the Learning Network on Sustainable energy systems

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Technical and Economic Viability of Biogas-based Electricity Generation for Distributed Renewable Energy Systems in Livestock Communities of Uganda

Presented by

FRED TUHAIRWE

COLLEGE OF ENGINEERING, DESIGN, ART AND TECHNOLOGY

MAKERERE UNIVERSITY

Outline

- Background of the study
- Objectives of the study
- Case study of a pilot biogas-to-electricity generation plant
- Incorporation of a gas engine into a domestic biogas plant
- Developing a model for a dairy-farm-based biogas-to-electricity mini grid
- Conclusion and recommendations
- Acknowledgements

Background

- Access to modern energy services is still very low in communities of Uganda, especially livestock keeping
- Generation and utilization of electricity from biogas is limited, amidst the abundant resources.
- Pilot biogas-to-electricity schemes are not performing to the expectations
- Biogas offers technical opportunities for decentralised approaches to provision of modern energy services.
- The study was implemented through three interrelated cases:
  - Pilot/existing biogas-to-electricity plant,
  - Addition of gas engine generator to a domestic biogas system
  - Design of a new system for a livestock community with neither a biogas system nor a electricity access.

Study Objectives

- To establish the challenges faced by an existing biogas production system for electricity generation that was established a pilot case.
- To investigate the viability of incorporating a gas-engine in a functioning domestic biogas system
- To develop a model for a dairy-farm-based biogas-to-electricity mini grid

1. Performance of the existing biogas production system for electricity generation

- A community-based biogas-to-electricity scheme established as a pilot business model

The plug flow (PVC material) digester and a gas-engine generator

Performance of the existing biogas production system for electricity generation cont'd

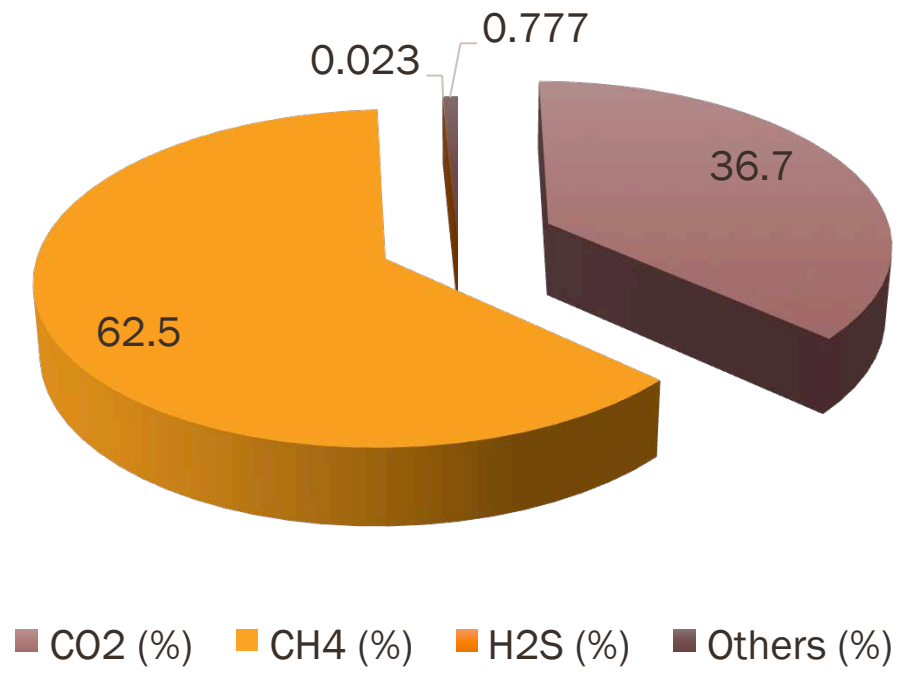
The maize milling machine and the battery charging centre as electricity load

Performance of the existing biogas production system for electricity generation cont'd

