Energy Systems for Developing Regions

Group 5
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Assessing the social, political, economic impacts of renewable energy systems in developing regions

Developing countries
- Indonesia
- Bolivia

Developing market
- Fuel cells

Developing economic sector
- Agriculture
- Dairy sector
Business Model for Decentralised Power Generation in Rural Indonesia

Nursita S. Pramono

Poster #37
Background: Indonesia’s Problem in Electricity Sector

- **Inequality of Electricity Access**
- **Low Electrification Ratio**
- **Reliability Issues**

**Root Causes**
- Geographical profile
- Funding
- Project delays

**Government Mission**
- Private investment
- Increase energy mix and energy security
- Other sectors’ development

A **Business Model** focused on **Rural Areas** that applies to **Decentralised Power Generation** and **Renewable Energy (RE)** and enables **Other Sectors’ Development**
## Criteria for Business Model

### VALUE PROPOSITION
Electricity for rural areas that emphasises on the impacts on local community improvement

### CUSTOMER INTERFACE
Distribution company

### INFRASTRUCTURE
Machines, devices, and activities

### REVENUE MODEL
Commercial price based on value proposition
Developing business model

**RESOURCES INVESTIGATION**
Demand, available resources, potential development and cost components

**IMPACT ASSESSMENT**
Multi-criteria, adapted from SUREDSS
- Physical
- Financial
- Natural
- Social
- Human

**CHOOSING RESOURCE**
Based on the biggest impacts

**FINANCIAL ASSESSMENT**
Financially viable or not

**MOST SUITABLE RESOURCE OF TECHNOLOGY IN THE TARGETED VILLAGE**
Case Study: Electrifying Rante Angin

Developing countries: Indonesia/Bolivia
Developing market: Fuel cells
Developing economic sector: Agriculture/Dairy sector
Case Study: Electrifying Rante Angin

**ISOLATED**
By the side of Towuti lake and surrounded by conservation forest

**NEED IMPROVEMENT**
No health service, no street lighting, limited information access, etc.

**RANTE ANGIN**

**AVAILABLE RE RESOURCES**
- **SOLAR**
- **BIOGAS** (rice husks)
- **MICROHYDRO**

**DIESEL GENERATOR**
Operates only 13hrs/day and frequently fails
Results

Developing countries: Indonesia/Bolivia
Developing market: Fuel cells
Developing economic sector: Agriculture/Dairy sector

SOLAR is the most optimal solution!
Results

**PV + BATTERY**
1,577 kWp
Impacts all sectors, especially human and natural impacts

**ECONOMICALLY FEASIBLE (in 20 years)**
0.12 USD/kWh
Rate of return > 10 %
Net Present Value > 0
Payback Period 14 years

CAN HELP PRIVATE COMPANIES TO ESTABLISH A BUSINESS USING DECENTRALISED POWER GENERATION IN RURAL AREAS, WHICH SUPPORTS LOCAL LIFE QUALITY IMPROVEMENT

Developing countries: Indonesia/Bolivia
Developing market: Fuel cells
Developing economic sector: Agriculture/Dairy sector
Distributed electricity generation from renewable energy in grid-connected rural villages

The case of Bolivia

Simon Meunier
Poster #36
Situation in grid-connected villages in developing countries

- Electricity from fossil fuels
- Electricity losses in the Transmission and Distribution (T&D) system
- High impact of electricity generation on global warming
- Electricity too expensive for the inhabitants of the village which therefore restricts electricity use
Solution: Distributed Electricity Generation (DEG) from Renewable Energy (RE)?

- More electricity comes from renewable sources
- Less energy goes through the T&D system so less losses
- Lower impact of electricity generation on global warming
- Possible lower price of electricity in the village which may increase electricity use
**Aim & Approach**

**Aim:** Quantifying the potential impacts of developing DEG from RE

**Approach:**

- 2 scenarios to be compared:
  - Baseline scenario: Only the Grid
  - Alternative scenario: DEG from RE

- Scenarios compared along two parameters:
  1. Cost of providing electricity to the village
  2. Impact on global warming
Case study: Totora

Photovoltaic (PV) energy is chosen in the case of DEG

45 Household surveys realised in Totora

Developing countries: Indonesia/Bolivia
Developing market: Fuel cells
Developing economic sector: Agriculture/Dairy sector
Results

Cost of providing electricity to the village

![Bar chart showing LCOE (cts$/kWh) for Only the Grid and DEG from PV]

