2. BUSINESS MODELS FOR OFF-GRID ELECTRICITY

LESSONS FOR THERMAL ENERGY SERVICES

Sustainable Thermal Energy Service Partnerships

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STEPs
Sustainable Thermal Energy Service Partnerships

FOREWORD

Technical documentation has been produced on different technologies which could provide thermal energy services like efficient cookstoves, biodigesters or solar water heaters. But not much has been written of how public private partnerships could provide thermal energy services like heating, cooling, and cooking and what kind of business models could help to disseminate these products in a sustainable manner

Actually, international aid projects have focused on implementing efficient cookstoves, biodigesters or solar water heaters in an experimental way – as projects – as technological products - without taking into account the service they provide.

But here is a wealth of literature on business models for off-grid electrification with solar home systems and public-private partnerships which helps to deliver affordable energy services for the poorest.

This working paper examines what lessons can be drawn from the work done in the field of business models for off-grid electrification and how the experience accumulated last 20 years can be capitalised in the field of business models for thermal energy services.

- Xavier Lemaire & Daniel Kerr, 2017.

Acronyms

ESCO	Energy Service Company
IDCOL	Bangladesh Infrastructure Development Company Limited
LPG	Liquefied Petroleum Gas
MFI	Micro-Finance Institution
PV	Photovoltaic
REB	Rural Electrification Board of Bangladesh
SHS	Solar Home Systems
Wp	Watt Peak

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0. Introduction and scope

This review is intended to serve as a primer on business models, currently in use across a number of different country contexts, for sustainable energy access, focusing on electricity access and lessons for thermal energy access. The countries covered the review are almost exclusively developing countries, across both rural and urban spheres. While this review does not intend to cover the gamut of potential business models for thermal energy access, a wide variety of models are covered for differing applications and priorities.

1.0 – Business Models for Sustainable Electricity Success

A number of business models have evolved over the course of the recent past in sustainable electricity services and access. The features, limits and applicability of some of these models are summarised here.

1.1. Cash Payments

- Under the cash payments model, the end-user pays a lump sum for a small energy system, for example a solar water heater, solar lighting, or a photovoltaic system. (Centre for Resource Solutions 2001, UNDP-GEF 2004)
- The end-user owns the system, and is responsible for operation and maintenance of the system. (UNDP-GEF 2004, Sovacool 2013)
- The sale of systems is commonly conducted through private entities, more rarely through state energy companies. Small-scale distributors directly sell stand-alone products (for example, solar lanterns, small photovoltaic kits) in Sub-Saharan Africa, for example in Kenya. (Friebe, von Flotow and Täube 2013, Ross 2001, Pode 2013)
- Limits of the direct sales model include it is often leading to purchasing of the cheapest components. Systems are also too small often for required needs, and there is generally no energy need assessment of the recipient household at the point of sale. (Chaurey and Kandpal 2009, Dei, Islam and Khan 2010, Gujba et al. 2012)
- Self-installation can lead to reduced operation and lifetime, due to improper maintenance. (Friebe, von Flotow and Täube 2013, Gujba et al. 2012, Centre for Resource Solutions 2001)
- Cash sales system can only reach limited number of households (~5% typically) with sufficient disposable income to afford lump-sum payment for system. (World Bank 2008)

1.2 Micro-credit

- Credit can be delivered either through a dedicated micro-finance institution or through micro-credit products from existing finance institutions (retail banks etc.). (UNDP-GEF 2004)
- Loans are usually small (<US$150), with short loan terms (<1 year to 3 years) and often close-to-commercial interest rates. (UNDP-GEF 2004, Centre for Resource Solutions 2001)
- Credit is most commonly used for commercial end-users (businesses, entrepreneurs), but also for rural cooperatives. Some cases have featured rural cooperative members acting as risk guarantors for each other, or the cooperative acting as a risk guarantor for members. (Yadoo and Cruickshank 2010, Zerriffi 2011)
- Micro-credit models can reach more end-users than a standard cash purchase model, and are applicable to groups/cooperatives more easily. (World Bank 2008, UNDP-GEF 2004, UNDP/UNCDF 2013)
- Cooperative lending increases investor confidence and model success rate: individual consumer lending may be more risk-prone. Cooperative models where risk guarantees are used (either on an individual or collective basis) generally increase investor confidence. (UNDP/UNCDF 2013, International Energy Agency 2003, Srinivasan 2005, UNEP, MacLean and Siegel 2007)
- One of the major barriers is the lack of capacity in many existing micro-finance institutions for energy projects. Lack of capacity can lead to inappropriate financing options being offered, which can hinder energy service diffusion. (Rao et al. 2009, Morris et al., USAID 2007)
- The consumer's ability and willingness to repay is often contingent on their satisfaction with energy system, and there are many cases where defaults have increased due to lack of consumer satisfaction. (Krithika and Palit 2011, Monroy and Hernandez 2008)

