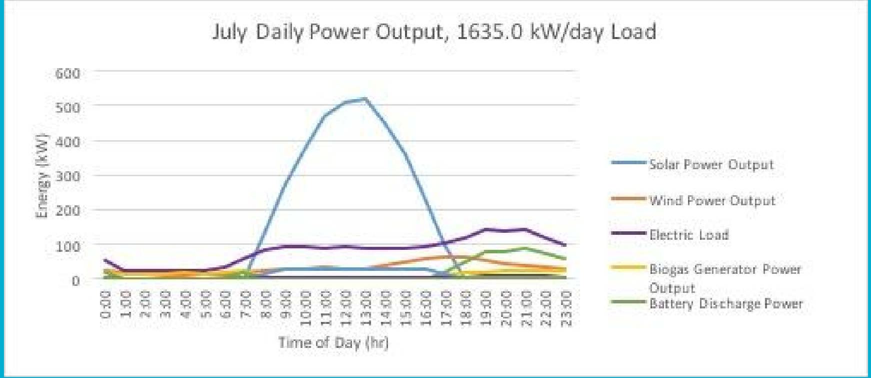

# Original Models

| Community Size (households) | Electric Load (kWh/ day) | Peak Load (kW) | PV (kW) | Wind (kW) | Biogas Generator (kW) | Storage (kW) | Converter (kW) | Cost of Energy | Net Present Cost (25 years) | Operating Cost | Initial Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **75** | 98.1 | 13.81 | 83.1 | 0 | 2 | 79.47 | 14.5 | $0.273 | $204,628 | $3,364 | $134,145 |
| **400** | 523.3 | 73.68 | 349 | 96 | 10 | 298.01 | 68.1 | $0.25 | $999,365 | $13,815 | $709,949 |
| **1250** | 1635.0 | 230.2 | 874 | 207 | 30 | 1,142.38 | 228 | $0.243 | $3,030,000 | $38,622 | $2,230,000 |

# Daily Power Output



# Changes to Model: 75 Households

| Model Type | Electric Load (kWh/day) | PV (kW) | Wind (kW) | Biogas Generator (kW) | Storage (kW) | Inverter (kW) | Cost of Energy | Net Present Cost (25 years) | Operating Cost | Initial Cost |
|---|---|---|---|---|---|---|---|---|---|---|
| **Original** | 98.1 | 83.1 | 0 | 2 | 79.47 | 14.5 | $0.273 | $204,628 | $3,364 | $134,145 |
| **1.5% Load increase per year** | 144.23 (year 25) | 130 | 0 | 2 | 119.16 | 21 | $0.317 | $285,797 | $4,054 | $200,866 |
| **75% biomass reclamation** | 98.1 | 37.54 | 0 | 8 | 19.86 | 9.7 | $0.194 | $145,312 | $3,682 | $68,178 |

# Changes to Model: 400 Households

| Model Type | Electric Load (kWh/day) | PV (kW) | Wind (kW) | Biogas Generator (kW) | Storage (kW) | Inverter (kW) | Cost of Energy | Net Present Cost (25 years) | Operating Cost | Initial Cost |
|---|---|---|---|---|---|---|---|---|---|---|
| **Original** | 523.3 | 349 | 96 | 10 | 298.01 | 68.1 | $0.250 | $999,365 | $13,815 | $709,949 |
| **1.5% Load increase per year** | 759.3 (at year 25) | 420 | 90 | 10 | 297.9 | 90 | $0.276 | $1,100,000 | $14,190 | $805,204 |
| **75% biomass reclamation** | 523.3 | 196 | N/A | 40 | 158.94 | 48.9 | $0.197 | $786,398 | $18,497 | $398,883 |

# Changes to Model: 1250 Households

| Model Type | Electric Load (kWh/day) | PV (kW) | Wind (kW) | Biogas Generator (kW) | Storage (kW) | Inverter (kW) | Cost of Energy | Net Present Cost (25 years) | Operating Cost | Initial Cost |
|---|---|---|---|---|---|---|---|---|---|---|
| **Original** | 1635.0 | 874 | 207 | 30 | 1,142.38 | 228 | $0.243 | $3,030,000 | $38,622 | $2,230,000 |
| **1.5% Load increase per year** | 2372.7 (at year 25) | 1600 | 375 | 30 | 1,490.38 | 350 | $0.304 | $4,560,000 | $53,726 | $3,440,000 |
| **75% biomass reclamation** | 1635.0 | 408 | 66 | 140 | 367.41 | 310 | $0.194 | $2,430,000 | $10,046 | $1,260,000 |

