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Acceptance and suitability of renewable energy technologies in Lao PDR

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ACCRONYMS

AAEP	Asia Alternative Energy Programme
APE	Asia Pro Eco
CDEA	Community Development and Environment Association
EDL	Electricité du Lao
ESCOs	Electricity Service Company
GTZ	Deutsche Gesseltschaft für Technische Zussamenarbeit
IED	Innovation Energie Développement
IPP	Independent Power Producer
LECS3	Lao Economic Consumption Survey 3
LIRE	Lao Institute for Renewable Energy
MIH-WB	Ministry of Industry and Handicraft – World Bank
NUOL	National University of Laos
PV Solar	Photo Voltaic Solar
RE	Renewable energy
RESDALAO	Renewable energy for sustainable development association
TRI/STEA	Technology Research Institute/Science Technology Environment Agency

EXECUTIVE SUMMARY

Introduction

The government of Lao PDR has set a target of providing 90% of households in the country with electricity by the year 2020. Representing a substantial increase from the estimated 45% of households currently powered through the grid, the government hopes that the increase will stimulate development and contribute to its wider poverty eradication strategy. Hydro-power (HEP) currently contributes 98% of electricity production, with some 20% of this power designated for export quotas. Considering the considerable environmental and social impact of HEP and the cost domestic grid extension to the dispersed agrarian population (estimated at €191.87 million) renewable energy options are widely recognised as a necessary alterative for rural electrification.

The successful development and dissemination of RE technologies in Lao PDR is reliant on their suitability and subsequent acceptance by largely isolated rural communities in need of energy while maintaining a minimum level of income. National scale policy targets will only provide the necessary incentive to increase investment in RE if local drivers of adoption are understood, such as employment, income and the contribution to regional economies. Social acceptability is therefore defined by the willingness of producers and consumer to adopt and use RE technologies, and the ability of state and private institutions to create an enabling environment for effective extension and support, determining which technologies are most suitable for the country and also for the diverse set of social and environmental circumstances.

Based on the findings of the various studies completed under the Asia Pro Eco (APE) project, this paper reviews the social acceptability of PV Solar and biomass in the context of the Lao PDR. The analysis is guided by two key questions: What are the constraints and barriers to successful extension of RE to rural areas? What improvements can should be made to RE policy and extension services, meeting the needs of local social and environmental drivers for change?

Policy review

Electrification is seen as a key component of the government's poverty eradication policy by raising the standard of living of the predominantly rural population, stimulating investment and providing opportunities to enter national and regional markets. Attention has focused mainly on the provision of grid electrification, but recent institutional reorganisation has increased the profile of RE within the Department of Energy. The government has focused on the providing finance through the off-grid promotion fund and the poverty reduction fund, set up through the Prime Ministers office to finance small-scale investment and services that contribute to village development including energy.

Policy and legislation for independent power producers (IPP) has been developed for hydropower but this experience has not been transferred over to the extension of off-grid electricity. If IPP legislation is linked to the government's reforms of decentralizing responsibilities in the administration and management of electricity activities, then further investment in market-based incentives within the private sector may assist in the promotion of off-grid extension to rural areas.

A major step in the development of a broad-based forum for research and development of RE is the recent formation Lao Institute for Renewable Energy (LIRE), combining a range of private, state and civil society. LIRE intends to develop research and development capacity within the country for RE ensuring technologies are commercially viable and affordable. An opportunity also exists to link LIRE with the Asia-Pro Eco networks developed through the project. How the institute intends to establish itself, and what its exact position is *vis-à-vis* policy, research and extension, remains to be seen.

PV Solar

There are two competing models for the extension of PV solar in the country: the rent-to-buy programme through the Ministry of Industry and Handicraft (MIH) with funding from the World Bank (WB), and the rental service through the private energy utility Sunlabob rural electrification systems. The WB-MIH provides a rent-to-buy scheme while Sunlabob runs a rental scheme. Both models address the main constraints to extending off-grid electrification to a diffuse and isolated population, by working through decentralized networks of entrepreneurial electricity service companies (ESCOs).

The long-term viability of RE in Laos depends on the ongoing competition within the sector. The ongoing investment by the World Bank project provides further subsidies for equipment, giving a clear competitive advantage to their member ESCOs. The goal of rural electrification may be reached in the short-term, but without financing models which are competition neutral, the subsidies will be at the expense of the long-term viability of the RE sector.

Ensuring successful adoption of PV solar by rural households requires the provision of energy services to increase the productive capacity of households, enabling them to meet monthly instalments and contributing to income security. There is little empirical evidence for the actual suitability of current income opportunities from lighting – such as silk weaving, head lamps for fishing, basket weavings and rice milling. PV solar may meet consumptive needs of households, but without further empirical understanding of how this energy contributes to household income there is no less reason to think that poverty alleviation will necessarily follow.

Biomass

Biomass energy appears to have enormous potential in Laos based on the availability of agricultural and forestry residues totalling some 18907 MWh or 1922 million l/ diesel fuel per year. However, to determine the actual potential of biomass in off-grid rural areas it is necessary to consider both the availability and accessibility of these residues to farming communities, especially as both agricultural and forestry resources are already under the increasing strain of food and income security. The acceptance of energy farming needs to be seen in the context of where production occurs relative to markets and support services, and the willingness of farmers to turn food crops over to energy production.

Shifting farmers to produce non-food crops for energy production from anaerobic digestion requires a considerable shift from the food production focus of farming communities, as well as challenging the food security, agricultural production policy of the government. Farmers currently have little experience with non-food crops, and even less with food crops that are used for non-food uses. The only example of a commercial non-food use of rice is for Beer Lao which farmers from around the country are contracted to produce Mallee rice in both wet and dry seasons. Careful consideration also needs to be given to the assumptions of organic fertilizer as a by product of biomass digestion. Although organic fertilizer and production shows potential in Lao PDR, a major shift is needed away from the use of chemical fertilizer for small-scale farming practices, and further attention is needed to promote organic farming as a niche sector in domestic and export markets.

Alternative RE technologies
In the case of the study bamboo gasification and Jatropha-based biodiesel careful consideration is needed as to what factors contribute to successful adoption by rural communities. Many communities have experience in cultivating bamboo stands on customary and degraded forest lands with the support of government policy and legislation. Nevertheless, given the somewhat controversial history of forestry in Lao, concern must be given to ensuring that acquisition of timber and waste does not place any further pressure on already highly contested resources. *Jatropha curcas* is abundant in Laos, growing in degraded forest area, and infesting some agricultural lands. Like the extension services for PV solar and biomass, the effectiveness of private investment needs to be matched with a good understanding of existing farming systems and the willingness of farmers to adopt new non-food crops that support rural livelihoods while also contributing to RE development.

Extension services
Electricity provision alone will not provide additional income for rural communities nor raise their standard of living. Promoting RE as an acceptable and suitable technologies for both on and off-grid areas is education, information provision, financing and maintenance services, requires effective extension models. Improved extension systems could emerge from sharing the experiences of private and public sectors: including ESCOs, franchises, government extension and contract farming. Biomass and energy farming in particular need to look at other extension experiences when including complex combinations of technical and farming extension, including multiple sectors such as energy, agriculture and forestry. Two key features need to be incorporated in extension services: 1. fostering responsible management and sustainable production of biomass while ensuring control and use of these resources do not compromise the rural livelihoods; 2. ensure that competition within market-based extension models continue to include remote and isolated parts of the country. As it is unlikely any one RE technology will provide a sustainable source of energy in either off or on-grid areas it is necessary to develop hybrid systems across micro (village) grids, based on a mosaic of energy supply and also a mosaic of energy extension and support.

Conclusions
The suitability and acceptance of PV solar and energy farming are dependent on a wide range of factors, including the cross-sector policy support, the development of adequate extension services and the willingness of farmers to incorporate these systems into their current income generating and livelihoods strategies. In order for PV solar to be a sustainable option at the institutional level it is necessary to ensure that clearer policy support is given to ensure that competition is maintained between public and private sector. The potential of biomass is predicated on either the transition of farmers to the production of non-food crops or the use of forest resources. In a country that continues to struggle with food security and sustainable management of forest resources, the introduction of RE technologies that place further pressure on these production systems needs to be introduced with caution. Further context-based empirical research in different parts of the country on the local drivers for RE adoption and education is needed to ensure that decision makers are able to make balanced decisions on RE for both off-grid electrification and improved on-grid energy efficiency.

