A systematic literature review of hybrid renewable energy micro-grids in South Africa and neighbouring countries

MBALENHLE MABASO

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REPS, STELLENBOSCH UNIVERSITY

Agenda

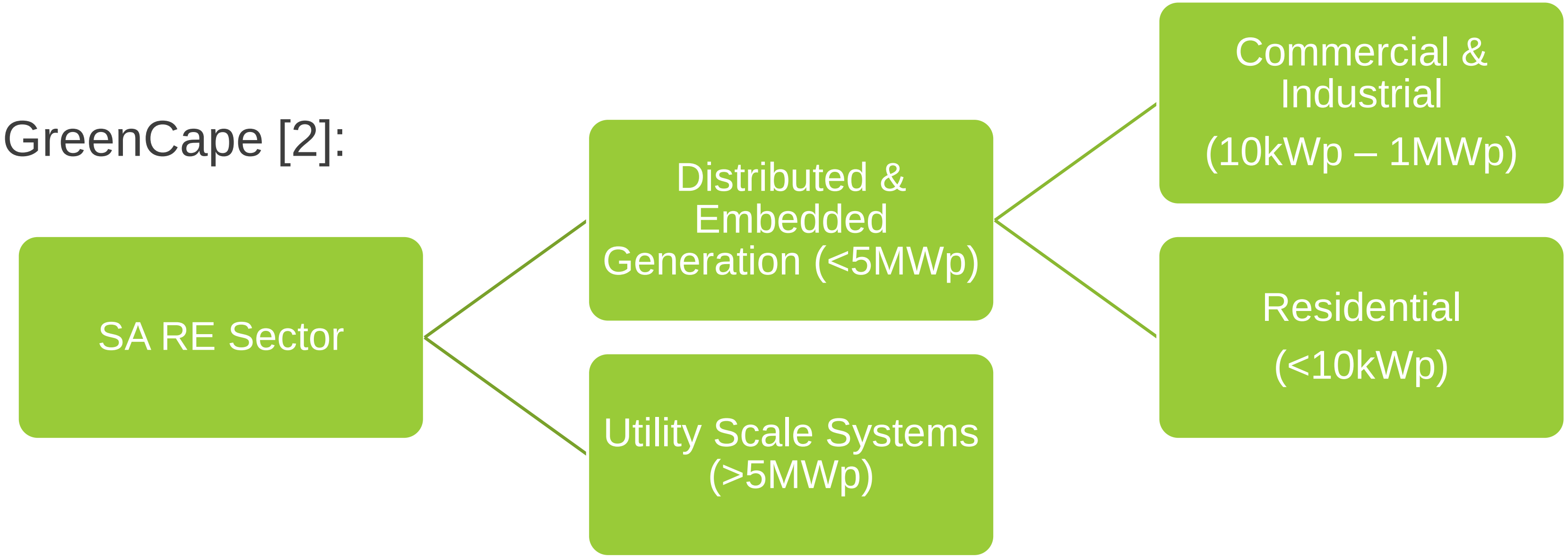
1. Introduction to Micro-grids
2. Micro-grid Modelling Tools
3. Micro-grid Projects
4. Case Studies: Lucingweni & Tsumkwe
5. Emerging Issues
6. Conclusion

Introduction to Micro-grids

US DoE [1]:

“a group of **interconnected loads** and **distributed energy resources** within clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid and that connects and disconnects from such a grid to enable it to operate in both **grid-connected** or **’island’ mode**”

GreenCape [2]:

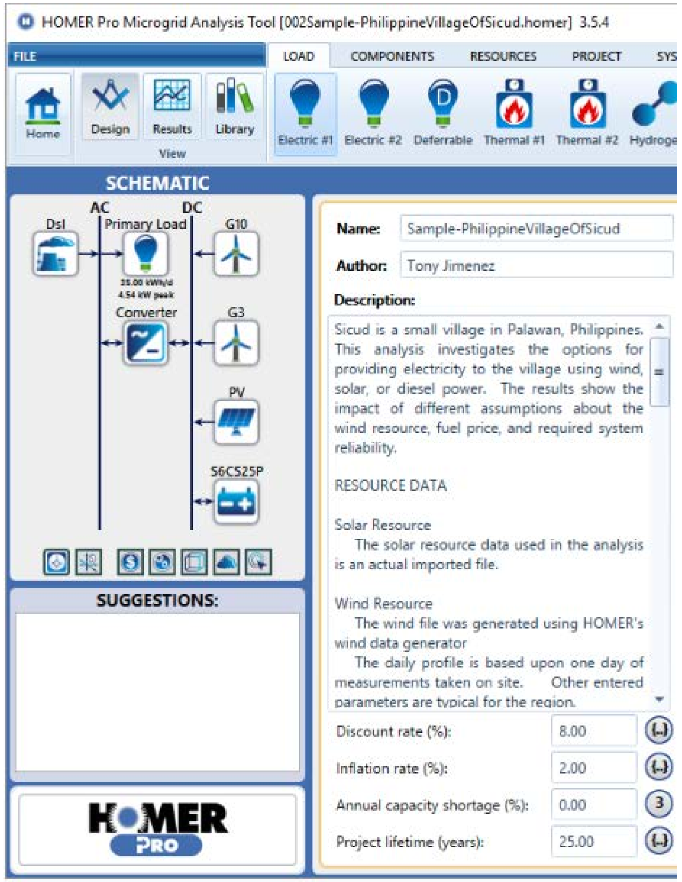


	Lower Tier of Service	Higher Tier of Service
Autonomous	**Autonomous Basic (AB mini-grids)** **Generation Sources:** PV, hydro and biomass **Tier of service:** Less than 24-hour power **End-users:** Remote community without major commercial or industrial activity **Added value:** • Enable enhanced energy access • Alternative to grid-extension • Improve quality of life • Cost savings	**Autonomous Full (AF mini-grids)** **Generation Sources:** PV, hydro and wind **Tier of service:** 24/7 power **End-users:** Remote communities with major commercial or industrial requirements; industrial sites disconnected from grid **Added value:** • Alternative to expensive polluting imported fuels • Diversification and flexibility of supply • Cost savings
Interconnected	**Interconnected Community (IC mini-grids)** **Generation Sources:** PV, wind and biomass/biogas **Tier of service:** High critical/interruptible **End-users:** Medium to large grid-connected community, such as university campus **Added value:** • Community control • Improved reliability • Response to catastrophic events • Cost savings	**Interconnected Large Industrial (ILI mini-grids)** **Generation Sources:** PV, wind and biomass/biogas **Tier of service:** Very high: Critical/uninterruptible **End-users:** Data centres, industrial processing or other critical uses **Added value:** • High reliability for critical loads • Enhance environmental performance • Resiliency