Performance of the biogas system for electricity generation

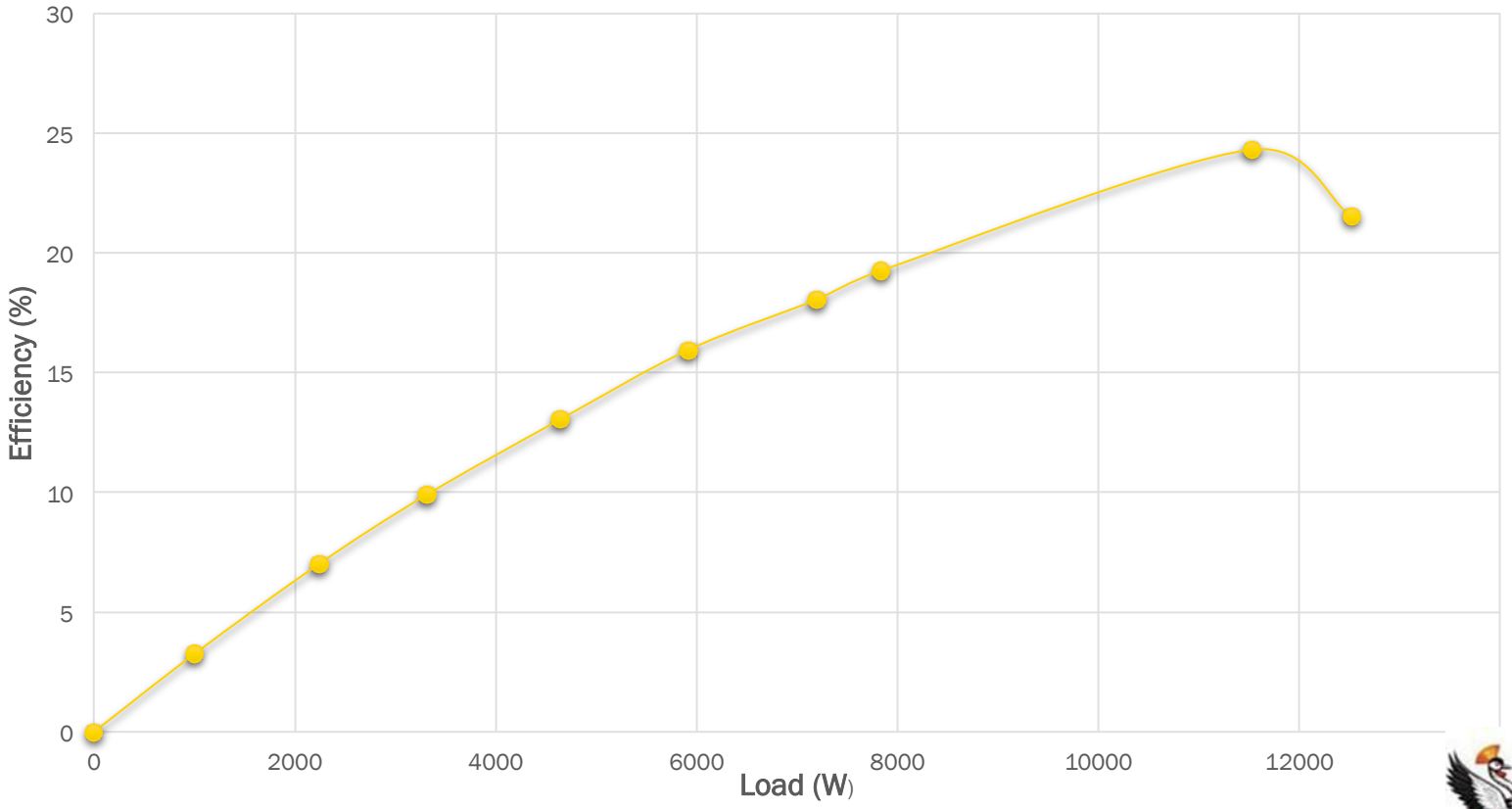
Criteria	Quantity	Performance	Quantity
Volume of PVC bag	200 m^3	volume of the digester in use	37.2 m^3
Expected feeding rate	1830 kg/ day	Current feeding rate	257 kg/day
Expected gas production per day	62.1 m^3	Total gas production	11.6 m^3/ day
Expected electricity per day	97 kWh	Electricity generated per day	18.0 kWh
Expected electricity per month	29 MWh	Electricity generated per month	541 kWh
Expected electricity per annum	35 MWh	Electricity generated per annum	6.5MWh