- **Only the Grid**: LCOE = 8 cts$/kWh
- **DEG from PV**: LCOE = 10.6 cts$/kWh

**DEG from PV is more expensive than only the grid**

Impact on global warming

- **96 tCO₂eq saved yearly by using DEG from PV instead of only the grid**
- **45% reduction of the impact on global warming by using DEG**
Conclusion

Currently

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Economic</th>
<th>Global warming</th>
</tr>
</thead>
<tbody>
<tr>
<td>Most beneficial solution</td>
<td>Grid</td>
<td>DEG</td>
</tr>
</tbody>
</table>

Currently, the motivation for DEG from RE is environmental

In the future: A possible economic motivation?

Cost of many RE technologies $\rightarrow$ Price of Electricity - DEG from RE $\leftarrow$ Price of Electricity - Grid Only

Developing countries: Indonesia/Bolivia
Developing market: Fuel cells
Developing economic sector: Agriculture/Dairy sector
Do fuel cells present a solution for backup power for telecoms?

Case studies of Ghana, Japan and Brazil

Claire Burtin
Poster #34
Context and objectives

1. What is BUP? Why is it important?

‘Ensure the continuous supply of power for sensitive loads during outages’

2. How to choose a backup power solution?

Telecoms
Data centres
Banks
Hospitals
Companies

Cost of downtime $9,000/min in data centre
Loyalty Security Social

3. Where fuel cells ARE the best solution?
How to choose a Backup Power solution?

- Costs
- Emissions
- Policies
- Noise
- Theft

Type of backup
- Batteries (Lifetime)
- Fuel cells
- Solar PV
- Diesel generators
- Supercapacitors
- Wind turbines

Fuel availability

Developing countries: Indonesia/Bolivia
Developing market: Fuel cells
Developing economic sector: Agriculture/Dairy sector

C. Burtin #34
Case studies: Ghana, Japan, and Brazil

Parameters for the case studies:

Telecom sector
Continuous load 3kW
Pre-selection of technologies

15-year-project
HOMER Software

Brazil
Outages: 2h
10 times per year
Latin America

Japan
Outages: 10 min/yr
Developed countries

Ghana
Outages: 6 hrs/day
African countries

Developing countries: Indonesia/Bolivia
Developing market: Fuel cells
Developing economic sector: Agriculture/Dairy sector

Developing countries: Indonesia/Bolivia
Developing market: Fuel cells
Developing economic sector: Agriculture/Dairy sector
Results

**Brazil and Japan**

**Batteries and PV**: cheapest and clean technologies

Subsidies needed to make FC competitive: $5,000-10,000/kW

Markets not suitable for fuel cells

**Ghana**

<table>
<thead>
<tr>
<th></th>
<th>Operating cost ($/yr)</th>
<th>Capital cost ($/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DG*</td>
<td>4612</td>
<td>6621</td>
</tr>
<tr>
<td>FC NG*</td>
<td>7226</td>
<td>5651</td>
</tr>
<tr>
<td>FC reformer*</td>
<td>7597</td>
<td>6317</td>
</tr>
<tr>
<td>DG only</td>
<td>1934</td>
<td>12518</td>
</tr>
</tbody>
</table>

Fuel cells compete with DG

FC are cleaner
DG are cheaper

Potential market for fuel cells

Annualized costs of operation and capital for different solutions.
* = includes PV and batteries
### Conclusions

Telecoms market in Africa ~300,000 sites by 2020

**BUT** issues with supply chains for hydrogen

<table>
<thead>
<tr>
<th>Country representative of</th>
<th>Outages</th>
<th>Japan</th>
<th>Brazil</th>
<th>Ghana</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>short</td>
<td>medium</td>
<td>long &amp; frequent</td>
</tr>
<tr>
<td>N. America Europe</td>
<td></td>
<td>N.America</td>
<td>Latin America</td>
<td>Africa</td>
</tr>
</tbody>
</table>

| Potential market for FC   |                | x     | x      | ✓             |

Developing countries: Indonesia/Bolivia
Developing market: Fuel cells
Developing economic sector: Agriculture/Dairy sector
Policy designs for Renewable Energy in the UK Agribusiness

Dimitrios Vardouniotis

Poster #39
Aim & Background

- Low O&M
- Low Interest rates
- Free Feedstock
- No land costs

Opportunities

UK targets can be achieved

Economic benefits for the farmers

Developing countries: Indonesia/Bolivia
Developing market: Fuel cells
Developing economic sector: Agriculture/Dairy sector
**Approach**

**How can the unique features of agriculture influence the energy future of the UK?**

*The System Dynamics (SD) model resembles a ‘policy laboratory’*

*Trial & Error approach to achieve the desired results*

A successful policy aims to find the right balance between the outcomes.

