Improving Energy Sustainability in Poor Rural Communities in Indonesia

ANZSES Information Evening, Sydney, 30 September 2008

Maria Retnanestri
m.retnanestri@unsw.edu.au

Presentation Outline

• Background about Indonesia
• Electrification ratio & socioeconomic development in Indonesia
• Renewable energy potential & installed capacity
• Visit to PV sites, positive findings & issues
• The I3A Framework: Implementation, Accessibility, Availability, Acceptability
• Assessment of PV case studies using the I3A framework
• The Australian Development Research Award (ADRA) research project

Background about Indonesia

Key figures

Population: 237.5 million
- Java Island: 60%
- Pop'n per sq km: - Jakarta: 13,000, Papua: 7
- Average: 1,000

Electrification Ratio: 54%

Installed Capacity: 22.5 GW
- Coal-fired: 31%,
- Combined Cycle: 28%,
- Large Hydro: 14%, Diesel: 13%,
- Gas: 12%, Geothermal: 2%

Private generation: 7.2 GW

Average kWh/capita: 484
(NTT: 61; Jak: 2800)

Demand growth: 8%

The problems in extending the Indonesia’s power grid:
- Geographic/demographic characteristics of the archipelago
- High cost of transmission, low level of demand

Solutions for remote area electrification:
- Diesel, Micro hydro, PV, Wind

Electrification Ratio & Socioeconomic Development

<table>
<thead>
<tr>
<th></th>
<th>Indonesia</th>
<th>Australia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population</td>
<td>237.5 million</td>
<td>21 million</td>
</tr>
<tr>
<td>HDI (2005)</td>
<td>0.728 (107/177)</td>
<td>0.968 (3/177)</td>
</tr>
<tr>
<td>Population below poverty line (2006)</td>
<td>17.8 % (approx. 40 million)</td>
<td></td>
</tr>
<tr>
<td>Energy Prod: Consump, GWh</td>
<td>126 ; 108</td>
<td>236 ; 219</td>
</tr>
<tr>
<td>kWh/capita</td>
<td>484</td>
<td>11,849</td>
</tr>
<tr>
<td>fossil fuel CO2 (tons per capita)</td>
<td>1.7</td>
<td>16.2</td>
</tr>
</tbody>
</table>

HDI components: life expectancy, educational attainment and standard of living
HPI components: poor health, literacy, access to clean water and earning below a dollar a day
Renewable Energy Potential & Installed Capacity in Indonesia

<table>
<thead>
<tr>
<th>RE Systems</th>
<th>Technical Potential</th>
<th>Installed Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>PV</td>
<td>4.8 kWh/m2/day</td>
<td>&gt;10 MWp</td>
</tr>
<tr>
<td>Micro Hydro</td>
<td>460 MW</td>
<td>84 MW</td>
</tr>
<tr>
<td>Biomass</td>
<td>50 GW</td>
<td>302 MW</td>
</tr>
<tr>
<td>Wind</td>
<td>4 m/s</td>
<td>0.5 MW</td>
</tr>
<tr>
<td>Geothermal</td>
<td>27 GW</td>
<td>800 MW</td>
</tr>
</tbody>
</table>

RE has the potential to contribute to rural community socioeconomic development. However, due to the decentralized nature of RE, a holistic approach is required, that considers:

- The sustainability dimensions of RE delivery: institutional, financial, technological, social, ecological
- The hardware, software & orgware aspects of RE delivery, where:
  - RE Hardware: The equipment used in RE systems
  - RE Software: The skills & information required to master the use of RE hardware
  - RE Orgware: The set of institutions required to develop, implement & maintain RE systems

PV Sites Visited

- Industries, Donors, Research Agency, NGO-1997-2003 WB/GEF site
- Oeledo: 1997-2000 E7 site
- Pusu: 2004 DPE-Womintra site
- Nusa & Oelnase: Water pumping
- Kamenggh: Water Pumping System
- Kamenggh: Water Pumping System
- Kiritana: 1997-1999 AusAID Project
- Delindo: 1997-2000 E7 site
- North & East: Water pumping

Getting to the Field

1) An un-sealed muddy road to Padasuka Village, Lampung, Sumatra, 27/04/2005.
2) Crossing dry river bed on the way to Oeledo Village, Rote Island, NTT, 17/05/2005.
3) Fly to East Sumba. 4) Ferry Boat to Rote Island. 5) Small ferry boat, Cirata lake. 6) By motorbike, Lampung.

