Centre for Energy and Environmental Markets

UNSW

Improving Energy Sustainability in Poor Rural Communities in Indonesia

ANZSES Information Evening, Sydney, 30 September 2008

Maria Retnanestri
m.retnanestri@unsw.edu.au

Centre for Energy and Environmental Markets

UNSW

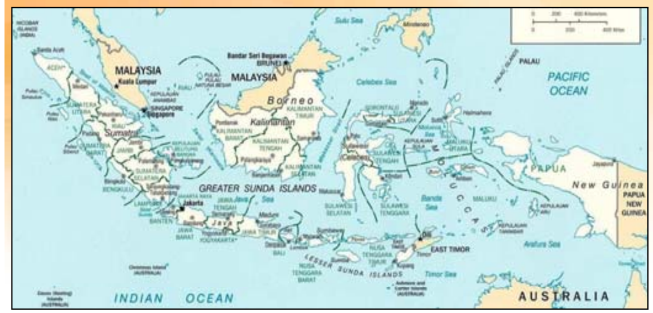
Presentation Outline

- 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

Centre for Energy and Environmental Markets

UNSW

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

Centre for Energy and Environmental Markets

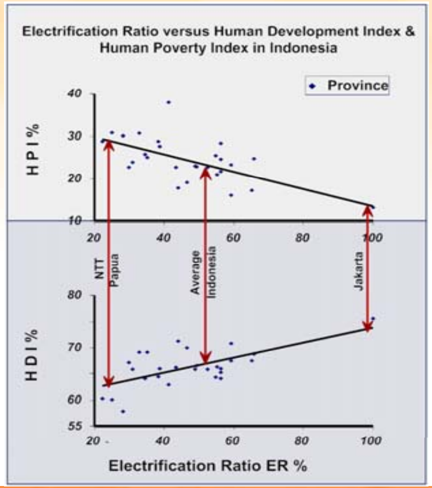
UNSW

Electrification Ratio & Socioeconomic Development

Electrification Ratio, Human Development Index and Human Poverty Index

	Indonesia	Australia
Population (2008)	237.5 million	21 million
GDP/capita (2007)	US$ 3,700	US$ 36,300
HDI (2005)	0.728 (107/177)	0.968 (3/177)
Population below poverty line (2006)	17.8 % (approx. 40 million)	-
Energy Prod; Consump, GWh	126 ; 108	236 ; 219
kWh/capita	484	11,849
fossil fuel CO2 (tons per capita)	1.7	16.2

HDI components:
life expectancy, educational attainment and standard of living
HPI components:
poor health, illiteracy, access to clean water and earning below a dollar a day



Renewable Energy Potential & Installed Capacity in Indonesia

RE Systems	Technical Potential	Installed Capacity
PV	4.8 kWh/m2/day	>10 MWp
Micro Hydro	460 MW	84 MW
Biomass	50 GW	302 MW
Wind	4 m/s	0.5 MW
Geothermal	27 GW	800 MW

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

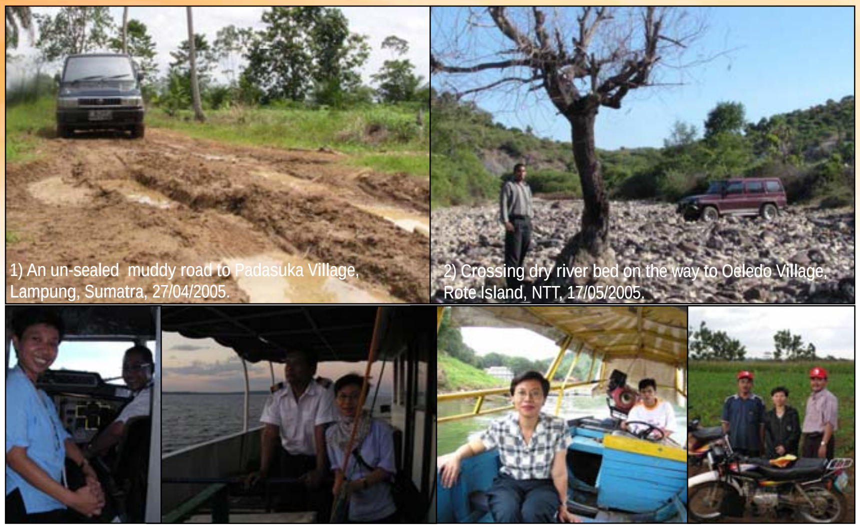
-Organic market sites
-1997-2003 WB/GEF site
-2004-2006 BRI Triodos Project

