# Biogas Potential in South Africa:

## and what a small team at UCT is researching in that regard


by

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with support from

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**QUESTION 6 [10 marks]**

A fruit processing factory needs low pressure steam, which it produces in a gas fired boiler. LP gas* availability and cost have recently been a concern for the factory's management. Their process engineer has come up with an energy-saving project. She proposes the installation of an anaerobic digester to produce methane-rich biogas from the factory's waste water which contains organic material. This biogas has a sufficiently high methane content to be used as fuel in the existing boiler.

a) The proposed biodigester would produce 100 $m^3$ of biogas per day. In terms of energy content, 1 $m^3$ of biogas = 0.5 kg of LP gas. The factory pays R 20/kg for LP gas. Estimate the LP gas savings, in kg/day, and in Rand/day, assuming 24 hour operation.

# Agenda

- Previous studies on the potential of energy from waste in South Africa
  - And how that has narrowed down to biogas
- Going beyond assessments of potential
  - What we're doing
- And some other (interesting) questions
  - Biogas sanitation systems – working elsewhere?
  - Biogas as an energy source in informal sector production?

# Opening remarks

- It’s time for this conference
  - Some good things are happening
  - They’re happening too slowly
  - They’ve happened faster elsewhere
  - There’s a theory why & how they happen
  - Can we make things happen faster?
- A challenge that sets biogas apart?
  - You tell me ☺

# There is bio-energy potential!

| Bioenergy estimates | | | | | | |
|---|---|---|---|---|---|---|
| | Authors | What estimated | Prim. Energy PJ | Final Energy PJ | Prim. Energy GWh | Final Energy GWh |
| | Marrison & Larsson (1996) | cropped biomass (10% of suitable land) | 1350 | | | |
| | Lynd et al. (2002) | bio-energy potential | 1470 | *735* | | |
| | | of which waste | 300 | | | |
| | Austin et al. (2006) | WtE solid waste in metros only | 71 | *18* | *20000* | *5000* |
| | Burton et al. (2009) | Energy from waste water | *94* | *31* | 26000 | *9000* |
| | | | | | | |
| Comparative numbers | | | | | | |
| | Eskom (2011) | Electricity output | *2472* | *806* | | 224000 |
| | SAPIA (2011) | Liquid fuel sales | | 770 | | |
| | White paper (2003) | RE Target (2013) | | *36* | | 10000 |

# But there are ecological risks of crop-based bio-energy

Environmental Science & Technology

Policy Analysis

pubs.acs.org/est

## Replacing Gasoline with Corn Ethanol Results in Significant Environmental Problem-Shifting

Yi Yang,[§]

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States

**ABSTRACT:** Previous studies on the life-cycle environmental impacts of corn ethanol and gasoline focused almost exclusively on energy balance and greenhouse gas (GHG) emissions and largely overlooked the influence of regional differences in agricultural practices. This study compares the environmental impact of gasoline and E85 taking into consideration 12 different environmental impacts and regional differences among 19 corn-growing states. Results show that E85 does not outperform gasoline when a wide spectrum of impacts is considered. If the impacts are aggregated using weights developed by the National Institute of Standards and Technology (NIST), overall, E85 generates approximately 6% to 108% (23% on average) greater impact compared with gasoline, depending on where corn is produced, primarily because corn production induces significant eutrophication impacts and requires intensive irrigation. If GHG emissions from the indirect land use changes are considered, the differences increase to between 16% and 118% (33% on average). Our study indicates that replacing gasoline with corn ethanol may only result in shifting the net environmental impacts primarily toward increased eutrophication and greater water scarcity. These results suggest that the environmental criteria used in the Energy Independence and Security Act (EISA) be re-evaluated to include additional categories of environmental impact beyond GHG emissions.

