AN ADRA RESEARCH PROJECT TO OVERCOME BARRIERS TO RENEWABLE ENERGY IN RURAL INDONESIA BY COMMUNITY CAPACITY BUILDING USING THE I3A FRAMEWORK

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ABSTRACT

This paper reports on the design and early outcomes from an Australian Development Research Award (ADRA) project to be conducted in 2008-2010 by Australian and Indonesian researchers. The project aims to identify and disseminate ways to use photovoltaic energy systems (PVES) and other renewable energy (RE) resources to facilitate sustainable development for communities in rural Indonesia without access to electricity grids – almost 50% of Indonesia's population in 2005 and unlikely to fall due to Indonesia's archipelagic nature. The project will focus on Papua and *Nusa Tenggara Timur* (NTT) provinces in Eastern Indonesia, which have low electrification ratios as well as low Human Development Indices (HDI) and high Human Poverty Indices (HPI). By 2006, approximately 10MWp of PVES had been installed in Indonesia for lighting, water pumping, telecommunications, health clinics, etc. However many have failed and many other communities still lack basic electricity supply. This project aims to better understand why some PVES projects succeed while others fail, develop best-practice guidelines and transfer that knowledge to policy makers, project designers and implementers, rural communities and Indonesian research and education institutions. The project will use the I3A (Implementation, Accessibility, Availability, Acceptability) framework described in a companion paper submitted to this conference, to explore how local communities can initially succeed with PVES installation and then continue to socially innovate to meet their evolving needs, considering institutional, financial, technological, social and ecological issues. Expected outcomes include recommendations on policy and best practices for project planning, design, implementation, monitoring and evaluation and education.

RESEARCH PROJECT DESCRIPTION, OBJECTIVES & BACKGROUND

Australian Development Research Award (ADRA) Project EFCC 011 is an interdisciplinary collaboration between University of New South Wales (UNSW) and Indonesian researchers. The objective of the project is to identify and disseminate ways to overcome barriers to the use of photovoltaic energy systems (PVES) and other renewable energy (RE) resources to facilitate sustainable development for communities in rural Eastern Indonesia that do not have access to conventional electricity supply. In particular, the project aims to develop a better understanding of why some PVES projects succeed while others fail to facilitate sustainable rural development (SRD), and to transfer the practical know-how generated to policy makers, to those involved in project design and implementation, rural communities and Indonesian research and educational institutions. This paper discusses the implementation of the project while a companion paper (Retnanestri et al 2008) discusses the I3A (Implementation, Accessibility, Availability, Acceptability) framework that is used in the project.

In 2005, almost 50% of Indonesia's population, equivalent to approximately 110 million souls, had no access to electricity supply (PLN 2006). The archipelagic nature of Indonesia constrains the full extension of the national electricity grid to remote areas and there are similar problems with the supply of conventional fuel. Fossil fuel prices are rising and climate change impacts should be urgently reduced. It has been argued that "lack of adequate energy services in rural areas has social as well as environmental and health effects" (Goldemberg 2000). This is corroborated by the statistics in Indonesia which saw that of the 33 Indonesian provinces, Papua and *Nusa Tenggara Timur (*NTT) in Eastern Indonesia have the lowest electrification ratios as well as low Human Development Indices (HDI) and high Human Poverty Indices (HPI)[1], see Figure 1.