1.3 Fee-for-service/Energy service companies

- Fee-for-service business models have the potential to reach the greatest proportion of the rural population compared to cash purchase/micro-credit models, as this model requires the lowest end-user initial capital. This makes the fee-for-service model most applicable to low-income areas and consumer groups, for example those living in rural areas. (Pode 2013, World Bank 2008, UNDP-GEF 2004, Palit 2013, Friebe, von Flotow and Täube 2013)

- An Energy Service Company (ESCO) is a common provider of a fee-for-service model. ESCOs can be a private entity or a non-commercial institution supported by government/investment agency grants. (Friebe, von Flotow and Täube 2013, Krithika and Palit 2011, Calderoni et al. 2012)
- Through an energy service company model based on a fee-for-service business model, system ownership is retained by installing company, and the ESCO also has maintenance responsibility. End-users then pay a small monthly fee (usually US$5-15) for the energy services delivered. (Krithika and Palit 2011, World Bank 2008)
- Demand aggregation can enable ESCOs to obtain favourable financing terms from lending institutions, as a way to offset the high start-up capital requirements of the fee-for-service model. (Pode 2013, Bhattacharya 2013, Sovacool 2013)
- Issues with the ESCO/fee-for-service models experienced in case studies include the weakness in the ESCO being responsible for the entire energy service value chain. A lack of available personnel with technical/business skills in the energy field can also be an issue. (Chaurey and Kandpal 2009)
- To ensure a full-cost-recovery mechanism, ESCOs are more likely to target affluent rural households, which can mitigate the increase in available consumer base at the core of the model. (Dei, Islam and Khan 2010, Sovacool 2013, Chaurey and Kandpal 2010)

1.4 Hire purchase/small-scale dealer credit models

Hire-purchase/small-scale dealer credit models exist in a number of Sub-Saharan African contexts.

Small-scale dealer credits are used frequently in the Kenyan solar home systems market, where local shops in rural areas stock PV system components, available either for direct purchase or on a small-scale credit determined by the vendor. This allows consumers to enter into an informal financial relationship with the seller, bypassing the need for a formal credit structure with regard to the purchasing of renewable energy systems, allowing consumers who may not be part of the formal banking services system access to financial services.

Hire purchase schemes are most commonly used with salaried workers paying for cost of systems over time. Examples exist in the Mozambican mining industry, where employers take contributions out of workers' monthly salaries to fund solar home systems for the workers, in collaboration with local vendors. Such schemes also exist in Kenya. (World Bank 2008, UNDP-GEF 2004)

1.5 Solar concessions or open territorial access

In terms of territorial development, different approaches have been tried. Often the market is completely open and a solar SME can extend its business at any point of a country. But sometimes, concessions have been used in a public-private partnership context for developing world applications, such as with South African rural electrification concessions, or LPG concessions in Mozambique. These concessions can solely target private consumers, or a mix of public and private consumers, and operate by and large as private companies, with some level of initial public funding, subsidy, or guaranteed purchasing contracts.

2.0 – Examples of Existing Business Models

The following short cases have been selected as indicative examples of their respective financing schemes, with broad support in the academic literature and an extended duration of experience and implementation as key factors. These examples also specifically pertain to developing world contexts, and target the demographic groups that are relevant to the STEPs project: the rural and peri-urban poor, with a lack of access to clean, sustainable energy, be it in terms of electricity or thermal fuels.

2.1 South African SHS/LPG concessions in Kwazulu-Natal

Lemaire (2011, 2014) notes a successful fee-for-service electrification and thermal concession model in Kwazulu-Natal, South Africa: "Eight energy stores are located in the concession that covers 10,000 Km^2, and more than 13,000 solar home systems *[in February 2015 more than 19,000 solar home systems]* have been installed. Energy stores stock parts and sell not only small photovoltaic components, but also Liquefied Petroleum Gas. The sale of Liquefied Petroleum Gas enables the stores to increase their turnover by supplementing their provision of energy services to rural households (the "energization" approach).