INTRODUCTION

To meet the national goal of poverty eradication the government has the ambitious target of providing 90% electrification by 2020 (GoL 2001). Given the enormous variation of environments throughout the country, the high cost of extending the grid to the dispersed and isolated population, and the considerable environmental and social impact of HEP projects, it is widely recognised that the development of renewable energy technologies is required.[1] Based on the findings of the Asia Pro Eco (APE) project this paper reviews the social acceptability of PV Solar and biomass in the context of the Lao PDR. In a non-industrialised country, where local technology innovation is limited and the majority of technologies come from international markets, the successful adoption of technologies depends on its appropriateness to the livelihoods of consumers and producers. Social acceptability is therefore defined by the willingness of producers and consumer to adopt and use renewable energy (RE) technologies and the ability of state and private institutions to create an enabling environment for effective extension and support, determining which technologies are most suitable for the country and also for the diverse set of social and environmental circumstances. This report is guided by two key questions: What are the constraints and barriers to successful extension of RE to rural areas? What improvements can should be made to RE policy and extension services, meeting the needs of local social and environmental drivers for change?

The following section outlines what driving forces are relevant for the successful adoption of RE in developing countries. Section three then provides a short background to diversity of social, cultural and environmental contexts in the country, highlighting the demand of renewable energy and the difficulties the government has in meeting its targets. Section four and five then outline the specific details of PV Solar and biomass with respect to the suitability of both technologies for rural and urban areas of Lao PDR. Section six then identifies other RE technologies emerging in Lao PDR, highlighting opportunities and threats to their further development. Section seven then discusses potential and existing extension systems relevant for RE in Laos. Finally, conclusions and recommendations are made towards improved selection and targeting of technologies and users.

RENEWABLE ENERGY IN DEVELOPING COUNTRIES

It is often assumed that RE provides social as well as environmental benefits, yet there are few substantive studies verifying these benefits or identifying key drivers of successful adoption. The stated social benefits of RE commonly include employment and income generation, either directly, from feeding into the grid, or indirectly through increasing energy efficiency. While increasing energy security and independence is increasingly prominent in national policy throughout the world - coupled with environmental and health benefits from the reduction of carbon emissions – the adoption of RE technologies are more likely to depend on local drivers such as increased employment, income and improved regional economies (Domac et al. 2005). In developing countries, such as Lao

[1] Lao PDR has an estimated HEP potential of 18000 MW of which only 623 MW or 1.15146 GWh/yr has been developed, but plans are underway to develop more of the 86 memorandum of understandings signed over potential dam sites (GoL 2001). The earning potential of hydro-power for the national economy is indeed considerable, with approximately 20% of the electricity produced for export in partnership with foreign investors (see Appendix). Despite this energy generating capacity only 45% of the country’s households are powered through the grid consuming 140 kWh per capita/y.

PDR, the successful development and dissemination of RE technologies depends on their suitability to isolated rural communities: providing energy, while maintaining a minimum level of income.

The fall in the price of PV solar the main focus of national development agencies and international development organisations in both Asia and Africa, where it has been used to power communications, vaccine refrigeration, solar home systems and solar battery charging. Despite debate over both the extent and success of these systems (Green 2004), there has been ongoing investment by donor agencies who see solar as one of the appropriate RE technologies for the developing world. It appears PV solar is an important technology in developing countries, but does not represent a fix for meeting the modern energy needs of off-grid rural communities. Instead it is often used as a stop-gap until the grid can be extended rather than a long-term energy technology (Karekezi 2002; Green 2004). More empirical evidence is needed to assess just how successful these systems are in increasing income and improving the livelihoods of rural communities, while also providing a long-term RE alternative.

The potential of biomass energy has been recognised now for some decades (Bhatia 1985), yet little research has been done on assessing the difference between potential and actual benefits. Analysis is needed to determine how biomass fits into existing production systems and how it can compliment existing livelihood patterns and energy production systems. In doing so, a more holistic approach is needed where, as Hall et al. (1992) argue, "Biomass energy should not be considered as an 'energy source' but also as a reflection of the way in which many traditional (and some modern) societies produce, distribute and consume various biomass resources including energy" (p.63). Investigating sectors otherwise excluded from energy debates - such as the use and access to land-use, forestry, agriculture, and livestock rearing – is a starting point for research and also for future extension and development.

Recent exploratory studies into biomass across the globe have reported on the energy potential from forest, agriculture and waste with little (if any) reflection on the social acceptance of these energy sources. For example, Parikka (2004), using FAO statistics on forest residues and agriculture, estimates that the total world biomass energy is 100 EJ/a, or around 30% of the total global energy consumption today (Table 1). Breaking her analysis into regions, she shows that there is considerable potential for utilising the remaining third of biomass, which exists in the 40-50% waste of timber milling. The current use of biomass differs substantially between regions, reflecting an uneven distribution and use of resources also relevant at sub-national levels.

While providing a general background to the potential for global and regional biomass as a source of RE, the global and regional figures provide a dangerous generalisation of highly complex patterns of use and access to these resources. The use of biomass differs significantly between countries and regions, including different socio-economic groups using similar forms of biomass for often drastically different purposes.[2] Looking to Asia, the over use of biomass provides one insight into the abundance and importance of biomass, reflecting 'production, distribution and consumption', but without further investigation on the specific social drivers of biomass use there is little chance of understanding its true potential as a sustainable source of renewable energy.

[2] For example, nearly 90% of fuel wood collected is produced and consumed in developing countries for cooking and heating while 79% of industrial round-wood production is from developed countries (FAO 2006).

Table 1 Biomass energy potentials and current use in different regions (EJ/a, EJ=10^{18})
(Source: Parikka 2004)

Biomass potential	**North Amer.**	**Latin Amer.**	**Asia**	**Africa**	**Europe**	**Middle east**	**Former USSR**	**World**
Woody biomass	12.8	5.9	7.7	5.4	4.0	0.4	5.4	41.6
Energy crops	4.1	12.1	1.1	13.9	2.6	0.0	3.6	37.4
Straw	2.2	1.7	9.9	0.9	1.6	0.2	0.7	17.2
Other	0.8	1.8	2.9	1.2	0.7	0.1	0.3	7.6
Potential sum (EJ/a)	19.9	21.5	21.4	21.4	8.9	0.7	10.0	103.8
Use (EJ/a)	3.1	2.6	23.2	8.3	2.0	0.0	0.5	39.7
Use/Potential (%)	16	12	108	39	22	7	5	38

Those that support biomass as a source of environmental and socio-economic development argue that increased local production leads to: improved health, environment and education; increased social cohesion and stability, by reinvigorating local economies and reducing rural-urban migration; regional development leading to reduced trade balance, and diversification of production; supply-side benefits of increased productivity, enhanced competitiveness and improved infrastructure; and finally, demand side benefits including increased employment, income and the development of support industries (Domac et al. 2005). While success varies according to the nature of the technologies implemented, local economic structures, social profiles and production processes, it is maintained that there is a clear link between biomass production and employment generation. For example, Domac et al. (2005) provide the first attempt to investigate the social conditions of biomass production, yet they lack a clear description of what 'social profiles' they are referring to. While employment may increase in developed countries, where regional agricultural economies show great potential for reinvigoration from biomass production, there is little evidence that the same is true for developing countries. Indeed the statement made by Domac et al., that organised biomass systems will increase work hours otherwise spent collecting wood fuel, needs to be empirically assessed in the nature of employment, agriculture and work efficiency in rural areas of developing countries.

In addition, claims that the current unsustainable nature of agricultural production systems can be turned around with more modern systems of practice, while also mobilizing larger employment, creating greater nature conservation opportunities (Domac et al. 2005), and reducing such phenomena as desertification, all need to be clearly justified. While there is some indication that planting crops of degraded forest land has led to renewal of land and increased production, these must be done with the close consideration of local tenure arrangements and with suitable crops (e.g. Hall et al. 1992). The lessons learnt from plantation forestry and palm oil production can help flag a series of potential threats to sustainable management of land and forest resources that are closely related to social drivers of income, employment, access and control.[3]

[3] Examples include, social impacts of external control over palm oil plantations (Koczberski and Curry 2004), conflict over land tenure and ownership of forest resources (e.g. Peluso 1992) and state control of local access and management arrangements (e.g. Hirsch 1990).

Broad statements of how RE can improve 'social cohesion', increase employment and income and have social and environmental benefits need to be grounded with empirical studies, especially in developing areas of Asia where biomass is already exploited at high levels. This paper is a first attempt to understand how the 'social profile' of RE adoption in the Lao PDR, providing insights into existing barriers, constraints and future directions for the development of PV solar and biomass in poor rural areas.