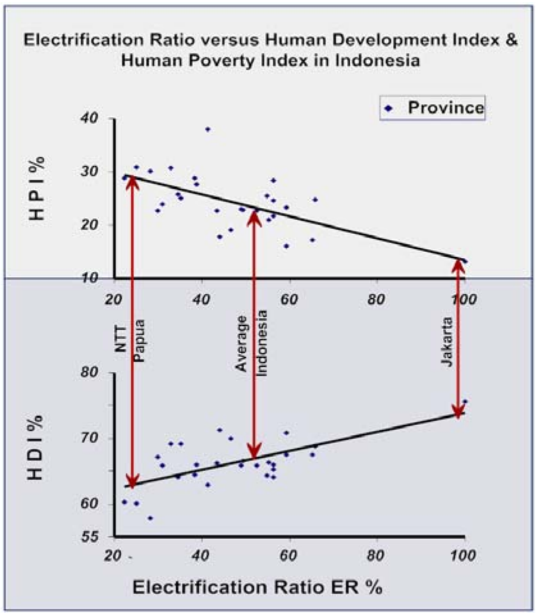

Fig. 1: Trends and Correlation of the Indonesian Provincial Electrification Ratio (ER), Human Development Indices (HDI) and Human Poverty Indices (HPI) (Sources: BPS 2004, PLN 2004, UNDP 2004).

Table.1: Renewable energy potential in Indonesia

RE System	Technical Potential	Installed Capacity
PV	Average Insolation 4.8kWh/m^2/day	10 MWp
Micro-hydro	460 MW	84 MW
Biomass	50 GW	302 MW
Wind	9 GW, average wind speed 4m/s	0.5 MW
Geothermal	27 GW	800 MW

[1] HDI is a measure of life expectancy, educational attainment and standard of living while HPI is a measure of poor health, illiteracy, poor access to clean water and earning below a dollar a day (UNDP, 2004).

Renewable energy (such as solar, hydro, geothermal, wind in certain areas, and biomass) could play an important role in remote Indonesian communities (Outhred & Retnanestri, 2006) considering its abundant, widespread availability. Table 1 summarizes RE potential in Indonesia including PV, microhydro, biomass, wind and geothermal (ADB 2003, ESDM 2005). Given the right condition, RE systems can contribute to improving community well-being by improving access to clean water, better quality of lighting, access to telecommunications and infotainment, and job creation, which altogether can improve HDI and reduce HPI, to facilitate SRD.

Fig. 2: (1-3) PV water pumping system in NTT Province: Access to clean water saves time for fetching water from the creek, for gardening and other household productive activities. (4) SHS in Lampung Province: Kerosene lamps are the domain of primary school children; with children in SHS households no longer at risk while preparing kerosene lamps, while also having a better quality of light in which to study at night. (Photos: M Retnanestri 2005).

Fig. 3: (1) Fish solar dryer in Aceh using a combination of wind-sunlight and biomass sources (Photos courtesy of Azet Surya Lestari Co). (2). PVES used in the December 1992 tsunami in Maumere, Flores (NTT Province), deployed to power telecommunication during the emergency handling following the disaster (photo courtesy of Claus Dauselt). (3). The installation of a SHS in Lampung creating jobs for the local people (Photo: M Retnanestri 2005).

Findings from fieldwork undertaken in Indonesia in 2003 and 2005 to investigate the PVES delivery sustainability suggest some positive examples, demonstrating the extent to which PVES can contribute to SRD including PV water pumping system in NTT province that provide clean water and support farming/gardening activities, solar home systems (SHS) in Lampung that provide better quality of lighting for studying and also replace kerosene lamps reducing fire risks, solar dryers and PV-wind-biomass systems for agricultural activities, as well as the use of PVES for disaster response, improving community resiliency, see figures 2 and 3.

Despite those positive examples, many renewable energy projects have failed and basic electricity supply remains inaccessible to many remote Indonesian communities (Retnanestri et al 2005). Indonesia also lacks people who have been educated and gained practical experience in the design, manufacture, installation, operation and maintenance of RE systems.

In the delivery of RE energy service, it is imperative to look at all of the RE hardware-software-orgware aspects (IIASA 2006), where in the case of PVES:

- Hardware refers to the photovoltaic panels, battery and associated balance of system equipment as well as the end-use equipment required to deliver valued energy services such as lighting, communications or refrigeration.
- Software refers to the information and skills needed to design, install, operate, maintain, decommission and reinvent[2] the hardware and/or its use.
- Orgware refers to the institutional context that facilitates the sustainable development and application of PVES.