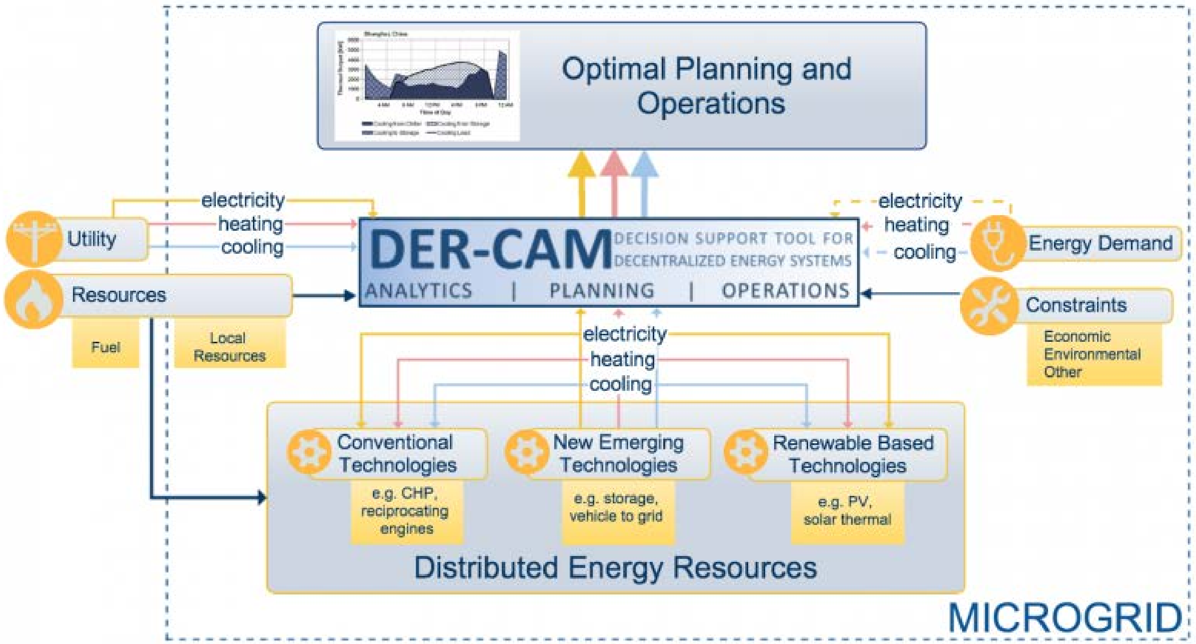
Source: IRENA [2, p.3]

Micro-grid Modelling Tools

HOMER [4]



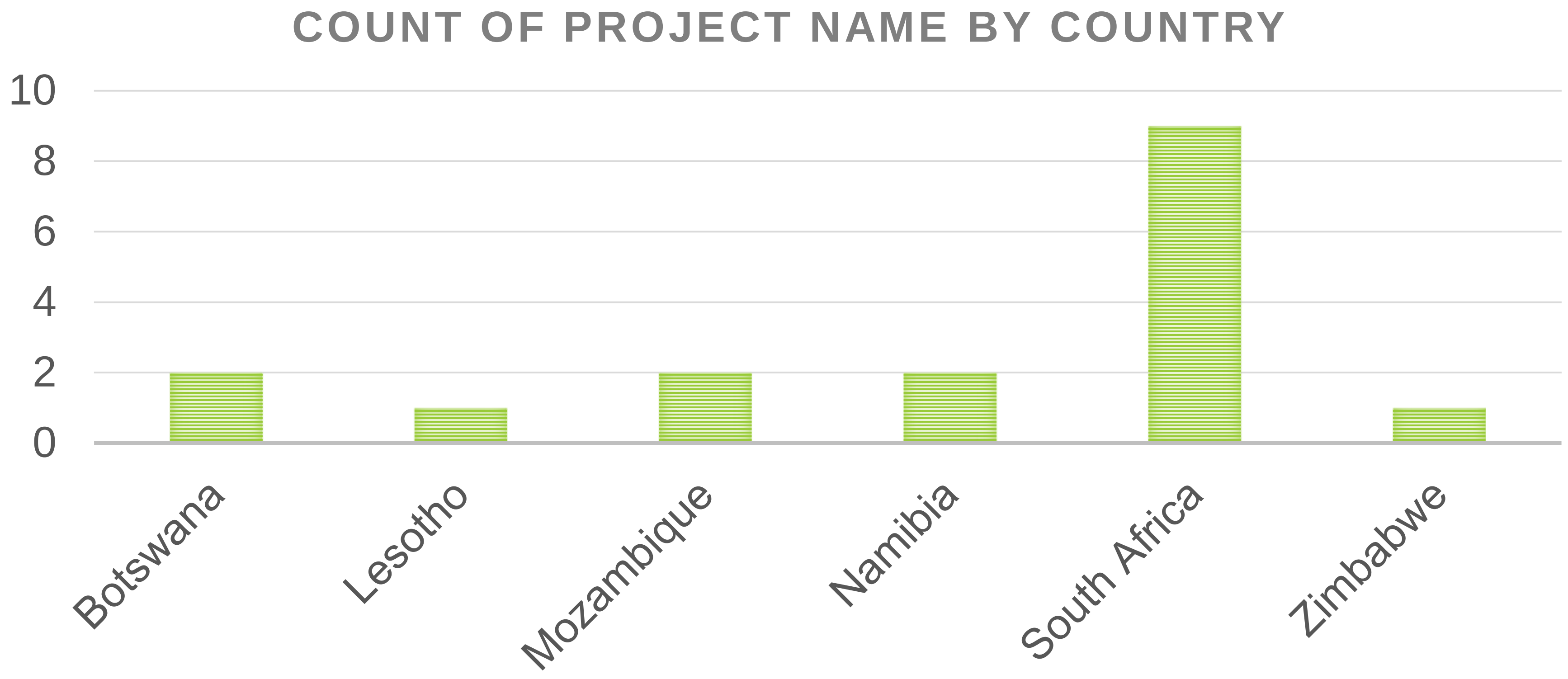
DER-CAM [5]