SOCIAL CONDITIONS OF DEVELOPMENT IN LAO PDR

To understand the suitability and acceptance of RE in Lao PDR it is necessary to understand the wider socio-economic conditions of the country's predominantly rural population. Across the country there is a strong reliance on both subsistence and semi-subsistence forms of agriculture with few income generating opportunities to poor market and transport infrastructure (see ADB et al. 2001; see UNDP 2001). The main income sources for rural households are highly seasonal through the sale of livestock and rice. Depending on the location of the village there are also a range of other income opportunities including fisheries, handicrafts, small-scale trade and seasonal work such as labouring.

Following further economic reforms towards a market economy the country has experienced growth in mainly urban areas in recent years. Average monthly household income from agricultural production is €585, yet there is a considerable divide between urban and rural areas, with rural areas consuming an estimated €87 per household per annum - half as much as the level in Vientiane (NSC 2004). The differences in food consumption is also telling, with urban areas contributing 45% of monthly consumption to compared to less than 5% in rural areas (NSC 2004).

Electricity consumption doubled between 1997 and 2003 reaching 901,76 GWh in 2004 (EDL 2004). In that time household energy consumption increased 108% at an average rate of 13% per annum, as compared to 15% per annum for industry and agriculture. The average monthly energy expenditure throughout the country is about 4-15% of household income (NSC 2004), spent on a range of energy sources for lighting such as kerosene and diesel lamps, and automobile batteries charged by small diesel generator. In more affluent areas, including Vientiane, electricity consumption has increased to power a range of lighting, cooling and entertainment appliances (Nanthavong 2006). Overall fuel wood remains the main source of energy production comprising around 60% of total energy consumption, with fuel oil making up a further 20-40% (Figure 2).[4] Nevertheless, there is considerable variation in the use of these technologies throughout the country, with mini and pico hydro power used mainly in the North and diesel-battery charging systems used in the South of the country (PROACT 2001).

There are significant challenges to meeting the government's goal of 90% electrification by 2020. The cost of extending the domestic grid is estimated at €191.87 million (US$242.87 million) (RESDALAO 2006). If communities wish to be connected they are required to contribute up to half of the cost of electricity poles as well as the cost of connecting individual households – including meter box and fuse. With about 80% of un-electrified villages having less then 100 households (PROACT 2001) the cost is both too much for the communities and the provincial authorities. The national electricity authority, Electricity du Lao (EDL), recognises that many consumers will need special funding because of the low tariffs for most consumers which will require continued support via the rural

[4] The proportion of fuel oil consumption dropped significantly after the 1997 Asian economic crisis. Since that time consumption of fuel oil has not recovered relative to other fuel sources.

electrification fund and international support to the sector, already totalling an estimated €19.8 million a year.

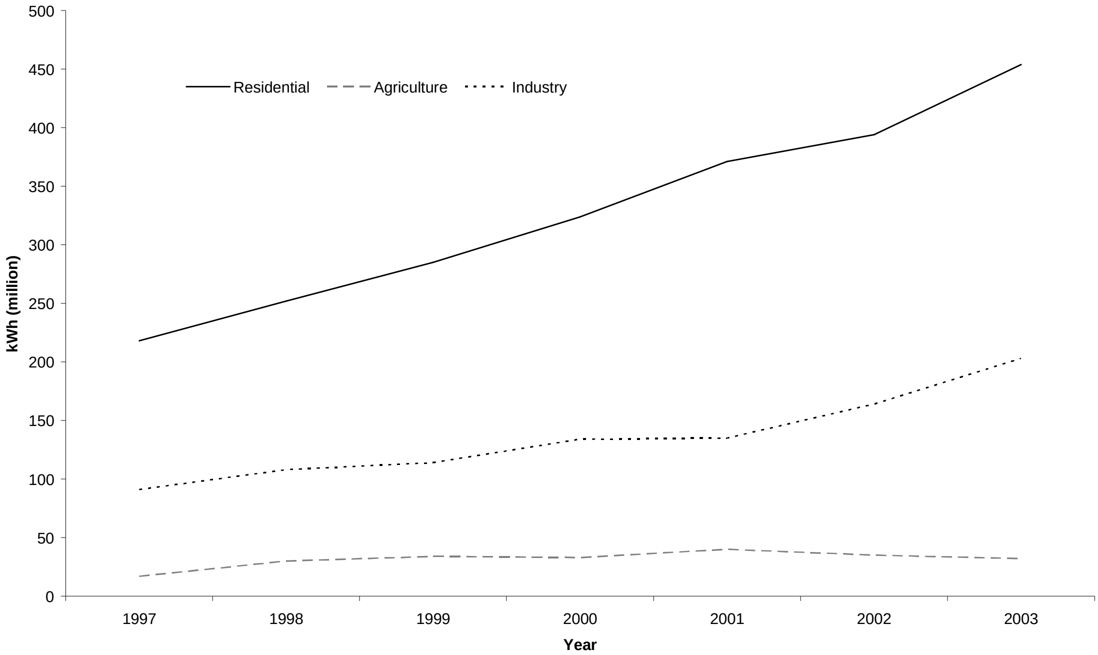

Figure 1. Electricity consumption, 1997-2003.
(Based on: EDL/MIH 2003, cited in Nanthavong 2006)

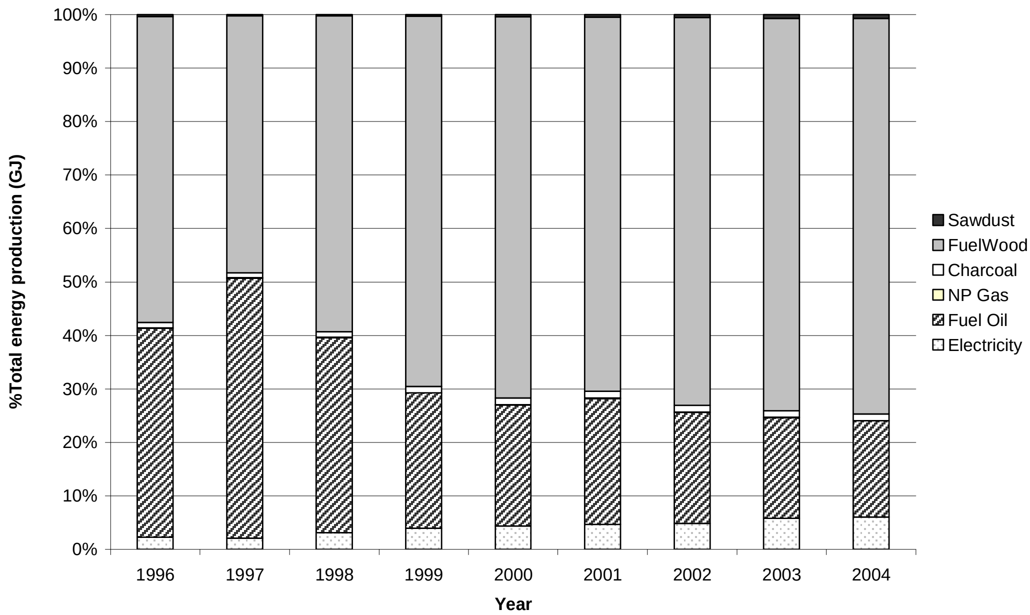

Figure 2. Proportion of domestic and export energy use (GJ)

POLICY AND LEGISLATION

The government's electrification programme is aligned with increasing social development of the largely rural population as well as increasing economic development by attracting industries and investment. The overall goal of the government is set out in the poverty eradication policy to 2020 (GoL 2000), of which electrification is seen as a key component; raising the standard of living of the predominantly rural population, creating opportunities to enter a national and regional markets, and attracting foreign investment.

The electrification programme aims to provide affordable, reliable and sustainable energy supplies to urban, rural and remote areas of the country, through both the extension of the grid and development of a range of 'electricity systems' in off-grid areas including small-scale hydropower, solar energy, wind power. Most of these technologies are aimed at the provision of energy for rural areas. To promote connection of the grid the Electricity Law (DoE 1997) defines different tariffs for rural and urban areas, reflecting the difference in socio-economic conditions across the country.

Faced with the task of increasing electrification in off-grid areas the government has focused on the development of different funding mechanisms. An Off-grid promotion fund, set up through the Prime Ministers office, is financed by both state and foreign sources. The government has also set up a poverty reduction fund to finance small-scale investment and services that contribute to village development. Communities wishing to electrify have access to grants, loans, and contributions with priority going to those villages with a high rate of poverty. A requirement of the fund for rural electrification is that the application is approved by the district and should include the participation of eligible businesses or service providers. As widely recognised in the stakeholder meetings held by this project, there is a considerable lack of education and expertise in the design of such projects and, as such, access to these funds has been limited.