# Energy from waste water

## Study for the WRC (2008/9)

### Technologies for recovery of energy from wastewaters: Applicability and potential in South Africa

**William Stafford**
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**Brett Cohen**
*Energy Research Centre, University of Cape Town*

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*University of Pretoria*

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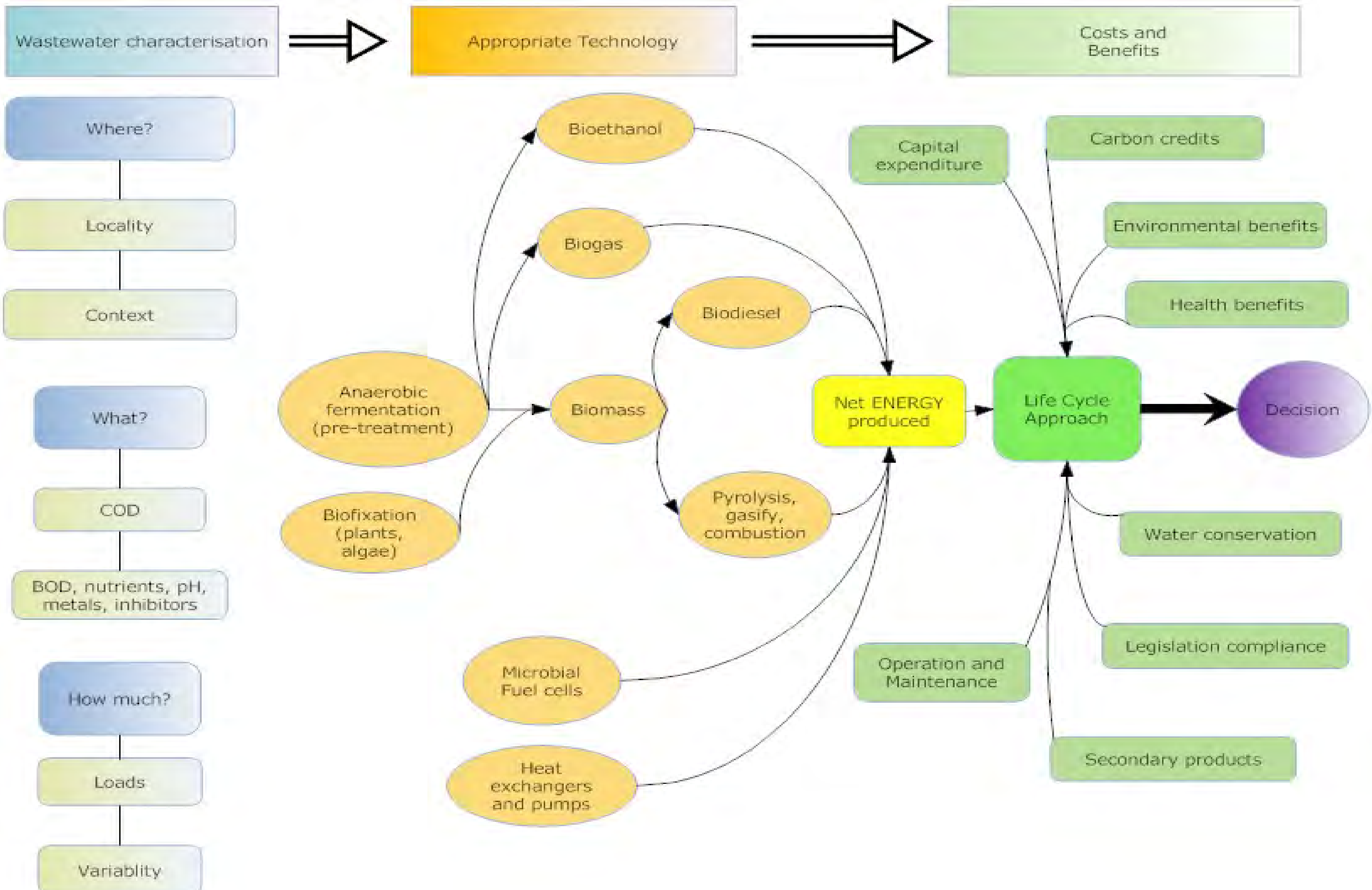
# Energy from waste water: study approach