-Industries, Donors, Research Agency, NGO
-1997-2003 WB/GEF site

-Kamanggih: Water Pumping System
-Pambotajara village: DPE Project
-Kiritana: 1997-1999 AusAID Project

-Oeledo: 1997-2000 E7 site
-Pusu: 2004 DPE-Womintra site
-Nusa&Oelnase: Water pumping

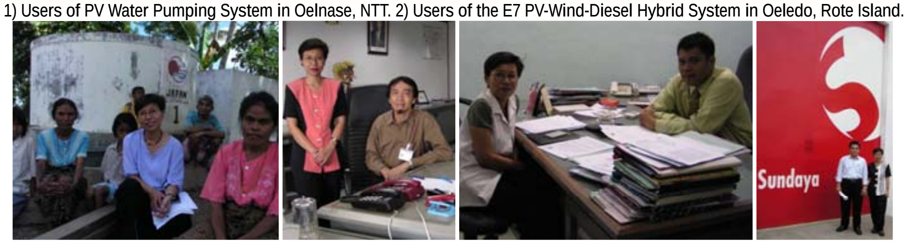
Getting to the Field


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, 4) **Small ferry boat, Cirata lake, 5) 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.

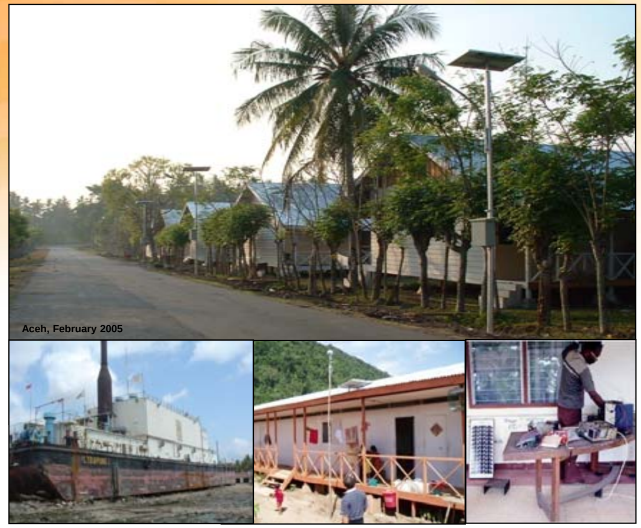


3) PV Water Pumping Users, East Sumba. 4) Research Agency, Jakarta; 5) Bank, South Sumatra. 6) PV Industry, Jakarta.

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.

Off-grid PV Applications in Indonesia: *Some positive findings*



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

1&3. 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 Enery International, Azet Surya Lestari, Bappenas, Claus Dauselt