Technologies through the off-grid extension office have been somewhat experimental, such as the Japanese funded Houay Xe Hybrid Power Station in Oudomxay Province, with most attention given to PV solar through the World Bank Off-grid Electrification project. While there is considerable experience in working with the private sector in the development of large-scale hydropower this has not been carried over to the development and extension of off-grid electricity. With the assistance of the World Bank rural electrification programme the government has also developed a network of electricity service companies (ESCOs) at the provincial level to assist in the extension of the grid. To date these have mainly focused on the extension of PV solar, facing numerous challenges including non payment and poor technical support (see below).

The reform of legislation to promote independent power producers has been mainly through large-scale hydro-power to Thailand. The considerable impacts of large projects and the protracted assessment periods mean that alternative small-scale power sources have considerable potential, especially if these are developed by local communities or local ESCOs. If independent power producer (IPP) legislation is linked to the government's reforms of decentralizing responsibilities in the administration and management of electricity activities, then it may assist in the promotion of off-grid extension through market-based incentives. Despite recommendations from years of experience from the WB in SE Asia there seems to be little integration of rural electrification policy with solar-home-system delivery (Martinot and Cabraal 2000). Furthermore, there appears to be little attention given to the how these alternative development models will ensure IPP contracts and ESCOs will promote better socioeconomic conditions within rural communities by providing income opportunities to rural communities.

The promotion of biomass for energy requires cross-sectoral policy development. The review of the agricultural legislation shows few barriers to biomass energy production. Food security remains a central objective of government policy, stating that conversion to agricultural land must not jeopardise food production. However, adequate provision is made in the law to diversify into non-food crops for national economic development.

The government is currently undergoing a series of legislative reforms that will see considerable changes to the structure of the power sector. Part of these reforms is the improvement of research, legislation and funding for renewable energy. While details of the reforms are not yet available it is expected that more favourable conditions for both domestic and foreign investment will be developed. The government also plans to elaborate on clearer guidelines for what can be termed 'socially and environmentally responsible management' (Department of Electricity 1997), although it remains unclear what these will be. The current institutional arrangements of the government support the ongoing development of the energy sector and provision is made to promote investment, technical support, environmental protection, and policy. Furthermore, it is noted that the government's aim of promoting greater commercial viability of EDL may be further strengthened through renewable energy technologies.

Providing economic incentives for RE production, especially for technologies that are in need of dissemination, can be promoted through policy and institutional changes, including subsidies and tax incentives (Hall et al. 1992). RE technologies such as biomass, that involve landuse, agricultural production and natural resource use require long-term funding, the alignment of sectoral policy, and new forms of technical support before considering further economic incentives.

A major step in the development of a broad-based forum for research and development of RE is the recent formation Lao Institute for Renewable Energy (LIRE), combining a range of private, state and civil society groups such as the National University of Laos (NUOL), The Renewable Energy for Sustainable Development Association (RESDALAO), Sunlabob and the Xao Ban Group (see www.lao-ire.org). LIRE intends to develop research and development capacity within the country for RE with a tentative mission to "explore, develop and sustain efforts for making Laos develop its own energy sector with own renewable sources of energy – with energy prices that are commercially viable and affordable to most of the Lao people." (Sunlabop 2006). Importantly, the organisation, having drawn in rural development minded groups, maintains the importance of the RE sector for "poverty alleviation, good governance and nature conservation" (ibid.). How the institute intends to do this, and what its exact position is *vis-à-vis* policy, research and extension remains to be seen.

PV SOLAR

First introduced into the country in the 1980s for telecommunications, PV solar is now a major component of the off-grid electrification programme and the most widely recognised RE technology – with 48% of surveyed business enterprises and 63% of households indicating they knew about PV solar. PV solar's current market growth of 30% per year is largely driven by government incentives resulting in significant cost reductions (Nanthavong 2005). While PV solar has the distinct advantage of being widely known and accepted RE technology in rural Lao communities, there remain considerable concerns over its long term use as a solution for rural electrification.

Extension models

Following the government's IPP policy there are two competing models for the extension of PV solar in the country: the pilot programme conducted through the Ministry of Industry and Handicraft (MIH) with funding from the World Bank (WB), and Sunlabob rural electrification systems, a private energy utility. From 1999 to 2004 the Ministry of Handicraft has managed a World Bank soft loan to finance solar home systems using a rent-to-buy model. As part of a wider Asia Alternative Energy Programme (AAEP) the World Bank has for a long time sought to overcome three hurdles to successful implementation of PV Solar in off-grid areas: 1. High capital cost associated with equipment; 2. high transaction costs due to limited supply, sales outlets and technicians and; 3. market distortions such as duties and tariffs that increase the price for PV solar (Cabraal et al. 1998). In response, the extension model enrolls Energy Service Companies that buy, install and maintain systems in close proximity to consumers, create revolving funds that can be used to finance leasing and hire purchase arrangements and help local banks create short-term financing arrangements for home systems (Martinot et al. 2001).

In Lao PDR the World Bank model enables households to purchase systems on credit with a repayment period of between 5-10 years. A key feature of the system is service provision by a network of ESCOs who in turn support village trained technicians who collect the monthly re-payments. Households benefit from the rent-to-buy scheme because of the affordable price, with an in-built hardware subsidy of 50%, as compared to outright purchase of the home systems. The World Bank notes that solar panels become an important economic asset to poor families, since it retains high re-sale value and it is assumed that the significant private investment made by the household forces them to increase their income at the end of the hire-purchase period - with the added benefit of motivating them to keep the equipment in good working condition (Harvey 2004).

Sunlabob started a rental service for PV home systems as an alternative to the MIH off-grid electrification programme. Households do not pay any initial installation costs, only paying for the electricity they use while the systems remain property of the company. Sunlabob also maintain the systems through a network of franchised service providers, much like the MIH system of ESCOs. A main advantage of the system is that the service providers are well trained with the incentive of ensuring long term use of the home systems. For households there is the added bonus of up or downgrading the systems to meet their consumption needs without any further charges on equipment.

Despite the promise of better management and planning by ESCOs, franchises and households alike, both systems face high default rates on repayment and farmers face difficulties in using the PV solar systems to invest in productive assets. The monthly repayments of the MIH-WB system is three times cheaper than the Sunlabob system (€3.20-3.55) - because of the 5-50% subsidy[5] - and boasts up to 95% on-time repayment of loans (Harvey 2004). The higher price of the Sunlabob system has limited its potential with only 10% of the current target off-grid population able to afford the PV system. If compared to battery systems Sunlabob is roughly twice as expensive, limiting adoption of the PV system to wealthier households. On the other hand, the Sunlabob rental system is more flexible allowing for payments to correspond with the seasonal rice harvest. The MIH-WB system is also constrained by the long waiting time for extension, dependent on

[5] The subsidy is calculated on a sliding scale based on the size of the Solar Home System ranging from 50% for 10 W systems to 5% for 50W systems.

the willingness of ESCOs to join the programme, the participative training with village electricity of committees and training of village technicians which can take from one to two years. In comparison Sunlabob provides quick installation through their franchises, not relying on the long service chain and reaction time between technicians, service providers and the MIH. With failure rates of the PV systems as high as 20% the efficiency of maintenance and service for these systems is an important determinant of the future adoption and the success of off-grid electrification programmes.

Maintaining competition

The long-term viability of RE in Laos depends on the ongoing competition within the sector. Public-private investment in development has become an increasingly important focus of the World Bank through their Development Marketplace award scheme, which Sunlabob received in 2005 in partnership with World Wide Fund for Nature Lao. Following the success of the first phase of the MIH-WB rural electrification project, the Bank subsequently put out a tender to manage the second phase which was won by the French company Innovation Energie Développement (IED). In this new phase, which runs until 2009, IED must maintain the existing network of ESCOs and the current 6000 installed units, while meeting the target of installing 10000 additional units. Although running in parallel to private sector, including Sunlabob, IDE will be working with a World Bank funded supply-side subsidy of up to 85% on PV solar equipment. While reducing the cost of equipment these subsidies also distort competition in the sector, leaving operators outside the MIH-WB scheme with little incentive and almost impossible market prices.
Stakeholders in the RE sector argue that the challenge for both the private and public sector alike is to find financing models that are competition neutral. Instead of reducing costs for one competitor, in this case ESCOs within the MIH system, public funds could go to capacity building and demand-side subsidies so they can afford services they require at commercially viable prices – which would support the Sunlabob model endorsed by the World Bank through their Development Marketplace. If the MIH-WB systems persists with their public-private investment model, giving a clear competitive advantage to their member ESCOs, the goals of rural electrification may be reached, but seemingly at the expense of the long-term viability of the RE sector.