| Wastewater | Comment | Energy potential: Thermal power ($MW_{th}$) |
|---|---|---|
| Domestic blackwater (human faeces) | Municipal WWTP service only 60% of the population and therefore only 60% of human faeces is currently captured. The municipal \WWTP are distributed with approximately 968 WWTP. The majority of WWTP are small < 0.5 ML/day, larger plants 2.5 ML/day. WWTP also receive domestic urine, greywater and industrial loads (not considered here). | 509- 842 |
| Animal husbandry | Cattle in Feedlots Mixed solid and liquid waste slurries. Represent point sources which could be accessed through on site energy recovery. 9 feedlots represent more than half the total cattle in feedlots | 79 – 215 |
| | Rural cattle Considers solid waste only, collected at night in kraals. Only a small percentage of this energy is realistically recoverable | 1 271 – 3 445 |
| | Dairies Mixed solid and liquid waste slurries collected, include washing and milk spills. Represent point sources which could be accessed through on site energy recovery | 117 – 121 |
| | Piggeries Mixed solid and liquid waste slurries. Represent point sources which could be accessed through on site energy recovery | 18 – 715 |
| | Poultry farms Considers solid wastes only | 940 - 2976 |
| | Red meat and poultry abattoirs Considers liquid wastes only | 1 – 55 |
| Olive production | Distributed and seasonal | 4 |
| Fruit processing | Distributed and seasonal. Only the wastewaters from canning and juicing are considered (pulp and pomace excluded) | 68 |
| Winery | Distributed and seasonal. | 3 |
| Distillery | Distributed. Grain, grape and sugar-cane (molasses) considered. Compared to grain and grape, molasses has the greatest energy potential, is not seasonal and is less distributed (3 major plants, all in KZN). | 70 |
| Brewery | Distributed. 7 breweries | 17 |
| Textile Industry | Distributed | 22 |
| Pulp and Paper | 17 mills | 45-100 |
| Petrochemical waste | 4 refineries. One gas to liquid fuel refinery | 48 |

# Energy from waste water

**Key conclusions:**

- Potential energy recoverable from waste waters in SA:
  - 3200 – 9000 $MW_{th}$
  - Hence, conservatively, 3.2 GW x 8400 h/yr x 33% = 9000 $GWh_e$
- Of the reviewed technologies, anaerobic digestion most widely applicable
  - Reduces dissolved solids and suspended solids
  - Widely used in other countries
- Two very different opportunities:
  - Medium to large ‘industrial’ (incl. municipal)
  - Homestead / rural

# Some notes on solid wastes

- Very little overlaps between
  - EfWW study (Burton et al., 2009)
  - And WtE study (Austin et al., 2006) – solid waste in Metros
  - And next bioethanol study (Lynd et al., 2002)
- ~ 50% of Metro WtE potential amenable to biogas (e.g. mechanical biological treatment, with dry AD)
- Also significant potentials in agri-processing solid wastes
  - Cellulosic substrates also work well in AD
  - > 10% of the 300 PJ estimate?