Micro-grid Projects

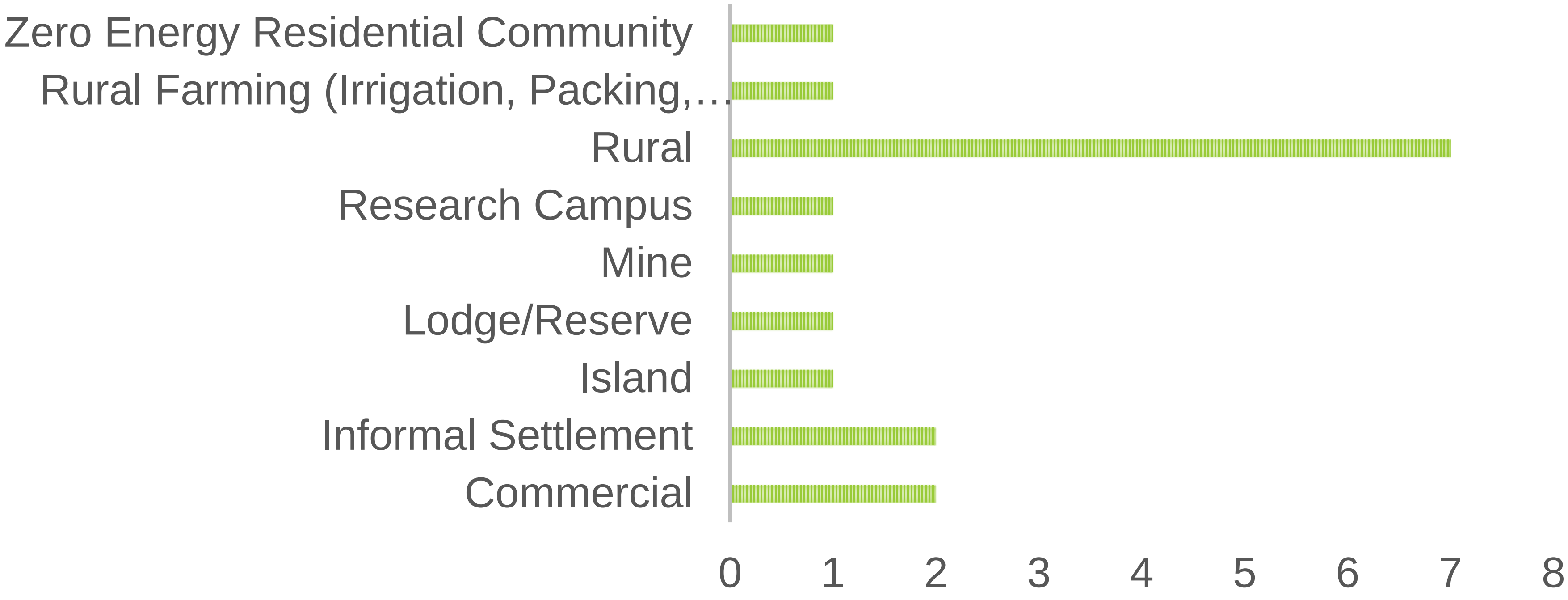
Project Name	Project Start Date	Country	Project Location	Location Type	Specifications	Grid Connected?	Energy Efficiency	Installer	Funder	Still in operation	With Storage?
Lucingweni Hybrid System	2004	South Africa	Eastern Cape	Rural	50 kW PV Array, 36 kW wind, ready boards and battery bank	No		Shell Solar	National Energy Regulator, Department of Minerals and Energy	No	Yes
Hluleka Nature Reserve Hybrid Mini-grid	2002	South Africa	Eastern Cape	Rural	10.6 kW Solar array, 5kW wind generators, diesel generator, battery storage	No	Gas stoves, SWH, Energy saving light bulbs	Shell Solar		Yes	Yes
Jabula Microgrid	2016	South Africa	Cape Town	Informal Settlement	750 Wp solar serving 9 families (includes basic appliances)	No		Specialized Solar Systems (SSS)	Zonke Energy	Yes	