Successful application of RE faces financial, technical, social and institutional barriers because the software and orgware dimensions of the technology are important in that context and must be simultaneously and effectively addressed. These barriers can be overcome by effective cooperation between all stakeholders (funding bodies, financiers, governments, project deliverers (companies and NGOs) and host communities). The deployment of RE hardware is relatively straightforward, however its ongoing operation and reinvention requires both the mastery of RE software and the presence of a local capable agent or institution (an aspect of orgware), which may require longer to introduce and which should be already present prior to hardware installation.

The following key findings from fieldwork in Indonesia in 2003 and 2005, summarize the prospects and issues for PVES sustainability in Indonesia (Retnanestri 2007):

- **Institutional:** Successful PVES installation has involved the establishment of local electricity institutions (software and orgware), which are indicators of the strengthening of local institutional capacity. However, in some cases, the lack of follow-up field assessment and local capacity to adapt PVES to local conditions has led to inadequate project performance and eventually PVES failure.
- **Financial:** Some revolving funds have been generated from past government projects and PVES has been used to support income-generating activities, which are indicators of financial sustainability. However, off-grid PVES delivery is characterised by scattered markets that are expensive to service and PV modules remain expensive. Thus, first-cost barriers remain to wide-spread PVES deployment. On the other hand, the energy service model (where users pay RE service subscription fee to providers) can exhibit lack of transparency and poor fund management.

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[2] Reinvention refers to the degree to which an innovation is changed or modified by users to fit their situation (Rogers, 2003, p17).

- **Technological:** Domestic manufacturers of balance of system components and PV panels have managed to penetrate the market and even export to other developing countries. However, inadequate after-sales service infrastructure and spare parts availability, poor installation practices and inadequate warranties undermine PVES continuity.
- **Social:** Given the right conditions, PVES has improved rural community well-being by providing access to clean water, good quality lighting, telecommunication and infotainment and has supported job creation, which together can improve HDI, reduce HPI and improve energy security. Thus off-grid PVES can be a useful vector for energy service delivery to facilitate SRD. However malfunctioning PVES hardware introduces externally imposed problems which in some cases can lead to social fragmentation.
- **Ecological:** PVES can be environmentally friendly and noise-free, enhance sustainable rural development and contribute to the greenhouse gases (GHG) mitigation strategies, as well as reduce the need to transport fossil fuels, in itself a GHG emitting activity. However, inappropriate waste disposal can undermine such worthwhile objectives.

Thus there is a need to understand and address barriers to RE in a systematic way to reduce the likelihood of bad outcomes and increase the likelihood of good outcomes of RE projects. Retnanestri (2007) proposed the I3A framework as an analytical tool to assess RE project sustainability, identify RE barriers, as well as a tool to design a sustainable RE project, by considering institutional, financial, technological, social and ecological aspects of PVES delivery, and simultaneously addressing issues related to the hardware, software and orgware aspects of the RE technology.

RESEARCH ACTIVITIES, METHODOLOGIES & TIMELINE

Figure 4 summarizes the activities, timeline and expected outcomes of the ADRA EFCC 011 project. The research activities include research involving UNSW and Indonesian project collaborators, fieldwork, workshops and seminars in Indonesia. The methodology of the project will involve:

- Primary data collection including a literature survey
- Secondary data collection including in-depth/semi-structured interviews of PVES stakeholders (policy makers, manufacturers, distributors, research agency, end users)