Mean percentage gas composition



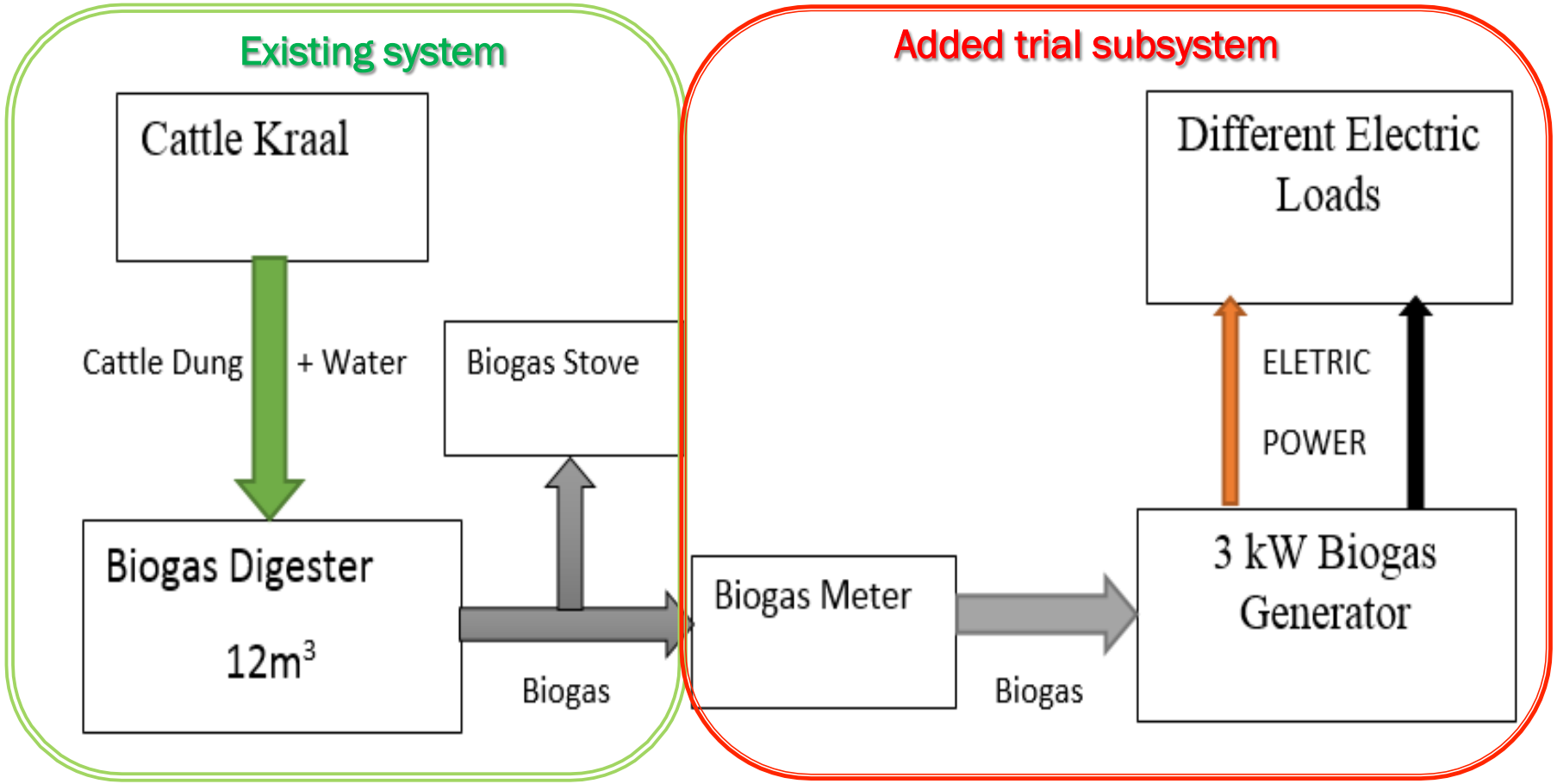
Performance - cont'd

- Average pH was 7
- Average pressure was 1.35mbar.
- A full time compressor was availed
- System operated at 25% below its total installed capacity