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

Off-grid PV Applications in Indonesia: *Some issues*

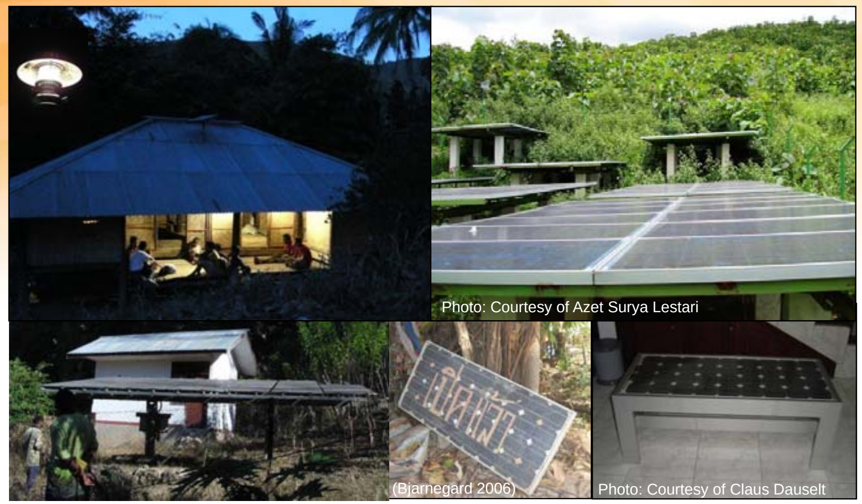


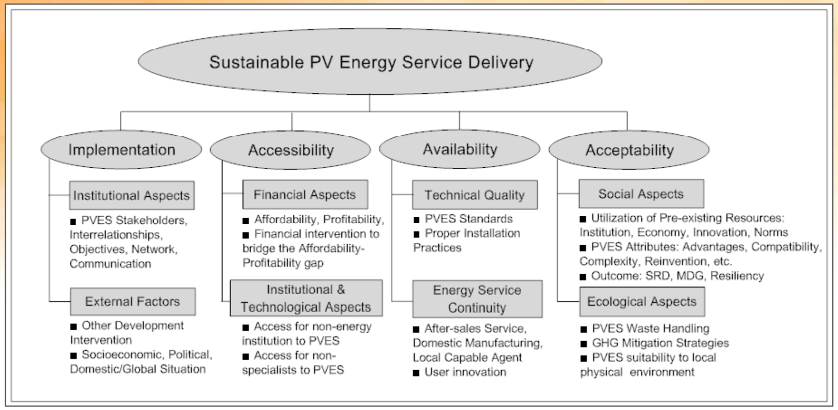
Photo: Courtesy of Azet Surya Lestari

(Bjarnegard 2006)

Photo: Courtesy of Claus Dauselt

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

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

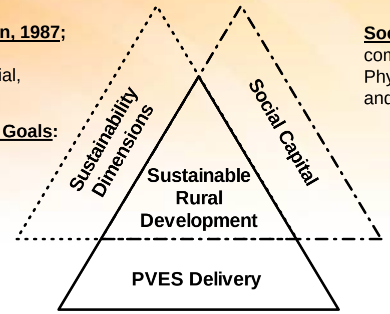
Conceptual background to the I3A Framework

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

Brundtland's SD definition, 1987;
SD Dimensions: Technical, Financial, Institutional, Social, Ecological

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

Social Capital, as part of a community capital as a whole: Physical Capital, Natural Capital and Social Capital



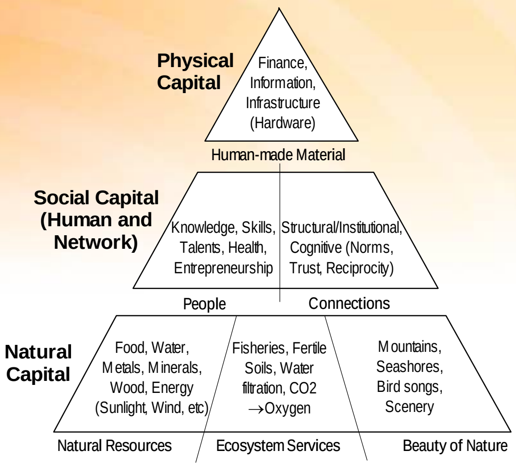
Objectives (Conceptual Level - Why)

Pre-existing Resources & Project Outcomes – What and What's Next?

Process and Mechanism (Operational Level – Who & How)

Diffusion of Innovation (DOI, Rogers, 1995, 2003):
"The process in which an innovation is communicated through certain channels over time among the members of a social system" (Rogers, 2003, p5).