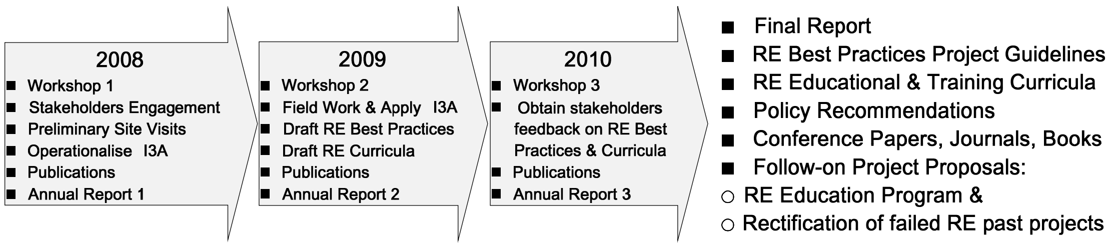

Fig.4: The ADRA EFCC 011 Project Activities and Timeline

The expected practical outputs of this collaborative project include: (a) recommendations on policy and best practices for project planning, design, implementation, monitoring & evaluation, (b) best-practice development projects, (c) knowledge dissemination through educational institutions, workshops & publications, (d) follow-on project proposals for RE education and ways to rectify failed past RE projects, and (e) direct learning opportunities for those involved in project implementation and for the host rural communities. This is in line with the ADRA program objective to "attract quality research that informs policy development and increases the general stock of knowledge around development issues" (AusAID 2008).

RESEARCH DESIGN AND THE I3A FRAMEWORK IN BRIEF

The project will use the I3A (Implementation, 3A) framework, see Figure 5, which refers to an Implementation that maintains RE's Accessibility, Availability and Acceptability, aimed at addressing issues related to the institutional, financial, technological, social and ecological issues related to an RE delivery, thus simultaneously looking at all aspects of the RE's hardware-software-orgware (Retnanestri 2007 and Retnanestri et al 2008).

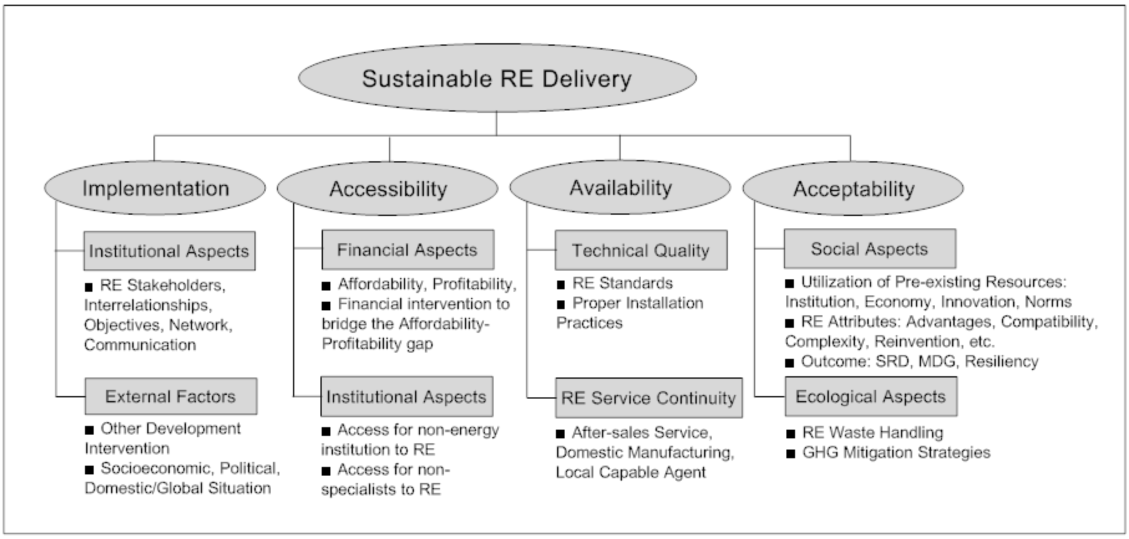

Fig.5: The I3A Model: Sustainable RE Delivery Framework

The premise of the I3A framework is that to be sustainable and equitable, RE projects should be implemented in an institutional framework that addresses RE accessibility (financial, institutional and technological), availability (technical quality and continuity) and acceptability (social and ecological), by assessing the following components:

- **Implementation** (institutional aspect) looks at the RE social system: the stakeholders and their objectives, skills, interrelationships and roles in RE delivery. The enabling environment describes external factors that may affect RE delivery.
- **Accessibility** (financial, institutional and technological) deals with addressing RE equity issues from the financial, institutional and technological perspectives (RE affordability, profitability, financing, skills and networks).
- **Availability** (technical quality and continuity) focuses on the quality and continuity of energy supply necessary to maintain user trust and confidence in RE systems and their providers.

- **Acceptability** (social and ecological) focuses on the social and ecological perspectives, identifying the extent to which RE can acculturate into local life, enhancing rural socioeconomic culture and promoting ecological care to facilitate SRD.

The overall objectives of the I3A framework are to acknowledge the interests of all stakeholders, maximize equity, assure RE service continuity and institutionalize RE by utilizing and enhancing pre-existing community resources to leave the host communities with the capacity to meet their evolving needs, such that RE can contribute to sustainable rural development. In practical terms, this means that RE project should be designed in partnership with host communities to meet their energy service needs and that host communities should be empowered to manage the operation, maintenance, financing and redesign of RE to meet their evolving needs.

Fig.6: (Left): The grid-connected 120 kW micro hydro project in Cinta Mekar village, West Java. (Right): The members of PLD (Village Electricity Management) Pusu: A monthly payment session for the SHS at the PLD office attended by all SHS End Users and PLD board members. (Photos: M Retnanestri 2005).

Figure 6 depicts examples of RE project implementation, in which the target communities were actively involved in the project design and implementation, resulting in the maintenance of RE project's accessibility, availability and acceptability beyond the initial project completion. Figure 6 (left) is the 120 kW micro-hydro installed in Cinta Mekar village, West Java, partly funded by the UNESCAP (United Nation Economic and Social Commission for Asia and the Pacific), the fund of which was channelled to the village cooperative, facilitated by the IBEKA NGO. In this project, the local requirements related to water allocation between crop irrigation and micro-hydro supply was accommodated by making a written agreement to allocate at least 300 litre/second to irrigate approximately 50 hectares of fields, prior to water being channelled to the turbine. The villagers were actively involved in the project design and implementation, including in the election of the cooperative board members and micro-hydro operators, and the use of revenue generated from the electricity sales to the grid for the village development (scholarship for the poor, infant vaccination, seed capital for off-farm enterprises and clean water provision).

Figure 6 (right) shows a monthly payment session for the SHS at the PLD (Village Electricity Management) Pusu office attended by all SHS End Users and PLD board members. The PLD was initially formed during the E7 “Renewable Energy Supply System (RESS)” rural electrification project that was completed in 2000 in Maluku, South Sulawesi and NTT (E7 2001). PLD members comprise of SHS users, and the officials (head, secretary/treasurer, and technician) were also elected from among the End Users. The formation of the PLD was facilitated by Womintra NGO whereby the Field Officer lived in the target village for a couple of months. The rule of the scheme, meeting schedules etc, were defined and agreed in the PLD meeting attended by all members and officials. The high payment rate at this PLD, above 95%, reflects not only user’s satisfaction with the energy service they obtained, but also the transparency, accountability and their significance as community members because they have their say about their role and have a perception of living in a democratic environment.

In those two RE project examples, the active involvement of the local communities in the project design and implementation proved to maintain RE project accessibility (financially, technologically and institutionally), availability (RE service continuity with the availability of trained local technician) and acceptability (RE is accepted by local communities and embodies a tool for SRD by improving local communities well being).

Apart from the examples mentioned above, the I3A framework has been tested specifically against three PVES case studies drawn from field research in three Indonesian provinces, as well as other PVES projects that failed. For detailed discussion on the three PVES case studies assessment using the I3A framework, see companion paper submitted to this conference (Retnanestri et al 2008) and Retnanestri (2007).