Results (a)


COUNT OF PROJECT NAME BY COUNTRY
10
8
6
4
2
0
Botswana
Lesotho
Mozambique
Namibia
South Africa
Zimbabwe

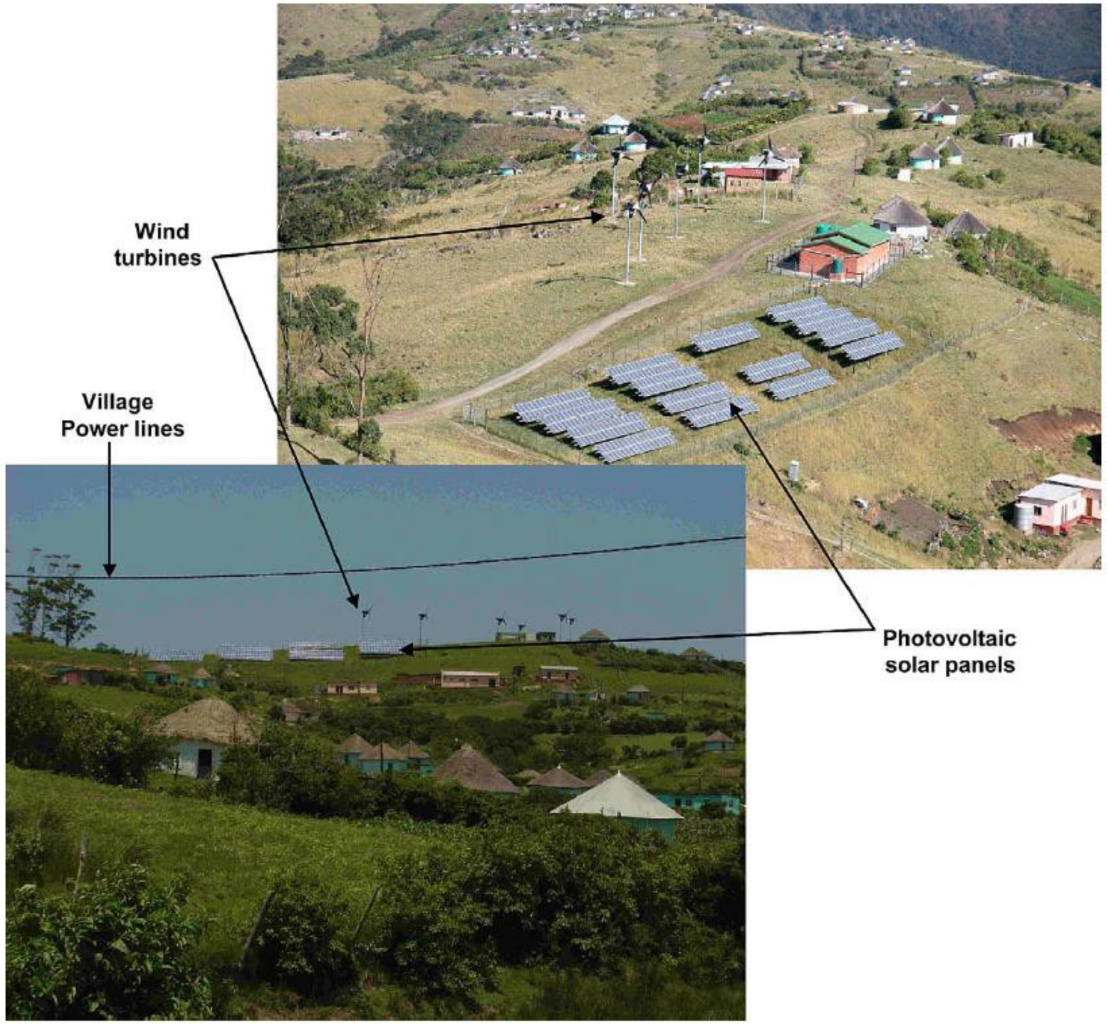
Results (b)