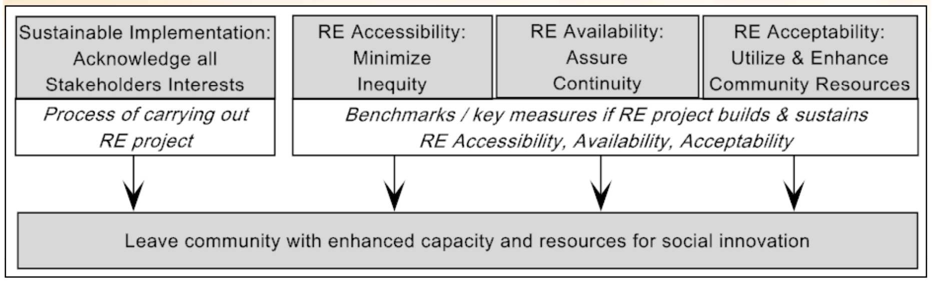
Social Capital as Part of Community Capital/Resources



Reproduced from Hart, 1998, with some modifications.

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

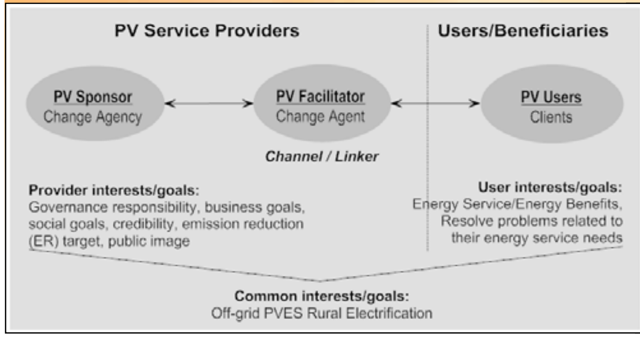


PV Case Studies: General Background

Case Studies Features	CS 1. The self-reliant / Organic SHS Market in Lampung	CS 2. The WB/GEF SHS Project 1997-2003 in Lampung & West Java	CS 3. The PLD Concept in NTT (SHS, Hybrid PV-Wind-Diesel System)
Geography	High rainfall, fertile land	High rainfall, fertile land	Dry land
Population (2003)	6.9 m; 196 p/km2	38 m; 1100 p/km2	4.1 m; 86 p/km2
GDP / capita (2002)	4.1 m Rp (US$ 500)	5.8 m Rp (US$ 650)	2.2 m Rp (US$ 250)
Labour composition	71% farmers	37 % farmers	Farmers & fishermen
Poverty (2003)	22% (1.5 m)	13% (4.9 m)	29% (1.2 m)
Electricity Generation	7.5 MW (44 small diesel generators)	16.35 GW (large thermal & hydro generators)	151 MW (4Hydro, 556 small diesel generators)
Electrification Ratio	37%	51%	22%
kWh/capita	186	598	61

Implementation/Delivery

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 Study2).
- **Horizontal Network:** Decentralized – allow 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.

Implementation/Delivery

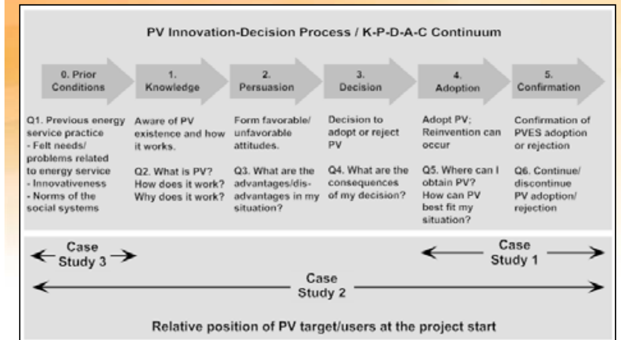
Institutional Aspect: Accommodation of local requirements

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.