Income generation and energy efficiency

An important driver for PV solar extension within the funding models is that PV solar will increase the productive capacity of households in off-grid rural areas, therefore enabling them to pay their monthly instalments in addition to contributing to their overall income security. The MIH-WB project promotes solar energy as a means of providing productive opportunities to households investing in a solar home system. Activities include weaving traditional *sinh* or silk weavings, charging batteries for head lamps used in night time fishing activities, basket weavings for tourists and extended hours for rice milling (Harvey 2004). While all these examples are taken from responses from households that have already adopted home systems further analysis is necessary to see how widespread this adoption is beyond individuals, and somewhat anecdotal evidence.
Sunlabob argues that rural communities can utilise PV solar for productive purposes if they choose activities that “leverage the advantages of rural production” and don’t compete directly with grid powered activities (Sunlabop 2003). By leverage they mean the increased in income above what would normally earn from existing rural activities if electricity was not available. Like the World Bank Sunlabob suggests that lighting in the

evening allows for more time during daylight hours for existing activities. Extending the day with lighting therefore increases the potential earning of the household through more efficient use of time. Sunlabob also argues that direct income is also through the local village economy by powering karaoke, TV, and small refrigeration or on the open market economy through handicrafts, solar pumps for growing vegetables, lighting tourist lodges, food processing, with the higher cost of energy being off-set by the lower cost of labour.

Although not investigated systematically evidence from the APE project suggests that different systems are not capable of providing adequate income generation. Most of the appliances used are for entertainment purposes – including television, household lighting and radio (Table 2). While these may increase the consumption of those households there is less reason to think that income generation, pay for both the monthly instalments and increase overall income security will necessarily follow. The problem is more of a limitation of the technology itself, rather than its poor application by either MIH-WB or Sunlabob. Both organisations have information on the income and expenses of their target population and have set their tariffs to meet the largely poor, rural consumer base.

If there is no direct return on investment to households in off-grid rural areas then collective financing arrangements may be more appropriate. Sunlabob has extensive experience with specialised PV solar systems for powering remote area vaccine fridges and powering bore water pumps, financed either by development projects, or collectively by communities. The more productive applications of PV systems on a collective basis may in fact be a more effective means of promoting PV Solar as a productive form of RE rather than at the household level, where the investment capacity and therefore size of PV solar installations are limited.

Table 2. Cost and potential usage of available solar systems
(Source: Sunlabob)

Solar system and unit	Retail price (€)	Examples of appliance use	Hours/day
10 W home system	131	2 x 5W lamps	2
		1 x 5W lamp	4
20 W home system	179	3 x 5W lamps	3
		2 x 5W lamps + radio-tape	2+2
30 W home system	234	3 x 5W lamps	3
		2 x 5W lamps + radio/tape	2+3
40 W home system	300	3x5W lamps + radio/tape	3+2
		35W TV (B/W 14") + 1x5W lamp	2+2
50 W home system	351	Lamps 4x5W + Radio/Tape	3+3
		35W TV (B/W 14")	3
		55W TV (colour 14"DC)	2
75 W home system	448	Lamps 4x4W + radio/Tape	4+4
		35W TV (B/W 14")	4
		55W TV (colour 14"DC)	3
100 W home system	704	4 x 5 W lamps + radio/tape + TV B/W 2	4+4+2
		55W TV (colour 14" DC)	4
150 W home system	986	1 x14" TV (colour 14" DC) + 15W VCD	4
Vaccine refrigerator	2172	Fridge + 4 x 5W	24+3
Water pump system	1474	2400 L/ day; total head 20 m	

Notes: B/W – Black and White

For on-grid urban areas the willingness of people to invest in RE is also based on energy efficiency. The survey of enterprises in urban areas conducted found that 62% of respondents responded that they would invest between €15-80 for their current energy usage to be reduced while a further 28% said they would invest up to €3950 (Nanthavong 2006). For large companies the willingness to invest in RE is understandable with an average annual expense on electricity of €19872. However, for small and medium enterprises such an investment is considerable, with average annual expenses for electricity at €330 and €2477 respectively.

BIOMASS

On face value it appears that energy farming holds enormous potential in Laos, with an abundance of biomass available from agricultural residues and forestry residues. As shown in Table 3, the total equivalent energy of available biomass resources is 18907 MWh/yr, equivalent to 1922 million l/yr of diesel fuel. While this potential makes up a negligible proportion of the 2989397 GWh produced through hydropower it shows enormous potential for off-grid areas considering the 223 million litres of diesel fuel consumed in 2004 (see Table 4).

Agricultural residues are readily available to most rural households. It is estimated that rice husks total 1.7 tons/household/yr while livestock manure holds the pontential of producing 1.95 m^3/household/day. Although these residues are abundant, they are rarely redundant. For example, both rice husks and manure are used to fertilize rice fields and in fish ponds as feed. Little information exists on the specific uses of these resources in Lao PDR or in Asia, but within subsistence or semi subsistence economy it is a resource that is seldom wasted. Forestry residues, including firewood and processing residues, such as sawdust, off cuts, and woodchips, make up two thirds of the potential 18907MWh/yr of biomass energy. Most of this potential exists as waste, which can be used as captive energy to power larger timber mills and potentially feed in to the grid. However, due to the quantity of residues required it is unlikely that smaller mills would have the capacity to invest in a digester.

Like studies of global, regional biomass potential the projections for Laos provide general policy indicators but do not address the specific drivers of adoption by farmers under the highly varied conditions found through the country. To determine the suitability and acceptability for off-grid rural areas, it is necessary to consider both the availability and accessibility of agricultural and forestry residues to rural communities, both already under the strain of ensuring food security and income to the predominant agrarian and natural resource dependent population.

Table 3. Energy potential of some agricultural and forestry residues in Lao PDR
(Source: CDEA 2006)

Biomass source	Type of fuel/energy	Equivalent energy	Equivalent diesel fuel
		MWh/yr ('000)	Million Litres/yr
Rice husk	Combustion	2108	214
Rice straw	Biogas	1030	105
Livestock excrement	Biogas	3269	332
Forest residues	Combustion	12500	1271
Total		18907	1922

Table 4. Imports of petroleum products to Lao PDR in 2004
Source: Department of International Trade, Ministry of Industry and Commerce

Fuel	Million Litres	Million €
Gasoline premium	1,4	0,41
Gasoline regular	120,8	29,56
Diesel	222,9	56,55
Kerosene (jet fuel)	11,9	3,00
Cooking gas	4,9	0,81
Lubricants	3,47	2,59
Total	365,37	92,29

Changing agriculture production

The APE project survey conducted in Vientiane municipality provides an insight to the largest urban and peri-urban area the Lao PDR (CDEA 2006). As indicated above, the living conditions of the respondents in this area are higher than the rest of the country – with higher levels of consumption and more advanced production practices. It is also presumed that their closer proximity to the capital city means they have a greater access to education, information and support services. Importantly, the area was one of the first in the country to receive grid electricity - which strongly influences their motivation for adopting RE technologies.

Just under a quarter of the respondents in rural areas are interested in biomass as a source of RE. However, the low level of experience and knowledge about biomass means it is more expedient to look at the willingness of farmers to turn their existing farming crops over to energy production.

The amount of crops grown each season is based on household consumption, labour availability and market demand. Two thirds of the farmers in urban areas surveyed indicated they would be more willing to change the products they grow than farmers in peri-urban areas, reflecting the higher dependence on agriculture and the consequences of lost food and income should these crops fail. These peri-urban farmers are more risk adverse having a greater overall reliance on agricultural production for both subsistence and income (ADB et al. 2001). Nearly half of the farmers interviewed have had experience in changing between market garden crops, such as tobacco, fruits and vegetables in response to market demand in Vientiane and Thailand. Variation in rice crops is less common as it is an important staple that farmers appear less willing to change.

Shifting farmers to produce non-food crops for energy production from anaerobic digestion requires a considerable shift from the food production focus of farming communities, as well as challenging the food security, agricultural production policy of the government. Farmers currently have little experience with non-food crops, and even less with food crops that are used for alternative non food uses. Of the total respondents only 28% said they would consider growing crops not for nutrition. However, in urban areas two thirds of respondents said they would consider growing food crops for alternative uses while only 15% of farmers in peri-urban areas said they could consider such crops.