The company gets a capital grant from the government, which represents the major part of the total cost of the solar home system. To get connected, customers need to pay just a small installation fee. The governmental subsidy for solar energy is roughly equal to the one given to the main electric utility to connect households to the grid. The customers have to pre-pay a monthly fee, which may (or may not) partially be paid by local municipalities. Some municipalities agree to pay half of the monthly fee, other municipalities do not. This creates considerable distortion between clients. Technicians visit the installations only when there is a problem or during the planned routine visits which take place every six months." Monthly fees in 2015 were approximately 6.50 USD, or around 77 ZAR (South Africa Rand).

"The energy stores are central to the process. People come to the energy stores mainly to charge a token which gives them a credit for electricity. The token also contains data on the functioning of the system, which can be transferred to a computer. All the data can be manipulated at the energy store, but are also immediately centralised at the headquarters. Even with this system of reporting, the process of resolving a failure can take several weeks, while the contract requires people to pay even when the system is not functioning. A point of dissatisfaction for clients is the limited amount of electricity provided by the system. Furthermore, during a survey, 2% of the systems were non-operational due to theft of components of the system." (Lemaire 2011, 2014).

2.2 The Kenyan PV market

Ross (2001) contains a study on solar PV systems for household use sales models. At that time the majority of small (~10 W) systems were sold directly. Pode (2013) expands on the case study of the Kenyan PV market. As of 2013 small, less than 50 Wp PV systems were retailing for around US$600, out of range for many rural consumers' purchasing power.

Hence, hire-purchase schemes were instituted in the country for salaried employees, for example those employed in the state sector. Standard loan interest rates (40%) were factored into the cost for longer repayment periods, but interest-free loans were available for short periods of 20 or 50 days. These hire-purchase schemes were generally used for solar lantern systems and small lighting systems.

The dealer-credit aspect of the Kenyan PV market has been a major contributor to its success. Modular purchases of solar home system components, combined with an informal credit arrangement with the dealer, have enabled Kenyan shop-owners to effectively incorporate solar home systems into their stock, increasing uptake in the country. (UNDP-GEF 2004, Chaurey and Kandpal 2010, Gujba et al. 2012, Yadoo and Cruickshank 2010)

As of 2015, total installed solar capacity stood at around 20 MWp, with around 470,000 households having access to a solar home system. The vast majority of small solar home system (1-10 Wp) were sold directly in the country, with over 1,500 SMEs registered as selling these products. Larger solar home systems (up to 100 Wp) were where the majority of micro-finance interventions in the solar PV market were.

2.3 Grameen Shakti, Bangladesh

One of the most commonly-cited cases of micro-finance institutional success is the Grameen Shakti organisation in Bangladesh. The Grameen Bank was first founded in 1976 as a micro-finance institution for Bangladesh's poorest citizens. Grameen Shakti was founded by the Grameen Bank in 1997 to service its existing micro-finance consumers with energy services as part of an integrated finance and service provision platform. This integration led to rapid and significant uptake of energy products and services.

At the very beginning, with limited funds Grameen Shakti could offer only one year finance which explain why up to July 1999, Grameen Shakti sold only 1,147 systems, with 200 technicians trained. But from 1998, by securing lines of credit from the International Finance Corporation/World Bank, Grameen Shakti has started to be able to provide a more diversified offer of loans up to three years.

Systems proposed today are ranging from 10 Watt peak to 130 Watt peak, with 50 Watt peak accounting for most of sales; the cost of a 50 Watt peak system with a battery imported from Japan is around 380 US$. Interest rates to customers are approximately 12%, and a security deposit of 2-3 months of payments is also taken.

As of September 2010, Grameen Shakti had installed more than 464,000 solar home systems, and the program was growing at a rate of 20,000 new clients per month. The particular success of Grameen Shakti needs to be compared to other similar institutions in Bangladesh, as the closest installs only 1,000 solar home systems per month. It is linked to the existence of an extensive network of now more than 950 decentralized branch offices, but also to an adapted door-to-door marketing strategy.