Implementation/Delivery

User Autonomy: Technological Familiarity & the KPDAC Continuum



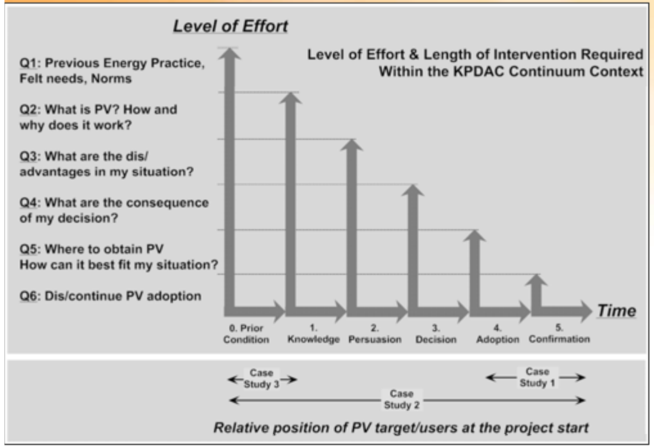
- **Case Study 1:** Stage 4-5: Users were familiar with SHS (system configuration, load management)
- **Case Study 2:** Stage 0-5: User familiarity with SHS varied
- **Case Study 3:** Stage 0: Initially skeptical that sunlight and wind could indeed be converted into electricity

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

Centre for Energy and Environmental Markets — UNSW

Implementation/Delivery

User Autonomy: Technological Familiarity & the KPDAC Continuum



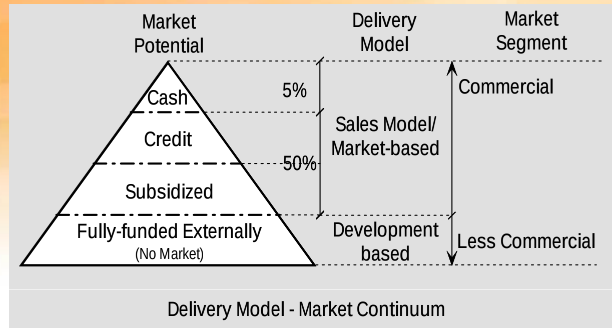
Generalization in facilitating technological capability:

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

Centre for Energy and Environmental Markets — UNSW

Accessibility: Equitable Access to PV

Financial, Technological, Institutional Accessibility



- **Case Study 1 -** More commercial segment, Market model based on traditional practice: Cash & credit based on agreed negotiation
- **Case Study 2 -** More commercial segment, Market model: WB loan, GEF 20% subsidy, 3 year credit period designed by project providers
- **Case Study 3 -** Less commercial segment, Development model: Capital investment provided by donor/local government

Centre for Energy and Environmental Markets — UNSW

Accessibility: Equitable Access to PV

Financial, Technological, Institutional Accessibility

Financial Accessibility:

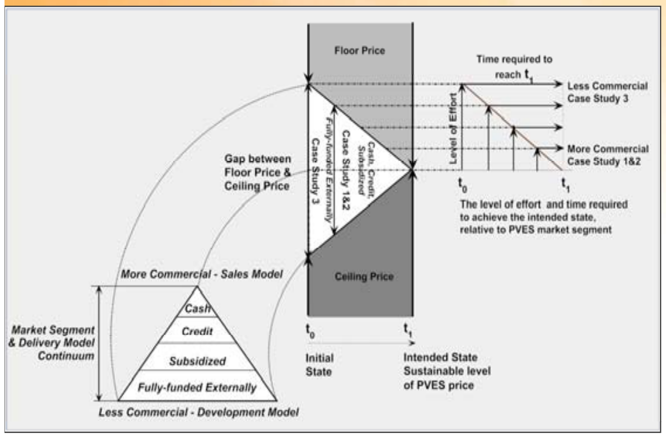
- **Case Study 1 –** Second hand PV module transaction, flexible system configuration, flexible payment terms (made possible by Users high degree of familiarity with SHS)
- **Case Study 2 –** Market facilitation (formal market), support on the supply side to establish rural outlets, testing facilities, 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