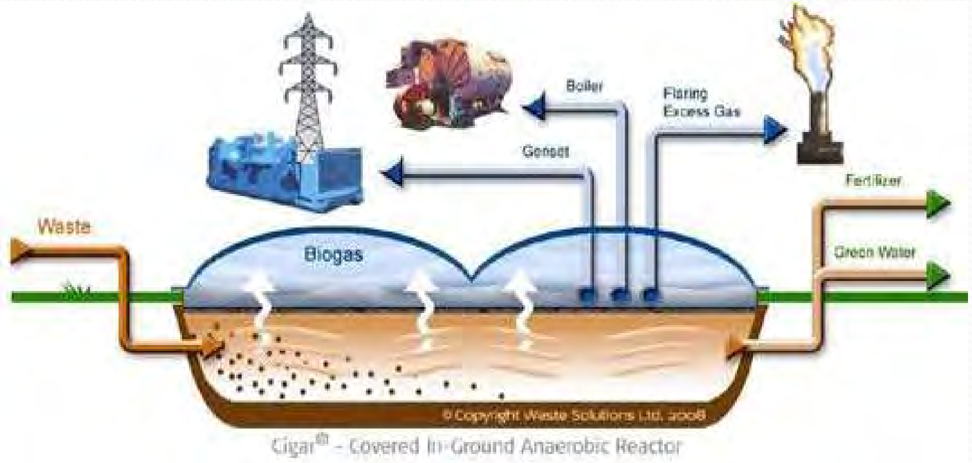
# Scope of biogas systems

| | Small decentralised<br>For own thermal use | Medium to large "industrial"<br>50 kW – 5 MW |
|---|---|---|
| Waste | • Farms / homesteads<br>  • Cow manure<br>  • Eco-sanitation<br>• Urban gardens<br>• Bio-centre sanitation | • Breweries<br>• Fruit processing<br>• Municipal WWTW<br>• Stock farming<br>• Abattoir wastes |
| Cropped | • Parks & Gardens Materials | • Silage maize<br>• Algae<br>  • E.g. growing on sewage maturation ponds |

# Going beyond assessment of potentials…

Constructed fixed dome-Giyani Project

Pre-fab fixed dome at a UCT residence




Large Scale Plant-Bronkhorstpruit Project

# Making it visible, learning how it works



Khayelitsha food garden: a 4-way partnership

# Are the small ones working?

**Performance evaluation of Leo Marquard Hall digester**

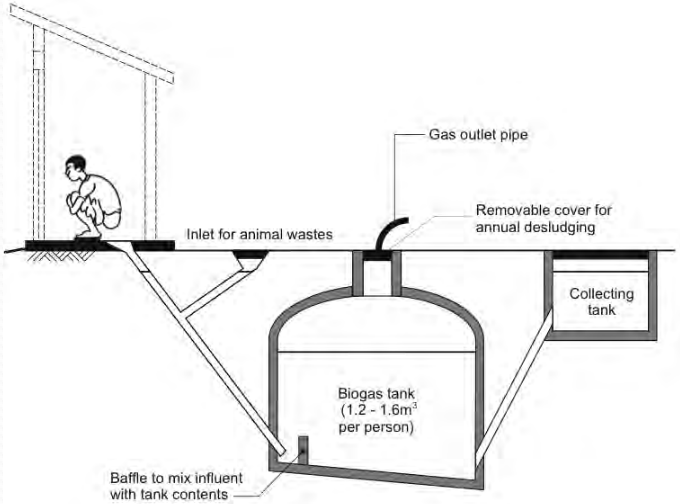
- Daily burning times <1h on 4.5 kW biogas stove
- pH affected by type of waste fed
- Efficiency from 41% (winter) to 51% (summer) in 10-week period

# A role in sanitation?

**Biogas & Informality**

- 62% informal urbanisation in SSA, inadequate sanitation systems
- Possible technology & little academic investigation so far:

*"A comparative case study investigation into the implementation of biogas sanitation systems in informal settlement upgrading"* by Dan Abraham



# Have biogas toilets worked?

Sulabh Public Toilets & Ablution – India:

- Pay & Use model ; free biogas ; faecophobia, beliefs:
- > 200 installations

- Sangli Community Biogas Toilet – Sangli, Maharashtra, India
  - Community lead ; biogas sold for less / equal; willingness to purchase biogas; 2 installations

- Umande Trust Public Biogas Toilets & Ablution Facility – Kenya
  - Design input from community ; lack of demand for biogas ; social acceptance ; > 50 installations

# Lessons on biogas toilets

| Case Commonalities |
|---|
| BT as non-profit sanitation enterprises |
| Value adding characteristics |
| Component of janitorial services |
| Biogas is considered a secondary benefit |

| Case Differences |
|---|
| Scalability, Reproducibility (2 of 3 cases) |
| Use of biogas varied – Umande bypassed biogas valorisation |
| Attribution to faecophobia varied |