Interviews

1) Users of PV Water Pumping System in Oelnase, NTT. 2) Users of the E7 PV Wind Diesel Hybrid System in Oeledo, Rote Island.
3) PV Water Pumping Users, East Sumba. 4) Research Agency, Jakarta. 5) Bank, South Sumatra. 6) PV Industry, Jakarta.
Off-grid PV Applications in Indonesia: Some positive findings

PV acculturation into local life: Users invested in bigger PV capacity systems, PV for clean water provision, gardening, rural telephone, communication to support economic activities, back up power → measures of user satisfaction with PV benefits & reliability.

PV use in the disaster risk management (DRM) context → Community resiliency

1.6. Aceh (2005): PV for street lighting, lighting at refugee barracks & communications
2. A 3,600t 10 MW diesel barge, swept 4 km inland, Banda Aceh
4. NTT (1992): PV for communications after the Maumere tsunami

Photos: Courtesy of Mambruk Energy International, Azet Surya Lestari, Bappenas, Claus Dausell

Off-grid PV Applications in Indonesia: Some issues

Users “disconnected” from technology: Lack of local capacity to adopt PV to better fit local conditions; Lack of adequate after sales service infrastructure

Beyond project life: Lack of adequate after sales service infrastructure, Social fragmentation

Photos: Courtesy of Azet Surya Lestari
The I3A Sustainable PV Energy Service Delivery Framework

**Implementation:** Institutional aspects & external factors affecting PV delivery

**Accessibility:** Financial, Institutional, Technological accessibility

**Availability:** Technological, Institutional aspects to maintain service quality & continuity

**Acceptability:** Social (PV Acculturation), Ecological aspects

---

Conceptual background to the I3A Framework

**PV in the nexus of Sustainable Development, Diffusion of Innovation & Social Capital**


The WEC’s Three Energy Goals: Accessibility, Availability, Acceptability

Objectives (Conceptual Level - Why)

Process and Mechanism (Operational Level – Who & How)

Social Capital as Part of Community Capital/Resources

The I3A framework: Assessment & design tool for a sustainable RE delivery

I3A Framework: An implementation that maintains RE energy service accessibility (financial, institutional, technological), availability (technological, institutional) and acceptability (social, ecological), considering the hardware, software and orgware aspects of PV energy service delivery during & beyond RE project life
PV Case Studies: General Background

Case Studies Features

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 1</td>
<td>The self-reliant / Organic SHS Market in Lampung</td>
<td>High rainfall, fertile land</td>
<td>93 m; 196 p/km²</td>
<td>4.1 m Rp (US$ 500)</td>
<td>71%</td>
<td>22%</td>
<td>7.5 MW (44 small diesel generators)</td>
<td>37%</td>
<td>186</td>
</tr>
<tr>
<td>CS 2</td>
<td>The WB/GEF SHS Project 1997-2003 in Lampung &amp; West Java</td>
<td>High rainfall, fertile land</td>
<td>38 m; 1100 p/km²</td>
<td>4.1 m; 86 p/km²</td>
<td>37%</td>
<td>13%</td>
<td>16.35 GW (large thermal &amp; hydro generators)</td>
<td>51%</td>
<td>598</td>
</tr>
<tr>
<td>CS 3</td>
<td>The PLD Concept in NTT (SHS, Hybrid PV-Wind-Diesel System)</td>
<td>Dry land</td>
<td>2.2 m Rp (US$ 250)</td>
<td>29% (1.2 m)</td>
<td>Farmers &amp; fishermen</td>
<td>Farmers &amp; fishermen</td>
<td>151 MW (4Hydro, 556 small diesel generators)</td>
<td>22%</td>
<td>61</td>
</tr>
</tbody>
</table>

Institutional: Stakeholders, Interrelationships, Roles, Acknowledgement of all Stakeholders Interests

Facilitator role: Secure PV adoption in the direction deemed desirable by Sponsor, balancing this with Users requirements
- **Vertical Network**: Centralized. Users are passive participants in the PV delivery process (Case Study 2).
- **Horizontal Network**: Decentralized – allows Users to be active participants (Case Study 1).
- **Hybrid Network**: Case Study 3 used combined vertical (in terms of technical design) and horizontal (in terms of project implementation & ongoing operation), allowing Users to be active participants in the RE delivery process.

The 120 kW Cinta Mekar Village MH, West Java. Accommodation of local requirements: A written agreement was made to allocate at least 300 litre/second to irrigate 50 hectares of fields prior to water being used for electricity generation.

PLD Pusu: A monthly payment session at PLD office, May 2005. Active involvement of Users: Users meet regularly to elect cooperative board members, define rules of payment, fines, fund management, etc.