Centre for Energy and Environmental Markets — UNSW

Accessibility: Equitable Access to PV

Financial, Technological, Institutional Accessibility

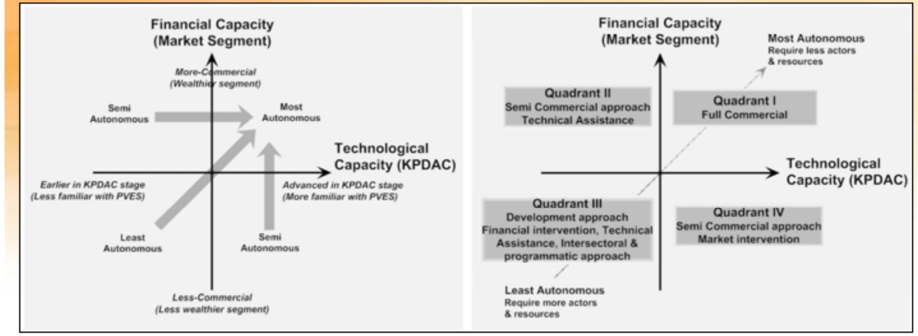


Generalization: Need relevant delivery model/ intervention approach for different market segment:

- **Commercial Segment:** Market facilitation to bridge the Affordability and Profitability gap
- **Less-commercial Segment:** Community empowerment; Active adopters rather than passive recipients of innovation/aid; Empower Users to be able to become part of the merchant society

Accessibility

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/orgware

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)

Availability

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

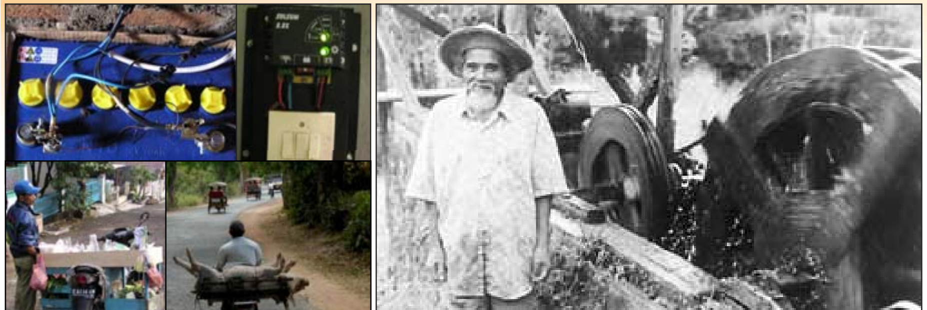
Acceptability: PV Acculturation into Local Community's Life

- 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

Acceptability: PV Acculturation into Local Community's Life

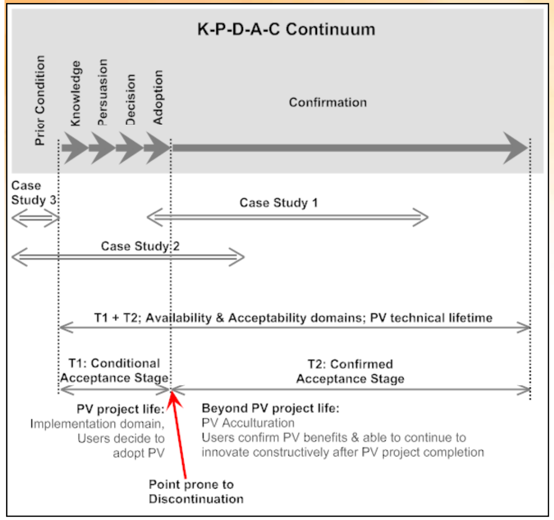
Reinvention: the degree to which an innovation is changed or modified by users in order to solve a wide range of user problems (not always favored but often inevitable)

- **Reinvention:** SHS w/o BCR
- **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



A traditional 5 kW Micro Hydro installation in the Tundagan village, Central Java, built by a local farmer (Bachri 2000).

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