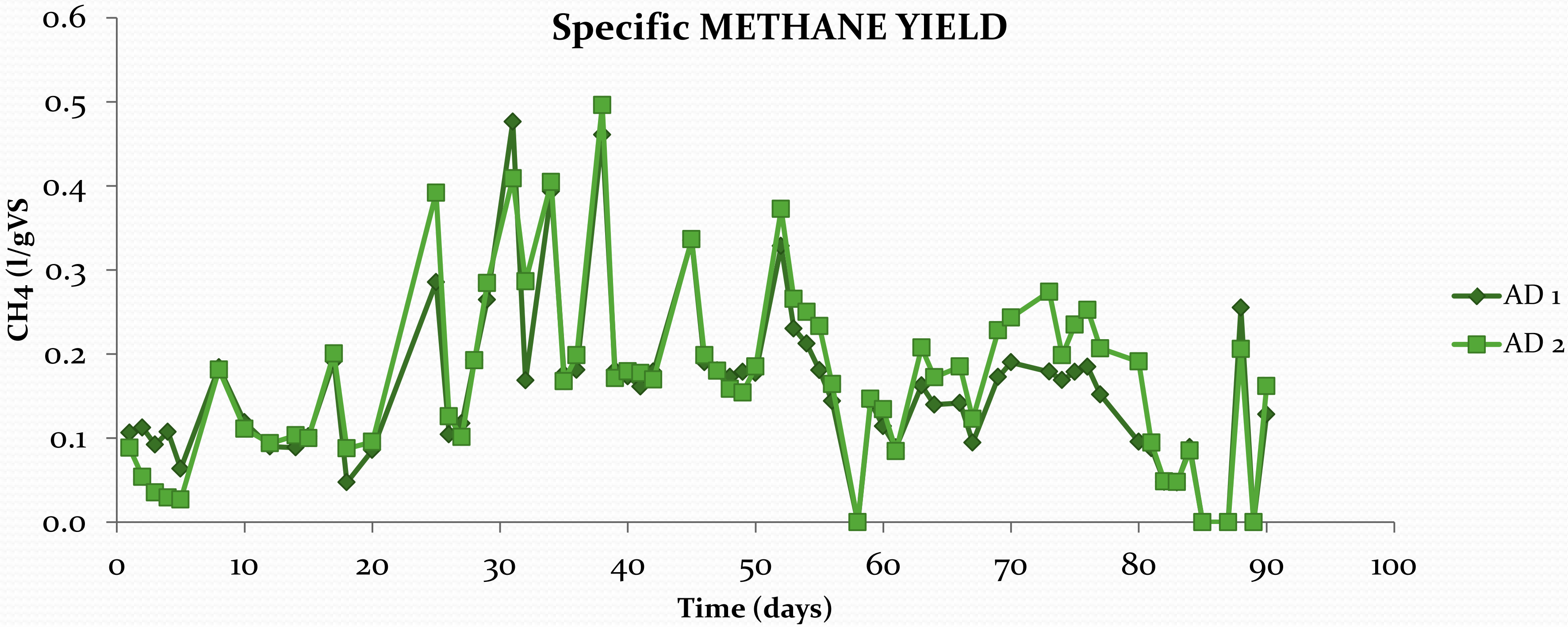
# Biogas in 'urban energisation'

**<u>Biogas as alternative to waste timber?</u>**

- Masters thesis: use of CCA- treated wood by informal caterers, elevated levels of arsenic in the air (and smoke!)

*"Investigation of the applicability of a cleaner production approach in the informal economy: the case of roadside catering in urban Africa"* PhD by Rissa Niyobuhungiro

# Biogas from roadside slaughtering wastes?




Simulating low-tech: not stirred, not heated, in 100 litre fixed dome units

# AD & biogas research at SA universities?

- Yes, at several
- See us at the universities desk

# Completed dissertations

- G. Munganga: “Bioprocessing Technologies for Municipal Solid Waste in African Cities”, MSc, 2012.
- I. Dalwai, “A Comparison of Technical and Environmental Merits of Producing Bio-Ethanol and Bio-Methane from Waste Paper Sludge”, MSc, 2012.
- L. Malla:”Greenhouse Gas Mitigation Cost of Energy From Biogas: A Techno-Economical Analysis of Co-Digestion Of Three Types of Waste”, MSc, 2011.
- C. Trautmann: “Investigation of the Use of Biogas in a Gas Hob and the Feasibility of Upgrading it on a Household Scale”, MSc, 2012.
- B. Amigun: “Processing Cost Analysis of the African Biofuels Industry with Special Reference to Capital Cost Estimation Techniques”; PhD, 2008.
- C. Nissing: “Creative deployment of technology in urban planning for sustainable energy use and supply in a South-North comparison”, PhD, 2007.
- J. Cohen: “A Life Cycle Assessment into energy recovery from organic waste: A case study of the Water Treatment Facility of SABMiller Newlands Brewery”, MSc, 2006.