Developing countries: Indonesia/Bolivia
Developing market: Fuel cells
Developing economic sector: Agriculture/Dairy sector
An example of successful policy (Solar PV)

- **FIT = Feed-in Tariff**
  - FIT = 5p/kWh
- **10% Subsidy**

42.5 GW & 21 GW on-farm

225 Mt CO₂e avoided

£32.8 billion

55% of 2050 target for the UK

Developing countries: Indonesia/Bolivia
Developing market: Fuel cells
Developing economic sector: Agriculture/Dairy sector
Case study results and conclusions

**Scenario A**
Developing countries: Indonesia/Bolivia
Developing market: Fuel cells
Developing economic sector: Agriculture/Dairy sector

**Scenario B**

**Scenario C**

IRR = Internal Rate of Return

<table>
<thead>
<tr>
<th>Scenario</th>
<th>IRR</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>27%</td>
</tr>
<tr>
<td>B</td>
<td>3%</td>
</tr>
<tr>
<td>C</td>
<td>31%</td>
</tr>
</tbody>
</table>
The potential of renewable energy deployment in the UK dairy sector

Artemis Pountourelis
Poster #38
UK dairy industry

- Largest agricultural sector (17% share of total agricultural production by value)
- Most energy-intensive livestock sector (3,012 GWh p.a.)
Could farm-scale renewable energy installations be the **solution** to the increasing energy costs?

- **Energy-intensive operations**
- **Energy-rich animal waste**
- **Farm-scale renewable energy installations**
- **Stable demand patterns**
- **Easy access to renewable resources**

**Renewable intensification**
- 40% increase in the share of renewables

**Decarbonisation**
- 30% reduction in GHG emissions over the 1990 levels.

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**Dairy Roadmap 2015**

Developing countries: Indonesia/Bolivia

Developing market: Fuel cells

**Developing economic sector:** Agriculture/Dairy sector
Scope of research

To what extent are such installations feasible?

Simulations

Which is the optimal technology?

Optimisation

What affects it?

Sensitivity analysis

Developing countries: Indonesia/Bolivia
Developing market: Fuel cells
Developing economic sector: Agriculture/Dairy sector
Case study

The technology selection depends on each farm’s assets and needs. No such thing as a “one solutions fits all”.

- 150-cow dairy farm located near Reading

Daily profile

Geographic allocation of dairy farms in England

63,403 kWh annually

Developing countries: Indonesia/Bolivia
Developing market: Fuel cells
Developing economic sector: Agriculture/Dairy sector
Case study - Results

- Comparison between the optimal system and the baseline scenario

<table>
<thead>
<tr>
<th>System Configuration</th>
<th>Total electricity produced (kWh/year)</th>
<th>Net Present Cost (£)</th>
<th>Emissions (kg CO2/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>-</td>
<td>87,269</td>
<td>25,968</td>
</tr>
<tr>
<td>20 kW AD</td>
<td>175,200</td>
<td>67,048</td>
<td>- 43,644</td>
</tr>
</tbody>
</table>

23% lower than baseline
2.7 times less than baseline

Displacement of energy costs and grid emissions!
Extrapolation of results - Conclusions

Case study farm → Aggregate of UK dairy farms

Optimal Technology *

<table>
<thead>
<tr>
<th>AD costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>£</td>
</tr>
<tr>
<td>£</td>
</tr>
</tbody>
</table>

Herd size

*As reported for the majority of the respective variable combinations

... BUT the final decision depends strongly on the main aim of the investment.
Conclusion of the presentation

Not only can renewable energy contribute to the attainment of environmental goals but it can also stimulate the social and economic growth of developing regions.

- **Developing countries**: Indonesia: Nursita S. Pramono, poster 37
- **Bolivia**: Simon Meunier, poster 36
- **Fuel cells**: Claire Burtin, poster 34
- **Agriculture**: Dimitrios Vardouniotis, poster 39
- **Dairy sector**: Artemis Pountourei, poster 38
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References

**Literature:**
Ponemon Institute LLC (2016) *Cost of Data Center Outages.*

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Thank you!

Questions?