The beneficial impact of solar home systems for rural households appears to be substantial in Bangladesh, in terms of access to a modern source of energy and reducing energy costs; potential demand could increase with further reduction in costs of photovoltaic modules (Komatsu et al., 2011). Payback periods for solar home systems replacing kerosene lamps are typically less than 3 years (Mondal, 2010). Nevertheless, the quality of installation and performance of components of solar home systems in Bangladesh can fluctuate, and specifications seem too flexible to safeguard end-users interests.

Systematic training of the heads of households in the proper use of solar panels is provided by 45 Grameen Technology Centres. Technicians from the company do a monthly visit during the financing period and propose an annual maintenance contract for a few US dollars per month afterwards. As in rural communities in Bangladesh, it seems inconceivable for a man to enter a house and interact with women during the absence of male member of the family who work outside during the day, 6,700 women have been trained to be technicians; they often follow a four-year technical degree paid by the Grameen Technology Centres before working back in rural areas (Sovacool and Drupady, 2011). Grameen Shakti leads also a program of dissemination of biogas and cook stoves; the company employs now more than 8,400 people, as of 2014 had installed over 1 million solar home systems. (Lemaire 2014).

Repayment rates for the Grameen Shakti services are exceptional, at around 98%. This case is also notable for illustrating the successes that can be achieved through cooperation with international capital markets or local financial markets and institutions, with multiple international donors, most notably the World Bank and European development organisations offering loan facilities to the company, as well as subsidies for system costs to improve revenue. (UNEP, MacLean and Siegel 2007, http://www.gshakti.org/, Pode 2013, Srinivasan 2005, Sovacool 2013)

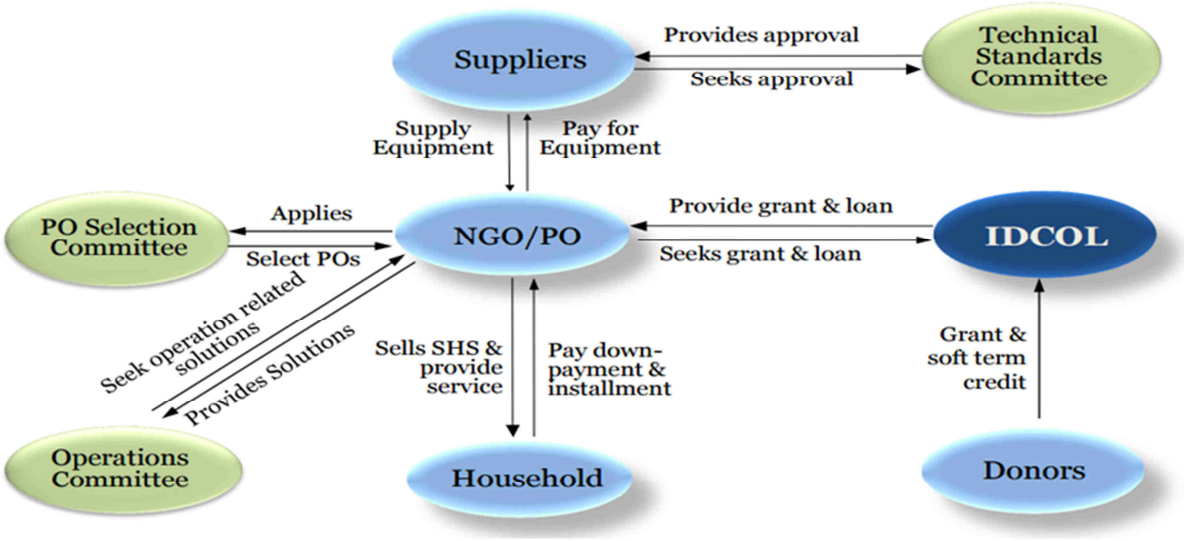
2.4 Public-private partnerships in Bangladesh (IDCOL)

Partnerships between public and private institutions can often lead to increased project success rates in renewable energy for poor or rural communities (Sovacool 2013, Mukherjee 2004), and a good example of this success can be found in the Bangladesh Infrastructure Development Corporation (IDCOL).

Dei, Islam and Khan (2010) for example details the partnerships between IDCOL, a semi-governmental organisation funded by the state but autonomous in organisation, and the Rural Electrification Board of Bangladesh (REB), as well as the Grameen Shakti energy services/microfinance organisation.

IDCOL's program of solar home system dissemination through both micro-credit (administered and implemented by Grameen Shakti) and fee-for-service (through the REB) financing mechanisms had reached 284,000 systems by March 2009.