User Autonomy: Technological Familiarity & the KPDAC Continuum

<table>
<thead>
<tr>
<th>Case Study</th>
<th>Stage 0-5: Initially skeptical that sunlight and wind could indeed be converted into electricity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case Study</td>
<td>Stage 0-5: Initially skeptical that sunlight and wind could indeed be converted into electricity</td>
</tr>
<tr>
<td>Case Study</td>
<td>4-5: Users were familiar with SHS (system configuration, load management)</td>
</tr>
</tbody>
</table>

Relative position of PV target/Users at the project start

Facilitators need to understand User position in the KPDAC continuum at project start to facilitate RE familiarity & build User autonomy.
Implementation/Delivery

User Autonomy: Technological Familiarity & the KPDAC Continuum

Generalization in facilitating technological capability:

The earlier the position of Users in the KPDAC continuum at project start, the greater the level of effort & length of intervention required to facilitate User technological capacity in RE.

Accessibility: Equitable Access to PV

Financial, Technological, Institutional Accessibility

Financial Accessibility:

- **Case Study 1** - Second hand PV module transaction, flexible system configuration, flexible payment terms (made possible by Users high degree of familiarity with SHS)
- **Case Study 2** - Market facilitation (formal market), support on the supply side to establish rural outlets, testing facilities, SHS standards
- **Case Study 3** - Users pay OM service subscription, project was combined with rural economy empowerment programs (enhancing pre-existing economy)

Case Study 3: Combined program of PV delivery & empowerment of pre-existing rural economy in NTT improved Users economic standing & helped Users to pay PV service & installments regularly.
Equitable Access to PV: Financial, Technological, Institutional Accessibility

PV Autonomy as a function of Financial & Technological capacities, viewed as a necessary condition for users to actively participate in the PV social system/network/organisation

Facilitators need to be aware of each rural community’s economic standing & PV technological capability to promote User autonomy effectively

• Case Study 1: Most autonomous (investment & PV familiarity)
• Case Study 2: Semi to more autonomous
• Case Study 3: Least autonomous (require more actors & financial supports)

Maintaining User Confidence in PV & Its Providers

Technical quality & continuity of energy service:

• Case Study 1: Local capable agent who can make business out of PV service availability (spare parts sales, electronic repair, battery maintenance); Users experience/innovation
• Case Study 2: Establishment of SHS standards, testing facilities & rural outlets
• Case Study 3: Agreed rules of technician availability, spare parts and their prices

PV Benefits: Saving from reduced kerosene use, greater comfort, reduced fire risk hazards, SSB & mobile phones charging

• Issues: PV light too bright, PV’s modularity provoked theft

RE Acceptance/Acculturation: A measure of the extent to which RE can improve rural sustainability (solve local energy needs, promote local socioeconomic development)
A function of Sustainable Implementation, Accessibility & Availability
The nexus of PV attributes & local requirements: Relative advantage, compatibility, complexity, observability, reinvention etc.

• PV Benefits: Saving from reduced kerosene use, greater comfort, reduced fire risk hazards, SSB & mobile phones charging
• Issues: PV light too bright, PV’s modularity provoked theft

Social innovation: SHS w/o BCR, use of PV to support swallow bird farming, to donate to the community, future possibility for solar-powered two-band radio
PV Acculturation into Local Community's Life

Availability & Acceptability During 
& Beyond PV Project Life – 
KPDAC Continuum

• Case Study 1: PV had stabilized (acculturated in local life)
• Case Study 2: Rural outlets facilitated conditional acceptance, confirmed acceptance remains to be seen
• Case Study 3: User involvement in project design & implementation facilitated conditional acceptance, confirmed acceptance remains to be seen

Conclusions & Follow-Up

• The I3A Framework can illuminate the extent to which RE can facilitate sustainable development, considering the hardware, software & orgware aspects of RE delivery, both during and beyond project life
• The I3A Framework can be used both as an assessment & design tool for an RE project, by applying the following criteria:
  - Sustainable RE Implementation/Delivery: Promote civic network, facilitate active participation, build User autonomy/capacity
  - RE Accessibility: Facilitate access to RE financing, skills, network
  - RE Availability: Ensure RE availability both during & beyond project life
  - RE Acceptability/Acculturation: Utilize & enhance pre-existing local resources
• Follow-up: an ADRA (Australian Development Research Award) project to identify & overcome barriers to RE in rural Indonesia by community capacity building using the I3A framework

The ADRA research project activities & timeline