Efficiency Vs load of the biogas generator

2. Incorporating a gas-engine-genset in a functioning domestic biogas system



Schematic diagram of the experimental design of the pilot project

Incorporating a gas-engine-genset - cont'd

-The domestic biogas plant

The zero grazed cattle in a Kraal and a fixed dome biogas digester

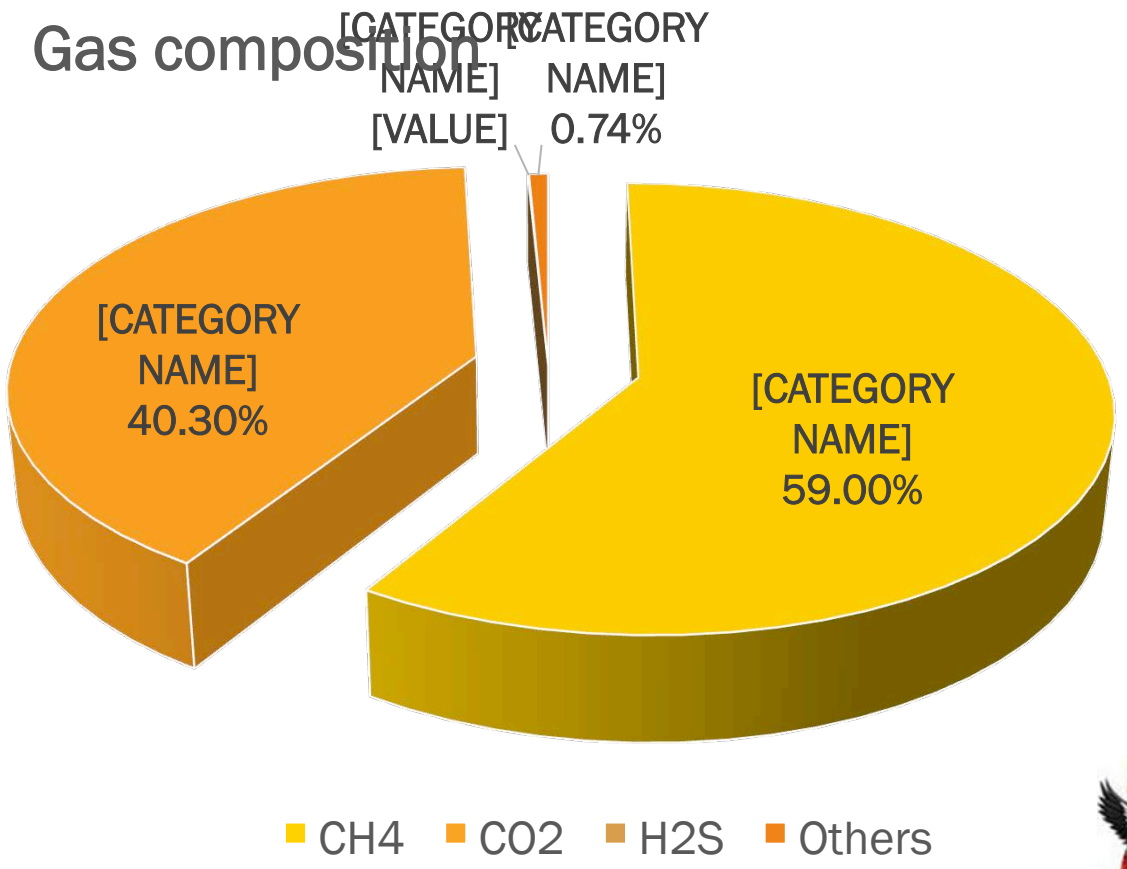
Incorporating a gas-engine-genset - cont'd