Figure 1. Organisational Structure of the IDCOL Solar Home Systems Program



Source: Haque (2013) IDCOL Solar Home System Program.
Available at: https://sustainabledevelopment.un.org/content/documents/4923haque.pdf

The Rural Electrification Board fee-for-service scheme offers systems to the consumer that remains under the ownership of the REB for a monthly fee, dependent on system capacity. A flat membership cost of 20 BDT (Bangladeshi Taka, USD 0.26) is paid, with monthly bills ranging from 180 BDT (USD 2.31) for a 40 Wp system to 392 BDT (USD 5.04) for a 100 Wp system. Satisfaction is also high in the fee-for-service consumer group, because due to the anticipated expansion of grid services to fee-for-service areas, system ownership retention by the government is a desirable factor. Pode (2013) also mentioned the IDCOL program, focusing on the micro-credit component (Palit 2013, Palit and Chaurey 2011, Krithika and Palit 2011).

Palit (2013) notes: "IDCOL has over-achieved its targets more than once: for example, it financed 50,000 SHSs by 2003 against a target for 2008; it achieved 200,000 SHS target seven months ahead of schedule in May 2009; and against a target to finance 1 million SHS by the end of year 2012, IDCOL achieved financing of 1,429,440 systems (as on April 30, 2012) with approximate cumulative capacity of 75 MWp."

The number of systems funded via micro-credit is a lot higher than with fee-for service. As of January 2017 the number of financed solar home system connections through the REB fee-for-service scheme had reached 14,125 households. As of October 2016, the micro-credit scheme of IDCOL had distributed 4.1 million solar home systems in total.

2.5 Microfinance in Karnataka State, India

With the 2013 estimates that in India, roughly 289 million rural people do not have access to the energy needed for lighting, Pode (2013) offers two examples of Indian state agencies and companies offering financing and maintenance agreements for rural renewable lighting:

"The MNRE provides a Central Finance Assistance (state loan) for buying SHS up to 30% (limited to INR 81 (Indian Rupee), USD 1.30) per Wp for general areas and for special category states/North-East states up to 90% (limited to INR 243, USD 3.91) per Wp. SELCO Solar Company, India offers financing as well as maintenance services to rural population for the promotion of off-grid renewable energy technologies (RETs)" (Pode 2013).

Kraus, M. and Nordström, S. (eds.), UNDP-GEF (2004) have examples of micro-finance models for renewable energy equipment (most commonly solar home systems) used in Karnataka state, India. MFIs in this model acted as a distribution channel for a direct purchase model for solar equipment (specifically small solar lantern systems). The financial institutions involved in this scheme ranged from rural MFIs offering short (6 months-1 year) loans at rates of 10-24%, to district cooperative banks, to rural regional banks for larger loan amounts and longer durations. Rural regional banks generally charged market rates for their loans, with 1-5 year durations. Down-payments were required for smaller systems, but not always for larger systems.

Harish et al. (2013) expands on the Karnataka case study with a survey of seven firms offering solar lighting systems and eleven separate villages with consumers of the firms' lighting systems. For the firms offering smaller lighting systems (for example single solar lanterns) the vast majority of purchases were made through direct cash payments to the firm, however for larger systems (small solar home systems with multiple lights), 70-100% of purchases are made with a micro-loan or rural bank loan. Some firms also have agreements with local banks to offer loans for system purchases with zero down-payments. Smaller purchases are sometimes made through some firms with informal dealer loans also. Loans for the larger systems are generally made at market rates (4 out of 7 firms), and over a period of 3 to 5 years. (Pode 2013, Harish et al. 2013, UNDP-GEF 2004, Rao et al. 2009, Mercados 2010, World Bank South Asia Energy Unit 2010, Chaurey and Kandpal 2009).

Rao et al. (2009) presents another project from Karnataka state, the provision of photovoltaic light points for street hawkers in Mysore. S^3IDF, a United States-based NGO, partnered with SELCO, an established Indian solar lighting firm, to provide photovoltaic lighting points and charging infrastructure in the town centre. The batteries for the lights are charged via photovoltaic at a central charging station in the daytime, delivered to the hawkers in the evening, and then returned at night for recharging. The batteries are supplied on a daily rental to the hawkers, at a rate determined by their ability and willingness to pay. Around 50 street-level retail outlets were powered for the first time through this project.