# Our publications

- "Technologies for recovery of energy from wastewaters: Applicability and potential in South Africa"; W. Stafford, B. Cohen, S. Pather-Elias, H. von Blottnitz, R. van Hille, S.T.L. Harrison and S. Burton; *Journal of Energy in Southern Africa*; **24** (1), pp.15-26, 2013.
- "Investigation of the Use of Biogas in a Gas Hob", Trautmann C. and H. von Blottnitz, *Waste and Biomass Valorization*, **4** (3), pp. 539-548, 2013.
- "A laboratory investigation of co-digestion of paper sludge with problematic nitrogen-rich organic wastes"; Patel, I. and H. von Blottnitz; SAIChE congress, September 2012.
- "Anaerobic co-digestion of paper sludge and blood waste: demonstrating a low-tech intervention for waste management in African cities"; Melamu, R., J. Bombile, L. Naik and H. von Blottnitz; SAIChE congress 2012, September.
- "Onsite food waste valorization: Experiences with an anaerobic digester at a university residence"; Naik, L., R. Melamu and H. von Blottnitz; WasteCon2012, 10-12 October, East London.
- "Stakeholder Collaboration and Learning during the Concept Design Phase of an Urban Biogas Project"; Melamu, R., A. Boyd, H.L. Wlokas, B.C. Roden, G. Austin and H. von Blottnitz; Knowledge Collaboration & Learning for Sustainable Innovation Conference, Delft and Cape Town, 25-29 October 2010, ISBN 9789051550658.

# Our publications (cont'd)

- "Pre-treatment of non-recyclable paper for energy recovery by anaerobic digestion"; Melamu, R., A. Lampard, K. Schafer and H. von Blottnitz; WasteCon2010, 4-8 October 2010, Johannesburg, ISBN: 978-1-920017-49-1.
- "Experimental investigation of the suitability of various organic fractions of municipal solid waste for energy recovery through biomethanation"; Munganga, G., R. Melamu, H. von Blottnitz and M. Nontangana; WasteCon2010, 4-8 October 2010, Johannesburg, ISBN: 978-1-920017-49-1.
- "Capacity-cost and location-cost analyses for biogas plants in Africa", Amigun, B. and H. von Blottnitz, *Resources, Conservation and Recycling*, 55 (1), pp. 63-73, 2010.
- "Capital cost prediction for biogas installations in Africa: Lang factor approach"; Amigun B, von Blottnitz, H.; *Environmental Progress and Sustainable Energy,* **28** (1), pp. 134-142, 2009.
- "Energy From Wastewater – A Feasibility Study", S. Burton, B. Cohen, S. Harrison, S. Pather-Elias, W. Stafford, R. van Hille, and H. von Blottnitz; Water Research Commission, Project K5/1732, 2008.
- "Investigation of Scale Economies for African Biogas Installations"; Amigun, B. and H. von Blottnitz; *Energy Conversion and Management*, 48 (12), pp. 3090-3094, 2007.

# In conclusion

- Is there potential for biogas in South Africa?
  - Yes, for a limited energy contribution
  - with co-benefits:
    - in waste management, mitigation of GHG emissions
    - Possibly sanitation
    - Possibly organic agriculture
- Two different opportunities:
  - Medium to large ‘industrial scale’:
    - Scope for 3 x 1000 MW proposal rounds
    - in 50 kW – 5 MW chunks
  - An integrated rural package (300 000 digesters?)
    - Sanitation, energy, organic farming?

THANK YOU

Enkosi kakhule

Kea leboha

Esp. to our research sponsors:

NRF, WRC, Eskom TESP