The 3kW gas-engine with a gas meter and the electric loads under test

Incorporation of a gas-engine-genset - cont'd

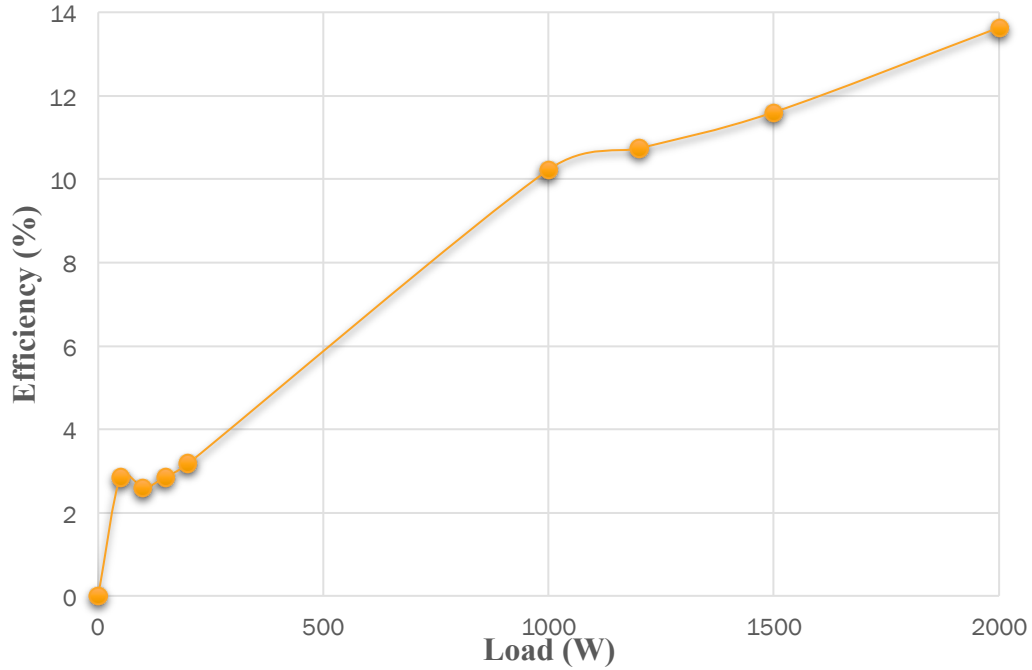
The gas bag containing biogas

- The net calorific value of the gas was 21.3 MJ/m^3



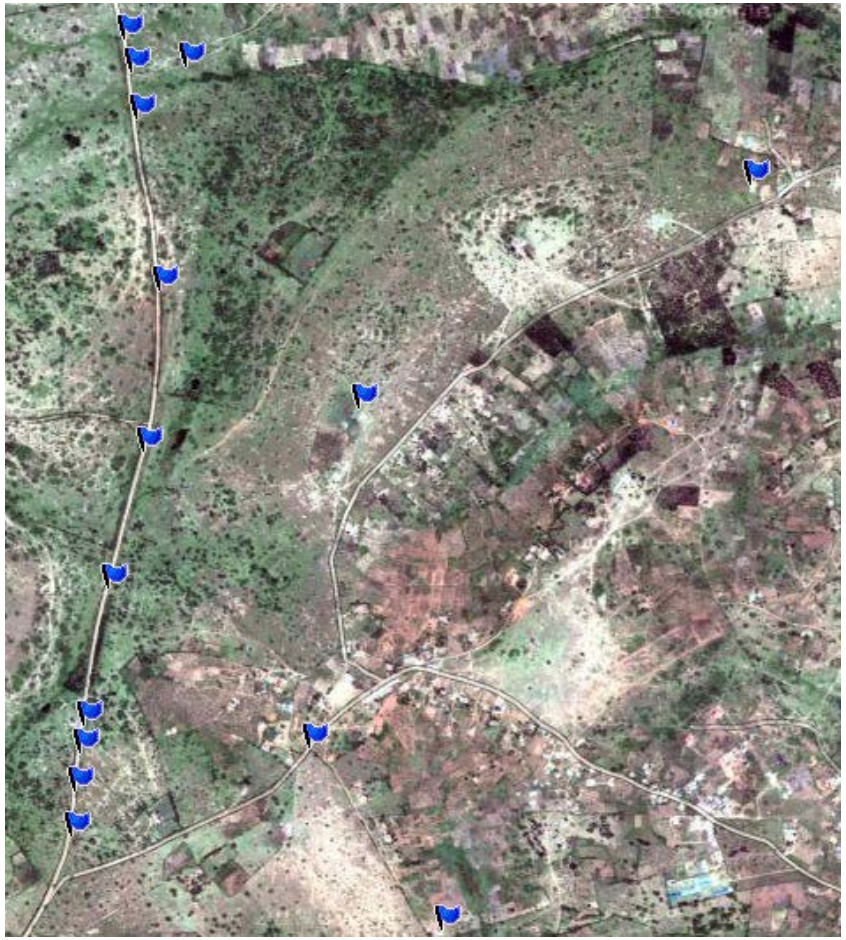
Incorporation of a gas-engine-genset – cont'd

- Performed adequately, however:
  - Difficulties in maintenance and the associated costs
  - Presence of H2S, resulting into corrosion



Efficiency against load for the generator

3. Developing a model for a dairy-farm-based biogas-to-electricity mini grid



Map showing GPS locations of the livestock farms and cattle in the farms

Developing a model for a dairy-farm based biogas-to-electricity mini grid - cont'd

Limited to the Financial Analysis using RETScreen software

Particulars	Unit	Amount
Total initial investment	USD	11,900
Specific Investment	USD/kW	3967
Annual cost of O&M	USD	200 (1.7%)
Annual electricity generated	kWh	13,140 (13 MWh)
Discount rate	%	10
Project life	Years	12
Cost of electricity (Electricity export rate)	USD/kWh	0.188
Equity Pay Back Period (PBP)	Years	5.3
Simple Pay Back Period (PBP)	Years	5.2
Pre-tax Internal Rate of Return (IRR)	%	15
Net Present Value (NPV)	USD	3030
Benefit-Cost ratio (B-C)		1.25
Annual life cycle savings	USD	445

Conclusion and Recommendations

- Low energy conversion efficiency
- Low capacity utilization and low gas quality
- A cluster of livestock farmers has potential for biogas as a S.PPS for DREs
- Capex needed to set up small DRE systems are within the means of the farmers
- Designers and planners of biogas-based DREs must take sustainability of the biogas plant into consideration
- Emphasis should be put on feedstock availability, management of O&M and adequate capacity building
- Gas engine sets need gas cleaning systems for best performance
- All systems need a good business model with a proper system sizing

Acknowledgements

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THANK YOU!