2.6 Tabulated list of cases

See following pages Table 1. Tabulated list of cases

Project Name	Dates Active	Country/ Region	Number of Systems Disseminated	Business/ Funding Model	Source of Funding	Website	Reference
African Rural Energy Enterprise Development (AREED)	2007 -	Western/ Southern Africa	32 clean energy enterprises funded as of 2013	Debt and equity financing for clean energy business establishment	UNEP	http://www.areed.org/	Pode (2013)
Rural Electrification and Renewable Energy Development (RERED)	2002 -	Bangladesh	~645,000 as of 2010, ~1.4 million as of 2014	Fee-for-service through Rural Electrification Board / micro-credits through partner organisations of project	World Bank/GEF and Gov. of Bangladesh	http://www.worldbank.org/projects/P071794/rural-electrification-renewable-energy-development?lang=en	Pode (2013), Lemaire (2014)
Transsolar Technologies	2009 -	India (Tamil Nadu)	35 kW / 25,000 litres/day heated water as of 2010	ESCO/performance guarantee contract	Private financing	http://www.transsolartechnologies.com/index.htm	Mercados (2010)
South African solar concessions (3 companies)	1999 -	South Africa (KwaZulu-Natal, Eastern Cape)	96,000 systems installed in total by 2015	ESCO/Fee-for-service	Gov. of South Africa	http://www.nura-energy.co.za/ http://www.gov.za/sites/www.gov.za/files/State%20of%20Renewable%20Energy%20in%20South%20Africa_s.pdf	Lemaire (2011, 2014)
Zambia PV ESCO Model	1998 -	Zambia	450 (3 companies in Eastern Province, 1998-2000)	ESCO/Fee-for-service	SIDA/Stockholm Environment Institute	http://www.hedon.info/RuralESCOSolarHomeSystemsZambia	Krithika and Palit (2011), Lemaire (2009)
Lighting a Billion Lives (LaBL) – charging station component	2008 -	India	600 villages in 15 states by 2011 have charging station enterprise	Fee-for-service / central charging station for solar lighting	TERI (Energy and Resources Institute, India)	http://labl.teriin.org/	Krithika and Palit (2011)
Rural Electrification and Renewable Energy Development (RERED)	2002 -	Sri Lanka	120,000 households using SHS, 6,000 with electricity from micro-hydro as of 2008	Output-based grants for business establishment, medium to long-term financing for SHS/village-scale micro-hydro	World Bank/GEF	http://www.worldbank.org/projects/P071794/rural-electrification-renewable-energy-development?lang=en	World Bank (2008)
Solar battery charging stations in Nicaragua	2006	Nicaragua	Seven charging stations servicing ~50 households each (2006)	Monthly fee to cover weekly battery charging and equipment replacement	Gov. of Nicaragua	--	World Bank (2008)
Decentralised Infrastructure for Rural Transformation (IDTR)	2003 - 2013	Bolivia	14 contracts from 350 – 2,200 SHS as of 2008	Medium-term service contracting (ESCO)	World Bank/Gov. of Bolivia	http://web.worldbank.org/WBSITE/EXTERNAL/NEWS/0,,contentMDK:22707543~pagePK:64257043~piPK:437376~theSitePK:4607,00.html	World Bank (2008)

