Feasibility study and business plan for manufacturing a 3 kW-electrical solar Stirling engine and dish, for off-grid electrical power supply units

L.Kayofa a, T.D. van Schalkwyk a & R.T. Dobson a

aSolar Thermal Energy Research Group (STERG), University of Stellenbosch

bCentre for Renewable and Sustainable Energy Studies (CRSES), University of Stellenbosch
Presentation Outline

- Background
- Stirling Dish Technology
- Research Problems
- Research Design
- Marketing Research
- Manufacturing Plan
- Economical Analysis of a Residential 3 kW Stirling Dish
- Conclusion
Background

- In 2009 Africa had 587 million people without access to electricity
- Rural areas 80% of this number (International Energy Agency)

Table I. Electricity Access in 2009 (International Energy Agency)

<table>
<thead>
<tr>
<th>Population without electricity million</th>
<th>Electrification rate %</th>
<th>Rural electrification rate %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Africa</td>
<td>587</td>
<td>41.8</td>
</tr>
<tr>
<td>North Africa</td>
<td>2</td>
<td>99.0</td>
</tr>
<tr>
<td>Sub-Saharan Africa</td>
<td>585</td>
<td>30.5</td>
</tr>
<tr>
<td>Developing countries</td>
<td>1,314</td>
<td>74.7</td>
</tr>
<tr>
<td>World</td>
<td>1,267</td>
<td>81.5</td>
</tr>
</tbody>
</table>
Background

- Rural areas are scattered and isolated
- Have a low population density which makes it expensive to extend electricity grids to rural areas
- One technology Africa can look into: Stirling dish
Stirling Dish System

- Stirling Engine
- Dual-axial Drive
- Parabolic Reflector
- Chassis
- Electronics
Research Problems

• Market potential in Africa has not been assessed
  • Market size
  • Risks in off-grid rural markets
• Profitable business venture
Research Design

- Market research
- Designers: Stirling engine and concentrator
- Manufacturing plan
- Economical analysis of a residential Stirling dish
- Economical analysis of the business
Market Research

- Customers: needs, attitudes and buying habits
- Conducted a survey in a rural community without access to electricity

Objectives of the survey:

- Determining the market interest of the solar Stirling dish amongst the people
- Formulating an overview of the energy situation in rural communities
- Determining a realistic price for the solar Stirling dish
- Identifying the needs of the customers that could be incorporated in the designs of the Stirling engine and the concentrator
Manufacturing Plan

- Plant location: Johannesburg
- Plant layout (physical arrangement) - U-shaped production line
- Space requirement: 4000 m²

Costs analysis:
- **Material costs**: raw materials
- **Manufacturing costs**: machining
- **Production costs**: labour and electricity
Manufacturing Plan

- **Results:**
- Manufacturing costs of one Stirling dish
- Selling price: R 90 000.00

- Number of days needed to complete one unit
  - Concentrator- 1/2 day
  - Stirling engine- 5/6 days

- Number of workers required
Economical Analysis of a Residential 3 kW Stirling Dish

• Deployment of the Stirling dish in rural areas is not necessary to compete with other technologies but to provide electricity.
• This type of purchasing plan is suitable for a homeowner with a low income.

Assumptions used in the analysis:

• Loan = selling price of Stirling dish with 10% down payment
• Period : 30 years
• Discount rate : 10%
• Inflation rate : 3%
Economical Analysis of a Residential 3 kW Stirling Dish

<table>
<thead>
<tr>
<th>ITEM</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Levelised Cost of Energy</td>
<td>1.38 R/kWh</td>
</tr>
<tr>
<td>Life line areas</td>
<td>2.11 R/kWh</td>
</tr>
<tr>
<td>Discounted payback period</td>
<td>10.74 years</td>
</tr>
</tbody>
</table>
Conclusion

- Viable market exist in Africa
  - 24% households have a total monthly income R 4000-10 000 or more per month
- Manufacturing of this technology is possible in Africa
- Purchasing plan that can make product more affordable to homeowners
Acknowledgements:

NRF
STERG
University of Stellenbosch

Contact details:

L. Kayofa
Solar Thermal Energy Research Group (STERG)
University of Stellenbosch
South Africa

lilongenik@gmail.com
+27 (0)21 808 4016

visit us:
concentrating.sun.ac.za
## Supporting information

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost of one power supply 3 kW</td>
<td>R 90 000.00</td>
</tr>
<tr>
<td>Manufacturing cost of concentrator</td>
<td>R 447.28</td>
</tr>
<tr>
<td>Manufacturing cost of engine</td>
<td>R 2 997.95</td>
</tr>
<tr>
<td><strong>Manufacturing overhead 10 %</strong></td>
<td>R 3 789.75</td>
</tr>
<tr>
<td>Material cost of concentrator</td>
<td>R 40 190.63</td>
</tr>
<tr>
<td>Material cost of engine</td>
<td>R 15 258.47</td>
</tr>
<tr>
<td><strong>Material cost overhead 10%</strong></td>
<td>R 60 994.01</td>
</tr>
<tr>
<td>Total costs</td>
<td>R 64 783.76</td>
</tr>
<tr>
<td><strong>Profit</strong></td>
<td>30%</td>
</tr>
</tbody>
</table>
Supporting information

- Machining: welding, drilling, milling, turning and broaching
- Concentrator = 2 workers
- Stirling dish = 25 workers
- PMT (annual interest rate, years and amount)
# Supporting information

<table>
<thead>
<tr>
<th>ITEM</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net Present Value</td>
<td>R 14 058.44</td>
</tr>
<tr>
<td>Internal Rate of Return</td>
<td>17.53 %</td>
</tr>
<tr>
<td>Levelised Cost of Energy</td>
<td>1.38 R/kWh</td>
</tr>
<tr>
<td>Life line areas</td>
<td>2.11 R/kWh</td>
</tr>
<tr>
<td>Discounted payback period</td>
<td>10.74 years</td>
</tr>
</tbody>
</table>
Supporting information