Meeting the water and energy needs in the rural areas of Malawi using solar PV technologies

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1. Introduction
- Water and energy are two global challenges that need urgent solutions
- Approximately, 15% of Malawians do not have access to potable water and even for those who do, the quality is questionable
- Only 10% of the country’s population have access to grid electricity and less than 1% of rural areas

2. Objectives
- Evaluate energy and water use in the rural areas of Malawi in the context of challenges, sustainable development, and human well-being
- Evaluate the potential for solar PV water pumping and carry out a Life Cycle Cost Analysis
- Develop a financing model for water provision

3. Methodology
The research was interdisciplinary and used mixed methods approach as illustrated in Fig. 1
- Quantitative
  - 219 Household questionnaires
- Qualitative
  - 4 Focus group discussions
  - 27 Village Head Interviews
- Techno-economic analysis
  - Technical design
  - Life Cycle Cost Analysis

4. Results
b. Techno-economic Analysis
- A directly-coupled solar photovoltaic water pumping system was designed (Fig 5)
- Water will be distributed to a public stand-post with four taps
- Results for water costs are shown in Table 1

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>System Size</td>
<td>1.5 kW</td>
</tr>
<tr>
<td>Amount of Water</td>
<td>20 m³/day</td>
</tr>
<tr>
<td>Cost of System</td>
<td>US$18, 600</td>
</tr>
<tr>
<td>Cost of Water</td>
<td>US$0.34/m³</td>
</tr>
<tr>
<td>Cost of water equivalent</td>
<td>US$1.08/month</td>
</tr>
<tr>
<td>Current Payment</td>
<td>US$0.19/month</td>
</tr>
<tr>
<td>Income</td>
<td>US$15/month</td>
</tr>
<tr>
<td>Ability to pay</td>
<td>US$0.75/month</td>
</tr>
<tr>
<td>Willingness to pay</td>
<td>US$0.38/month</td>
</tr>
</tbody>
</table>

Fig 1: Research Methods

Fig 2: Challenges with current water source

Fig 3: Queuing for water

Fig 4: Women collecting water from broken elephant pump

- From the qualitative study challenges were non-functionality (Fig 4), insufficient boreholes, theft and vandalism and long time spent collecting water.
- Primary source of lighting is disposable dry cell batteries; also used for radios
- Mobile phone charging is done at long distances of up to 20 km

c. Payment Model
- Sensitivity analysis showed that tariff caused the most impact to the NPV
- To meet the cost of the system, cross-subsidizing the water with cost of basic energy needs (mobile phone charging and lighting). For the new system cost of water is US$1.19 per household per month
- Cross-subsidizing reduces the break-even cost of water from US$1.19 to US$0.49 per household per month

4. Results

5. Conclusions
- The research concludes that with proper design and planning solar PV pumping can meet the water and basic energy needs of the rural areas
- The system can supply to more people than a borehole
- The system reduces manual pumping labor and time spent queuing
- Contributes to the Sustainable Development Goals of water, energy, education, health & gender
- Future Work: (i) subsidizing with water for irrigation (ii) Field performance studies and (iii) distribution of water to individual houses/compounds

Selected References
- Pritchard et al., 2007. Biological, chemical and physical drinking water quality from shallow wells in Malawi. Case study of Blantyre. Chiradzulu and Mulanje. Physics and Chemistry of the Earth, 32(15-18), 1167–1177

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