SELCO India – Cookstoves Program	2008 -	India	~2,000 stoves as of 2009	Micro-finance through existing MFI customer network of SELCO for cookstove products	SELCO India	http://www.selco-india.com/	Rai and McDonald, GVEP (2009)
IDCOL (Infrastructure Development Company Limited)	1997 -	Bangladesh	284,000 by 2009, 1.4 million by 2012 (Pode 2013)	Micro-finance for SHS, also fee-for-service	Gov. of Bangladesh	http://www.idcol.org/	Dei, Islam and Khan (2010)
Small-Scale Infrastructure Development Fund (S3IDF)	2008 -	Karnataka State, India	~25 central charging points for solar lighting for street hawkers as of 2009	Micro-financing for entrepreneurs managing charge points, fee-for-service for street sellers to charge lights	SELCO India	http://s3idf.org/	Rao et al. (2009)
Foundation Rural Energy Services (FRES), Yeelen Kura project	1997 -	Mali	1,400 households served out of a goal of 5,000 as of 2007	Fee-for-service financed by joint venture partners	NUON (Netherlands) / EDF (France)	http://www.fres.nl/en/	Klein et al. (2007)
Foundation Rural Energy Services (FRES), NUON-Raps (NuRa) [NB: one of the three South African solar concessions]	2001 -	South Africa	18,478 clients, 9 stores and 102 employees as of 2014	Fee-for-service for SHS and LPG	NUON + employee shareholdings	http://www.fres.nl/en/	-
Foundation Rural Energy Services (FRES), Yeelen Ba	2008 -	Burkina Faso	2,623 clients, 7 sales points and 29 employees as of 2014	Fee-for-service for SHS	NUON/Yeelen Kura (Mali)	http://www.fres.nl/en/	-
Foundation Rural Energy Services (FRES), FRES Uganda	2010 -	Uganda	3,273 clients, 4 outlets and 55 employees as of 2014	Fee-for-service for SHS	FRES	http://www.fres.nl/en/	-
Foundation Rural Energy Services (FRES), FRES Guinea-Bissau	2011 -	Guinea-Bissau	1,920 clients, 10 stores and 6 employees as of 2014	Fee-for-service for SHS	FRES	http://www.fres.nl/en/	-
Soluz Dominicana	1995 -	Dominican Republic	6,000 customers as of 2005 for SHS of varying scales	Fee-for-service/micro-rental for SHS (pre-electrification systems as well as off-grid)	Soluz / private financing	http://www.soluzusa.com/documents/NCI-Soluz_Innovation_in_Rural_Energy_Delivery.pdf	Rogers et al. (2006)

Kiribati Solar Energy Company (KSEC)	~1992 -	Kiribati	250 kW of installed capacity as of 2009, target of 500 kW	Fee-for-service SHS provision to households, also larger micro-grids from donor funding	PIGGAREP funding from UNDP/Governmental donors	http://www.sprep.org/Pacific-Islands-Greenhouse-Gas-Abatement-through-Renewable-Energy-Project/pacific-islands-greenhouse-gas-abatement-through-renewable-energy-project-piggarep-kiribati-interventions	Mala, Schläpfer and Pryor (2009)
NABARD/MNRE Financing Scheme	2011 -	India	~37,700 as of 2013	Subsidy-linked credit schemes for business development	Ministry of New and Renewable Energy, India	https://www.nabard.org/uploads/Solar%20-%20Modified%20Scheme.PDF	Pode (2013)
Global Rural Electrification Program - Morocco	2002 - 2008	Morocco	106,200 customers reached as of 2008	Fee-for-service public-private partnership scheme	Office National de l'Electricite (ONE)	http://www.afdb.org/fileadmin/uploads/afdb/Documents/Environmental-and-Social-Assessments/EESS-Renouvelable%20et%20PERG-Resume_English.pdf	Bazilian et al. (2012)
Renewable Energy for Rural Markets – PERMER	1999 -	Argentina	35,000 rural households, 1,750 public facilities and 500 businesses as of 2011	Fee-for-service concessionaires	World Bank	http://projects.wri.org/sd-pams-database/argentina/renewable-energies-rural-market-permer	Bazilian et al. (2012)
Luz para Todos (Light for All)	2003 -	Brazil	11 million beneficiaries as of 2011	Energy service companies offering fee-for-service schemes financed through government revolving funds	Reserva Global de Reversão (RGR), Conta de Desenvolvimento Energético (CDE)	http://195.76.147.227/renforus/site/?p=2410	Bazilian et al. (2012)
SELCO India/SEWA Bank Partnership	2007 -	India	50 entrepreneurs with solar light charging businesses as of 2007	Microloans from SEWA Bank to finance energy equipment (solar battery charging, solar lighting) from SELCO	SELCO Solar Light Ltd.	http://nexus.som.yale.edu/design-selco/?q=node/121	Bazilian et al. (2012)
Githunguri Dairy Farmers / Oikocredit	Pre-2007 -	Kenya	500 farmers received loans for biogas digester installation as of 2010	Micro-credit for biogas digester installation from partnering MFI	Oikocredit	http://www.oikocredit.coop/	Kariuki and Rai (2010)
Kenya Women's Finance Trust	n.d.	Kenya	5,000 with access to LPG, 250 solar home systems, 13 LPG enterprises established as of 2010	Microfinance for low income groups	IT Power/Shell Foundation	http://www.kwftdtm.com/	Kariuki and Rai (2010)