COUNT OF PROJECT NAME BY PROJECT TYPE



Case Studies

Tsumkwe Energy (Namibia) [6] and Lucingweni Project(South Africa) [7]



Case Studies

Lucingweni Project [7]	Tsumkwe Project [6]
• Government support • Inadequate community engagement • Low willingness to pay for electricity • Lack of a metering system • Free electricity for a few months • Introduction of a tariff only later • Vandalism and theft	• Government support • Regional council is responsible for diesel feedstock • Micro-grid was fitted into already existing structures • Adoption of a prepaid metering system • Community already had a culture of paying for electricity • The adoption of energy efficient appliances • It also sourced revenue from local businesses • Almost no incidents of vandalism or theft

Emerging Issues

High usage of diesel being displaced by solar PV
Grant funded
Socio-economic versus technical challenges
Growing interest in the commercial and mining sectors
Emerging business models of micro-grids, even in urban informal settlements

Conclusion

- Micro-grids are vulnerable to the social conditions not apparent at utility scale
- Critical to draw from lessons learnt
- A database of micro-grid projects would be beneficial
- Growing need for engineers & energy planners to consider socio-economic context at the design stage
- Opportunities for design improvements of micro-grids (esp. storage and control systems)

THANK YOU….

Q?

References

[1] R. Hanna, M. Ghonima, J. Kleissl, G. Tynan, and D. G. Victor, “Evaluating business models for microgrids: Interactions of technology and policy,” Energy Policy, vol. 103, no. January, pp. 47–61, 2017.

[2] Green Cape, “Utility-scale renewable energy sector,” vol. 53, no. 9, pp. 1689–1699, 2016.

[3] IRENA, “Innovation Outlook: Renewable Mini-Grids,” 2016.

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[5] Berkeley Lab, “DER-CAM”, https://building-microgrid.lbl.gov/projects/der-cam, Last Accessed 11 July 2017

[6] Tsumkwe Energy Project, http://energyfacilitymonitoring.eu/bringing-solar-power-to-tsumkwe/, Last Accessed 4 June 2017

[7] A. C. Brent and D. E. Rogers, “Renewable rural electrification: Sustainability assessment of mini-hybrid off-grid technological systems in the African context,” Renew. Energy, vol. 35, no. 1, pp. 257–265, 2010.