Under the ADRA EFCC011 project, the I3A Framework will be disseminated and tested further by investigating more RE case studies in Indonesia, and expanded further to include policy formulation, sustainable manufacturing of RE at local level, as well as RE waste recycling. Case studies from other RE technologies including micro-hydro, biomass, biogas and geothermal will be investigated. The outcome will be used to enhance understanding and skills among policy makers and practitioners to improve the access of rural communities in Indonesia and other countries to reliable, affordable and sustainable energy while enhancing community capacity and facilitating sustainable development.

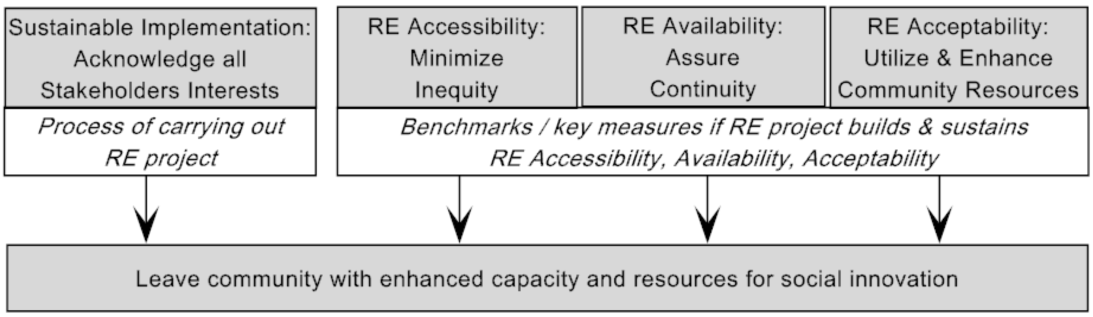

Fig.7: Use of the I3A framework as an analytical or design tool for a PVES project

The I3A model can be used both as an analytical and a design tool in which the Implementation (I) component will assess the implementation of the PVES project taking account of the stakeholders and their relationships (viewed as a social system, also referred to as PVES orgware). The 3A serve as sustainability benchmarks or key measures that assess the extent to which PVES accessibility, availability and acceptability are at least maintained and preferably enhanced over time to leave the community with capacity and resources to socially innovate to meet evolving needs beyond initial RE project completion. See Figure 7.

CURRENT PROGRESS AND FUTURE PLANS

2008 is the first year the ADRA EFCC011 project operation. Progress to date includes activities related to stakeholders engagement and the first PV workshop held in Jakarta in July 2008, involving policy makers, manufacturers, distributors, research agency and academics. Other activities proposed to be conducted in 2008 include a RE study tour (preliminary site visits), in which staff and students of an Indonesian university would visit various RE sites and manufacturing companies. Students would report on the outcome of the site visits in a seminar and participate in the establishment of a centre for RE studies.

The July 2008 workshop, focusing on PV, was carried out to identify issues related to current PV development in Indonesia. The second workshop, to be conducted in 2009, will look at experiences in RE more broadly, including biogas, micro-hydro, biomass and geothermal. The presentation in the workshop will be structured in such a way, based on the I3A framework, so that RE experiences are presented to highlight the challenges and opportunities in RE undertakings, looking at what went well, what went wrong and what needs to be done considering the institutional, financial, technological, social and ecological dimensions of RE implementation, for the purpose of further analysis.

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BRIEF BIOGRAPHY OF PRESENTER

Dr Maria Retnanestri completed her PhD degree at the School of Electrical Engineering & Telecommunications, the University of New South Wales (UNSW), Sydney, Australia, in November 2007. Currently Maria is a Research Associate at UNSW funded by the ADRA 2007 project EFCC011 to identify ways to overcome barriers to renewable energy for sustainable development in developing countries.