# Are these feasible? Who Pays? How Much?

- 75 HH
- $204,628 NPC
- $3,364 O&M
- $0.273 LCOE

| Payment Methodology | $/kWh | Annual Revenue | Present Value (25 Years) | NPC-PV |
|---|---|---|---|---|
| Avg HH Paying Avg SA COE | $0.100 | $3,581 | $75,014 | $129,613.62 |
| Avg HH paying at 8% of income | $0.181 | $6,482 | $135,806 | $68,822.15 |
| Avg HH paying enough to meet NPC | $0.273 | $9,775 | $204,789 | -$161.26 |

# Business Plan Possibilities

75 HH: $134,145 Capital Costs

| Payment Methodology | $/kWh | Annual Revenue | Present Value (25 Years) | NPC-PV |
|---|---|---|---|---|
| Avg HH paying at 8% of income | $0.181 | $6,482 | $135,806 | $68,822.15 |

### Public/Private Structure

- Private covers CAPEX
- Feed-in Tariff established for excess generation (if eventually grid connected)
- Gov subsidizes electricity cost

### Payment Strategy

- Small energy load: pay monthly flat rate
- Large energy load: pre-pay per kW/h
- Energy credits for collecting waste

### Operations & Maintenance

- Paid employee runs waste collection
- Located nearby; available for assistance and maintenance

# Analysis and Exploration

## Sensitivity

- Availability of biomass
- Cost of biomass

## Gamechangers

- Use excess electricity for value-added process or manufacturing?
- Selling excess electricity to grid?
- Concentrated livestock operations?

# Social Impacts

- Community acceptance is key to success
- Rural electrification in Kenya:
  - 100-200% increase in productivity per worker, depending on task
  - 20-70% growth in income levels
  - Improved education quality and students' access to the rest of the country
- Electrification has biggest impacts in agricultural sector and small or micro enterprises

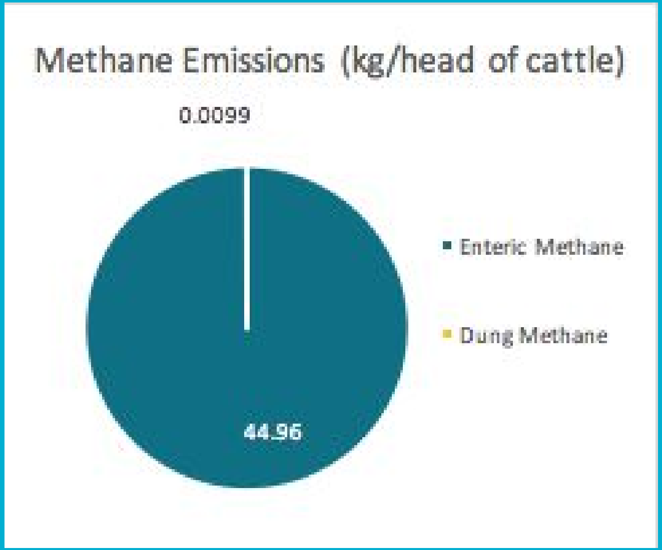
# Environmental Impacts

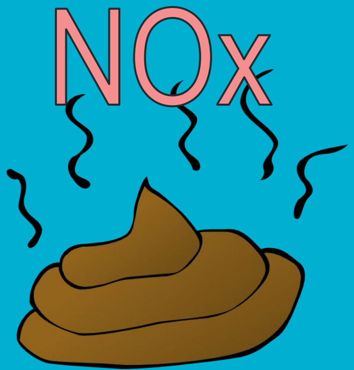
| Load Size (kWh) | $CO_2$ Emissions from Grid (tonnes of $CO_2$) | Emissions from diesel (tonnes of $CO_2$)* | Emissions from microgrid (tonnes of $CO_2$)‡ |
|---|---|---|---|
| 98.1 | 0.092 | 0.0245 | 0.00166 |
| 523.3 | 0.492 | 0.131 | 0.0083 |
| 1635 | 1.537 | 0.408 | 0.0249 |

* does not include emissions associated with transporting diesel to remote areas

‡ assumes biogas output is equal to that associated with original model

# Environmental Impacts




# Conclusions

- Specific technology input data & community characteristics crucial for HOMER to be of value
- Microgrid design is only ⅓ of process
- Renewable energy solution is possible
  - Can help with building economy of scale

# Thank You!

# Questions?

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