Possibly the only example of a commercial non-food use of rice in Laos is for the Beer Lao factory, which uses 30% of Malee variety (203) before adding imported malt from Germany. Farmers around the country, including Vientiane Municipality, are contracted by Beer Lao to produce and supply them with rice for the production. Farmers involved in the scheme receive seed on credit from the company which is repaid when the crop is harvested. The price is not guaranteed but historically the company has always paid higher than the market rate. Because of the large amounts required from the company farmers form collective groups, through which a team leader is responsible for reaching production targets set by the company. Failure to meet these targets does not result in any penalty from the company, except the repayment of the cost of the seed. The production groups are often formed around an irrigation system, to ensure collective agreement and use over dry season production. There is no competition with food security of the farmers as they only produce Mallee in less than half of their land holdings, and with an area of production in the dry season leaving the wet season for the production of the staple food crop of glutinous rice varieties.

Organic fertilizer

An additional benefit from anaerobic digestion is the production of organic fertilizer, which shows potential in Laos due to the high price of chemical fertilizer, small-scale farming practices and the promotion of organic farming as a niche sector in domestic and export markets (Dubbeldam 2006). Organic fertilizer is widely considered a key additional benefit from energy farming - providing farmers with a direct value added by-products and the willingness of farmers to use organic fertilizer is a direct indicator of the potential for energy farming and its by-products.

From the APE project survey on organic farming and fertilizer it was difficult to quantify the current use of chemical and organic fertilizer because of the lack of written records and difficulty farmers had in recalling their patterns of fertilizer use (CDEA 2006). Despite having large numbers of livestock in urban areas, it appears that peri-urban areas use more manure and compost to fertilizer both crops and vegetables. Nevertheless, chemical fertilizer appears to be more prevalent with another study finding an average of 203 kg used per household per year (Canada Project 2004). Farmers used chemical fertilizer predominantly on vegetables, finding it more effective in intensive irrigated systems, on crops with higher value. Contrary to what might be expected in semi-subsistence agricultural areas, the higher price of chemical fertilizer was not an important factor in farmer’s decisions over production, with only a few respondents recognising the lower price of manure and compost. One driver for chemical fertilizer use is the ease with which it is acquired and used compared to the organic equivalents. Farmers report that the convenience of chemical fertilizer outweighs its higher price. It will require a considerable change in attitude, brought about by education and extension, to determine whether farmers are willingness to switch to from their current use of chemical fertilizer to organic alternatives. The potential in other provinces in Laos, where incomes and access to higher value markets are lower, also need to be assessed to demonstrate the technical and economic feasibility of organic agriculture.

Biogas

Although not systematically investigated under the APE project, the difficulties with organic fertilizer promotion, and the potential difficulties of energy farming, are reflected in the promotion and development of biogas in Laos. Biogas was reportedly first introduced to Laos by the FAO in the early 1980s since which time it has been promoted by Dutch SNV and through Chinese development assistance. Despite the lengthy history, there are currently only 50 household systems in the country. The slow uptake of the technology has been linked to the lack of 'ownership' over the idea by Lao farmers and the lack of ongoing technical assistance given to households when plants break down (Pers. Comm. SNV). In addition, some people believe that the technology is unsuitability for communities with an abundance of fuel wood or for households that do not keep livestock under in close proximity to their houses.

Suitability of communities for biogas production reflects the suitability of production, distribution and consumption of the technology. For example, the target village of the Chinese pilot programme, Nong Phuvieng in Vientiane municipality, has specific characteristics suitable for biogas including its location and existing livestock activities.[6] Thirty households currently have digesters supplied through a Chinese government grant, at a cost of around US$500 per unit, aiming to reducing poverty and to use organic fertilizer for agriculture production. On the production side the community has a history of pig raising, with each family owning 3-5 animals, so there is only small adjustments to the existing production practices to channel the manure into the biogas system. Pigs have been a successful activity for the community because of the villages close proximity to traders and the major livestock market in Vientiane. Other attempts to introduce biogas with cattle have not given enough attention to this production side service, such as the TRI/STEA pilot biogas project that did not proceed because the biogas needs did not fit with the seasonal trade patterns of cattle from the village.[7] On the consumption side the adoption of biogas in Nong Phuvieng and more widely depends on competitions with existing energy sources. Biogas is accepted in Nong Phuvieng because it is a competitive alternative to charcoal and much cheaper than costs associated with electric lighting and natural gas cooking. However, in off-grid areas, where oil lighting and fuel wood cooking is prevalent, biogas must compete with relatively cheap and abundant energy sources. The technology also competes with PV solar in these circumstances which are often seen to provide more value for money in providing not only lighting but also entertainment and (potential) income opportunities. Biogas has also faced problems of service and

[6] Nong Phuvieng was visted by the APE project team on the 9/10/05. A community meeting with 59 participants was arranged to discuss wider aspects of energy consumption and after 5 households from the 30 currently with biogas plants were visited to discuss their experiences of using the technology.

[7] The TRI/STEA research centre was visited on the 7/10/05. Staff from the centre were interviewed regarding their current research activities and experiences in RE extension.

maintenance provision which could still prove problem for the Nong Phuvieng pilot project - currently supported through a government centralised chain of district, provincial, national and finally Chinese governance channels. Although little maintenance has yet been needed the success of such centralised channels is questionable and, given the experience of PV solar, may be more effectively decentralised to private sector ESCOs or franchisees.

Table 5 Estimates of energy consumption and production of selected industry cases in Vientiane

Company	Production	Energy requirements	Residue use/ waste treatment
Beer Lao	$1.2x10^9$ L/day	12 kWh/1000 L 6500 L/1000 L 3.5 oil/1000 L	Plans to process 15t/day solid waste, 30 ton/day sediment, 200kg/day paper waste in biogas digester to substitute for 30% oil consumption
1st May Lumber Mill	6000 t/day	unknown	Capacity for 90 t/month charcoal from sawdust – Thai demand is 300 t/month No use of 4900t/day off-cuts[a]
Vannis Pig Farm[b]	10000 pigs	44789 kWh/month 4.852 m^3/day	Approx. 10000 head - 10296.25 L /day manure 8 open ponds used for treatment of manure, 2 ponds used as fish ponds

[a] Calculated on a the conservative basis of 45% wastage from milling process (see Parikka 2004); [b] Information on Vannis Pig farm supplemented from Sisouvong et al. (2006)

While the extension of RE to households, both off and on-grid, show a range of difficulties and constraints in terms of production, distribution and consumption, the same cannot be said for industry in Laos. The forecasts for biomass production at both global, regional and nation scales focus on residues from forestry and industrial processing of agricultural produce. Industry in Laos also reflects a high level of residue availability that could be used as captive energy within these plants, with a view to developing them IPPs in the future. A rapid appraisal of some industry sectors in the APE project showed that the potential of wood residues, landfill, pig manure and industrial waste from the Beer Lao factory are all adequate to produce surplus supply of energy to feed into the grid Table 5). A major barrier to encouraging private investment in biomass energy is the subsidised price of electricity, currently at around 7c/KWh. The further expansion of biomass therefore requires political support to subsidise its development and adoption, in order to make it competitive with grid electricity. If biomass can be made competitive within the industrial sector before extending to rural areas, there may be more scope for successful adoption at the provincial and district levels.

ALTERNATIVE FORMS OF RENEWABLE ENERGY

The suitability and acceptance of PV solar and energy farming are dependent on a wide range of factors, including the cross-sector policy support, the development of adequate extension services and the willingness of farmers to incorporate these systems into their current income generating and livelihoods strategies. Although not the focus of the Asia Pro Eco project a range of alternatives to PV solar and energy farming were identified by stakeholders that could provide areas of further attention for donors, the government and Lao-IRE.

Bamboo

Sunlabob has identified bamboo gasification as a potential source of energy in the north of the country. Across Asia bamboo is an important resource used by rural communities for a range of handicrafts, building and food activities and protected within community forest and residential areas (e.g. Parikesit et al. 2001). However, in Northern Laos bamboo is said to be establishing itself in degraded forest areas where regeneration of hardwood species has been slow. The potential for using bamboo from these areas, where no existing pressure for use exists, could be a potential source of fuel for energy production as rural communities have experience in cultivation of bamboo stands and existing government policy and legislation supports activities improving degraded forest land. Bamboo cultivation may show promise as a community managed resource, providing an income opportunity that can be responsibly and equitably managed. Furthermore, given the somewhat controversial history of forestry in Lao, concern must be given to ensuring that acquisition of timber and waste does not place any further pressure on already highly contested and declining resource (see Hyakumura and Inoue 2006; Rigg 2006). Further research needs to be conducted to determine the specific arrangements for community access ensuring forestry policy equitably allocates access and control over these resources.

Jatropha

Jatropha curcas (Lao: *Mak Nyouw*) has been identified as a potentially useful source of biodiesel in Laos. The plant is abundant in Laos, growing in degraded forest area, and infesting some agricultural lands. Farmers currently are unable to use the plants and as such it remains a potential resource for the production of biodiesel. There is growing private sector involvement in developing Jatropha both the South and the North of the country. Sunlabob has shown interest in investing in the plant in partnership with the Association for Organic Products in Khammouane, as well as investing further in an existing plant in Xieng Khouang. It is reported that the Ko Lao company are also investing in a production plant in Vientiane as well as promoting farmers to grow Jatropha in rural areas. Like the extension services for PV solar and biomass, a good understanding of existing farming systems is required that takes into consideration the willingness of farmers to adopt new non-food crops, in order to ensure livelihood security while contributing to renewable energy production.

Wood gasification

The TRI/STEA research centre in Vientiane is working on a range of renewable energy technologies suitable for Laos. One of the most promising technologies is an improved wood gasification stove based on experiences from Africa, with improved fuel efficiency between 70-80%, and planned for commercial release in 2007. The strength of the stove is that it is made from local available, and often recycled, materials and utilises metal working skills widely available throughout the country. Unlike biogas, the stove makes better use of existing practices, replacing existing charcoal stoves. The downside to these stoves is that the stove still relies on forest resources and may not be considered renewable, instead coming under the heading of energy efficiency.

Integrated approaches

The potential for renewable energy in on and off-grid areas in Laos requires a highly integrated approach: no one technology can provide all energy needs of communities. Integrating electricity production in hybrid village grids with a standard voltage, allowing standard appliances to be used, remains an important objective of such an approach. PV solar can be combined with micro or pico-hydro generator sets, with a view to transferring to biodiesel, from Jatropha in the future.[8] Once in place these technologies can be offset to achieve greater overall energy efficiency and reduced the costs of storage and distribution of electricity to the community. The MIH has already had experience with such hybrid systems, such as the Japanese funded Houay Xe Hybrid Power Station in Oudomxay Province. Although showing potential such systems need to be specifically tailored to local conditions, they are extremely expensive to set up as they require technical, social and political support to ensure coordinated production and distribution of energy.

EXTENSION MODELS

Electricity provision alone will not provide additional income for rural communities nor raise their standard of living. There is a need to have a more extensive view over the provision of *energy services*, requiring additional support to catalyze income generating activities within rural communities requiring not one strategy but a variety of ‘fuel switching’ activities to ensure that rural communities have adequate energy (Green 2004). This means that extension models need to work together to develop an energy mosaic from various technologies in hybrid micro grids as discussed above.

Village-based participation

Promoting RE for both on and off-grid areas requires education, information provision, financing and maintenance services, requires effective extension models. To ensure greater social acceptance of RE technologies in rural Laos more investment needs to be made into village level institutions, such as the Women and Youth Unions, and various the development committees evident throughout the country.

The APE project found the majority of community members participate in various collective action groups at the village level (CDEA 2006). These contributions are in the form of money, with an average of € 7.83 per household/yr or up to 16 days per year. Only a very small proportion of members play an active role in the groups carrying out activities such as administration or providing technical support to other farmers. Participation within these groups is based around either a sense of civil responsibility in ‘community development’ or through civil obligation by being asked to join. A smaller proportion of respondents in both areas also saw joining these organisations as a means of accessing technical support. Interestingly, just under half of the respondents indicated they are willing to work with an RE development organisation in their communities, while further involvement would be significantly raised through better education about RE technologies. Any future extension activities should highlight the education of renewable energy technologies to allow informed decisions over whether to actively participate in such activities.

[8] Plans for such systems are already being considered by Sunlabob

Comparison of private sector extension models

Comparing the experiences of different extension and support systems for RE, from both private and public sector, provides insight into the possibilities for ensuring participation at the local level and possibilities for ensuring ongoing competition within the sector. A comparison of four extension services available in Laos are summarised in Table 6. This analysis of strengths and risks does not provide a definitive answer, but instead is designed to encourage further discussion over which mix of extension models are suitable for further development of PV Solar and energy farming.

The 'traditional' method of extension by the government is through setting up pilot or demonstration villages, based on a belief in rural Lao people's preference for more practical application or 'seeing and doing'. How successful these projects are outside the village is questionable given the institutionalised support from the government to these communities. As seen in the Chinese biogas project the efficiency of service provision, passing through the various levels of bureaucracy can be a potential limiting factor.

The ESCOs draw in the village level as a level of technical support, but have found that delays between ESCOs and low levels of training and capacity at the village level as hindered the successful adoption and maintain. Very remote off-grid areas may remain poorly serviced if ESCOs are unable or unwilling to travel long distances. Indeed, in some cases it may prove unprofitable to do so given the time and effort required. Although they rely on village technicians, there are potential delays in payment and in returning with spare or replacement parts. The systems and technology required for biomass, especially biomass, will require considerable start-up costs and ongoing training and maintenance. The profitability and sustainability of these technologies will occur over a long time period, the length of which may prohibit some investors from joining these networks. Like the ESCO system Sunlabob franchisees may find it difficult to travel to remote areas for maintenance and collection of tariffs. Also like ESCOs the poor profitability of making these trips may limit the extension of services to remote areas.

Biomass and energy farming include a complex combination of technical and farming extension. In off-grid areas, where access is limited and communities are dependent on semi-subsistence forms of production, considerable effort would be required to encourage the adoption and ongoing sustainability of energy production. The lessons leant from PV solar - to decentralize technical support to district or village level entrepreneurs - could prove useful, but it is unlikely these entrepreneurs will have the capacity to support production, distribution and consumption without the support from agriculture and forestry expertise. Furthermore, given the sensitive nature of forestry and the importance of agriculture, extension services need to foster sustainable production and use of biomass ensuring control and use of these resources do not compromise the rural livelihoods.

Contract farming of rice through the Beer Lao factory represents the only industrial level non food production of rice in the country and, as such, may provide useful insights into the difficulties and opportunities for biomass energy. While contracting provides benefits of systematizing agricultural production for energy needs it also holds some risk for farmers locked into production cycles. The experience of farmers supplying the Beer Lao factory appears to be positive: price agreements have always been honored, prices are higher than the food market value, and demand has continued to increase. Nevertheless, control over rice farming by actors outside the community could prove problematic if electricity demand fluctuates. Contract arrangements over 'non-food rice' could prove instructive for energy farming in Laos and further research over the risk and benefits of different farmer organization, and the support and protection that government legislation could provide should be further researched.

Table 6 Strengths and risks associated with extension models

Extension model	Strengths	Risk – Biomass	Risk – PV solar
Pilot village	▪ Encourages 'organic' extension through a working model	▪ Selection of village does not reflect conditions in different parts of the country ▪ Possible high cost of investment and maintenance not addressed	▪ High cost of investment and maintenance not addressed
ESCOs	▪ Decentralises maintenance to village level ▪ Encourages local private investment	▪ Increased external control over production by ESCOs ▪ Lack of technical capacity for complex system management ▪ High cost of micro grid requires external support	▪ Financial risk of failed equipment placed on community Long term sustainability not guaranteed ▪ High costs, long period of return
Franchises	▪ Affordable technologies for households ▪ Decentralised networked maintenance ▪ Encourages private investment	▪ High costs, long period of return ▪ Lack of technical capacity for complex system management	▪ Risk of failure on franchises ▪ High costs of service provision ▪ High costs, long period of return
Contracting	▪ Working private sector example through Beer Lao	▪ Indebtedness of farmers with failed crops ▪ High costs, long period of return ▪ Centralised control over agriculture	▪ Not applicable

Improved extension systems could emerge from sharing the experiences of private and public sectors. In determining the most suitable mix of extension models for both PV solar and energy farming the government must ensure that competition continues to develop in the sector while also ensuring that remote rural areas are also serviced. The lessons learnt from PV solar and contract farming provides insights for the development of biomass use, including multiple sectors: energy, agriculture and forestry. As it is unlikely any one RE technology will provide a sustainable source of energy in either off or on-grid areas, it is necessary to develop hybrid systems across micro (village) grids, based on a mosaic of energy supply and also a mosaic of energy extension and support.

CONCLUSIONS

The two renewable technologies reviewed in the APE project – PV solar and biomass - pose some interesting comparisons with respect to the social acceptance. PV solar is an established technology in Lao PDR with considerable effort having gone into its extension by both state and private sector actors. Nevertheless, problems remain. Despite the potential uses listed by the MIH-WB and Sunlabob it remains unclear as to the specific income generating activities that can be derived from PV solar. If these are not identified, or if extension services do not also offer different activities in parallel to the systems, then the long term viability of RE technologies, beyond a consumptive assets, also remains unclear. At the institutional level the long term viability of PV solar is under threat from public sector investment by the WB-MIH project. The current subsidies provided through the MIH-WB project has somewhat distorted competition between private sector competitors which may affect the choices that consumers have in the PV solar market in the future. To remedy this clearer state policy is needed to ensure that further subsidies promote rather than inhibit private sector investment in the sector by maintaining market competition.

The potential of biomass is predicated on either the transition of farmers to non-food crops or the use of forest resources. In a country that continues to struggle with food security and sustainable management of forest resources, the introduction of RE technologies that place further pressure on these production systems needs to be introduced with caution. This is not to say that biomass has no potential in Lao. At present 60% of energy comes from fuel wood and there is a large potential for timber residues in timber mills and agricultural residues in farming communities. However, in developing the technology investors need to be careful what the implications further pressure on agricultural and forest resources will have for mainly semi-subsistence based producers. To minimise the impact from these energy sources it is necessary to align policy within the energy agriculture and forestry sectors ensuring that development and extension also support the responsible and sustainable use of natural resources by asking what claims exist over agricultural and forest resources and who benefits from greater exploitation of these resources for energy production.

In addition to PV solar and biomass, there are a range of potential RE technologies that may contribute to the overall strategy for off-grid electrification and on-grid efficiency throughout the country such as Jatropha, bamboo gasification and wood stove gasification. Like PV solar and biomass little research has been done on the social acceptance of these RE technologies. Nevertheless, in combination these RE technologies may prove suitable if tailored to local conditions, meeting the income and livelihood needs of rural and urban populations. Like agricultural and forestry, biomass bamboo and improved woodstove technologies must be supported by policy which promotes suitable extension services and responsible use of these natural resources, ensuring compatibility with current resource access and tenure arrangements and local energy needs. Indeed, in a country with such diverse environments, income levels and market access as Lao, there is no one RE solution. Instead multiple technologies should be built into an energy mosaic of grid, micro grid and stand alone energy services that reflect the variety of income levels and environments. Supporting such a mosaic of energy supply requires integrated extension, service and support networks building on the experiences of existing ESCO, franchise networks and public systems across a range of energy, forestry and agricultural sectors. In this regard, further research should be carried out that in different parts of the country empirical studies should be carried out on what the specific are for successful adoption of RE in Laos. In doing so, policy needs to given greater credence to private sector competition and the development of alternative RE technologies, providing space for discussion and debate (such as through LIRE), ongoing financial support and improved multi-sector collaboration between agriculture, forestry and energy.

RECOMMENDATIONS

Policy and governance

- The promotion of PV solar requires high levels of investment over long periods of return. While support to the PV solar extension should be realistic in providing subsidies and incentives within the sector, support should not be given that removes competition within the sector.
- Building on the APE stakeholder dialogues, further support should be given to promote further discussion and deliberation over RE development, including private and public sector actors at local, provincial and national levels. The newly formed LIRE is one such platform that could be used for such dialogues. There is also a strong opportunity to develop such a platform through the network established through the APE network.
- Due to the cross-sectoral nature of biomass energy links should be made between different policy sectors, ensuring RE is combined with the concerns of agriculture extension and development, natural resources management and social welfare.
- Steps should be taken to ensure that legislation does not inhibit the use of agricultural and forest products for alternative activities such as energy production; however, due care should be given in ensuring that food security and responsible land and forest use is supported.
- Greater transparency in rules, laws and regulations as well as information on electrification is needed to support greater investment by local, national and international investors in the energy sector.

Extension and education

- Following the decentralised ESCO and franchisee network models, extension, servicing and maintenance should be developed locally, avoiding long repair and service chains, increasing local employment opportunities and ensuring quick response times. Furthermore, technical and educational support should be provided to promote the involvement of local investors in these networks.
- Attention should be given to developing education programmes for different RE technologies, focusing on electrification and income generating activities and energy efficiency.
- Small-scale financing arrangements should be set up to provide rural and remote villages with ready access to funds for household electrification. Building on the ESCO model, management of these funds, as well as extension and support, should be developed through organisations at the village level.
- Extension should focus on the provision of *energy services*, providing additional support to income generating activities within rural communities. These activities

may require an integrated strategy of 'fuel switching', or energy mosaic, to ensure multiple income activities can be developed in parallel.

Research and information needs

- The trade off between food security and biomass use needs further research and discussion, considering whether biomass should be used as an energy source in remote food insecure or forest dependent communities. In this respect the results from APE study in Vientiane should not be extrapolated across the country. Instead, local studies should be commissioned to examine the specific circumstances of communities in remote, rural, peri-urban and urban areas.
- Further research is needed to investigate the economics and potential conflicts within the forestry sector. Degraded lands and bamboo, what would the potential threats to forest land and claims over resources is energy sources were developed.
- Because of the variety of social and environmental conditions in Lao PDR further research should be completed throughout the country in a variety of different social and environmental conditions. These studies should include: detailed energy budgets in rural and urban areas to determine the efficiency of biomass form of energy *vis-à-vis* other forms of energy; consumption surveys outlining the consumptive and productive capacity of households.
- The ongoing integration of social and technical research should be further promoted, focusing on suitable extension methods, marketing strategies, integration into the rural economy and assessment of potential positive and negative impacts from RE development.
- Given the experiences of ESCOs and Sunlabob, and the emerging interest of other private companies such as Ko Lao, incentives should be given to include private sector in RE research and development activities, potentially under the newly formed LIRE.

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APPENDIX

Domestic energy consumption

Year	Electricity		Fuel Oil		NP Gas		Charcoal		Fuel Wood		Sawdust		Total
	GWh	GJ	1000xLitres	GJ	Tonne	GJ	Tonne	GJ	Tonne	GJ	Tonne	GJ	GJ
1996	467,1	1681560	716383	29228426	1662	74790	254107,7	762323	2253883	42823777	12955,97	259119,4	74829995
1997	535,51	1927836	1086930	44346744	2531	113895	260198,3	780594,9	2310239	43894548	12044,03	240880,6	91304498
1998	655,56	2360016	681578	27808382	1511	67995	266147,3	798441,9	2367979	44991596	11194,97	223899,4	76250330
1999	737,74	2655864	412087	16813150	101	4545	272521,3	817563,8	2427128	46115426	10408,81	208176,2	66614724
2000	799,78	2879208	365534	14913787	1294	58230	279178,5	837535,4	2475532	47035106	14308,18	286163,6	66010031
2001	892,83	3214188	395267	16126894	1294	58230	285552,4	856657,2	2525266	47980053	17672,96	353459,2	68589481
2002	967,54	3483144	365534	14913787	1294	58230	299433,4	898300,3	2743351	52123670	19528,3	390566	71867698
2003	1113,04	4006944	315758	12882926	2181	98145	268500	805500	2654400	50433600	24500	490000	68717115
2004	1138,24	4097664	300083	12243386	224	10080	285400	856200	2648300	50317700	25000	500000	68025030

Export energy production

Year	Electricity		Coal		
	GWh	GJ	Tonne	GJ	Total
1996	792,43	2852748	87807,83	2370811	5312159
1997	710,21	2556756	45781,19	1236092	3839339
1998	1694,45	6100020	55551,07	1499879	7657145
1999	2037,1	7333560	65926,52	1780016	9181540
2000	2961,59	10661724	214089,6	5780420	16659195
2001	2871,21	10336356	122931	3319136	13781294
2002	2798,34	10074024	214089,6	5780420	16071332
2003	2463,23	8867628	286663,8	7739923	16896678
2004	2543,22	9155592	317813	8580951	18056899

Conversion to energy are based on the following conversion figures: Electricity (3.6 MJ/GWh); Fuel Oil (40.8 MJ/l); NP Gas (45MJ/kg); Charcoal (30MJ/kg); Fuel Wood (3MJ/kg); Sawdust (20MJ/kg); Coal (27 MJ/kg)