Lighting a Billion Lives (LaBL)	2008 -	India	370,400 people reached in 1,500 villages as of 2012	Fee-for-service charging stations, financed through grant contributions from donor agencies	TERI (Energy and Resources Institute, India)	http://labl.teriin.org/	Chaurey et al. (2012)
Rajiv Gandhi Grameen Vidyutikaran Yojana	2005 -	India	n.d	Partnership and microfinance for villages over 100 persons with state renewable energy development agencies	Government of India (Ministry of Power)	http://rggvy.gov.in/rggvy/rggvyportal/index.html	Chaurey et al. (2012)
ADB/Sri Lanka Electrification Project	2004 - 2009 (program extended to 2016)	Sri Lanka	75,000 targeted by 2016	Revolving fund for new connections for rural households through micro-lending	Asian Development Bank (ADB)	http://powermin.gov.lk/english/?page_id=1410	Palit and Chaurey (2011)
Energetica Bolivia	2001	Bolivia	500 solar home systems to entrepreneurs in 2001	Flexible credit mechanism to fit rural farmer income streams	SNV World	http://www.energetica.org.bo/	IEA PVPS (2003)
CRE/Shell Solar Fee-for-Service	1997 - 2001	Bolivia	5,000 solar home systems by 2001	Fee-for-service scheme, CRE operating/maintaining	Shell Solar	--	IEA PVPS (2003)
Energy Sector Assistance Program	1999 - 2012	Nepal	339,309 SHS installed as of 2012	Direct subsidy for installation and maintenance to private companies from government	Government of Nepal	http://www.pciaonline.org/aepc	Palit (2013)
UNEP India Solar Loan Programme	2003 -	India	17,127 SHS loans provided as of 2006	Subsidies provided to set up microfinance institutions for renewable energy loans	UNEP	http://www.unep.org/climatechange/finance/LoanProgrammes/IndianSolarLoanProgramme/tabid/29561/Default.aspx	Maclean and Siegel, UNEP (2007)
Palawan, Philippines Solar Home Systems Financing Program	2004 -	Philippines	~1,000 SHS financed as of 2006 pilot project	UNDP financed establishment of microfinance facilities through Cooperative Bank of Palawan for SHS	UNDP/Development Bank of Philippines	http://siteresources.worldbank.org/EXTRENENERGYTK/Resources/5138246-1237906527727/5950705-1239134575003/UNDP0Palawan0R1ntation0Final0Report.pdf	Maclean and Siegel, UNEP (2007)

PROSOL Solar Thermal Equipment Financing Program	2005 -	Tunisia	23,000 m^2 of SWH capacity as of 2006	UNEP financing for SWH installations, costs recouped through on-bill monthly repayments to national electricity utility	UNEP	http://www.unep.org/climatechange/finance/LoanProgrammes/MEDREP/PROSOLinTunisia/tabid/29559/Default.aspx	Maclean and Siegel, UNEP (2007)
Village Energy Security Program (VESP)	2004 - 2012	India	79 projects sanctioned in 9 states, 65 commissioned, less than 30 operational as of 2012	Direct financing for energy projects (reference contains various failure cases)	Ministry of New and Renewable Energy, India	http://mnre.gov.in/file-manager/UserFiles/case_study_vesp.htm	Palit et al. (2013)
South Latipur Rural Electricity Cooperative	2000 -	Nepal	167 meter connections, 237 small enterprises electrified, 23 biogas digesters installed as of 2010	Micro-loans through cooperative revolving fund	National Association of Community Electricity Users in Nepal (NACEUN)	http://naceun.org.np/	Yadoo and Cruickshank (2010)
Profiles of 15 micro-finance institutions in Kenyan solar lighting market	Various	Kenya	8 of 15 already possess solar portfolio, further 2 would like to operate solar lighting loans portfolio as of 2013	Micro-finance for equipment	Various (predominantly subsidiaries of commercial banks)	--	Lighting Africa, Women's Initiative (2013)
Profiles of 8 large-scale microfinance initiatives across South Asia, Latin America and Sub-Saharan Africa	Various	Various	Various (scale is predominantly in thousands of loans/customers)	Micro-loans for energy products	Various	--	Morris et al., USAID (2007)

Source: compilation by X.Lemaire and D. Kerr, revised 2016.

3.0 – Lessons on Thermal Energy Services

Several business models have been used for increasing access to sustainable electricity in developing countries and could be used for thermal energy services.

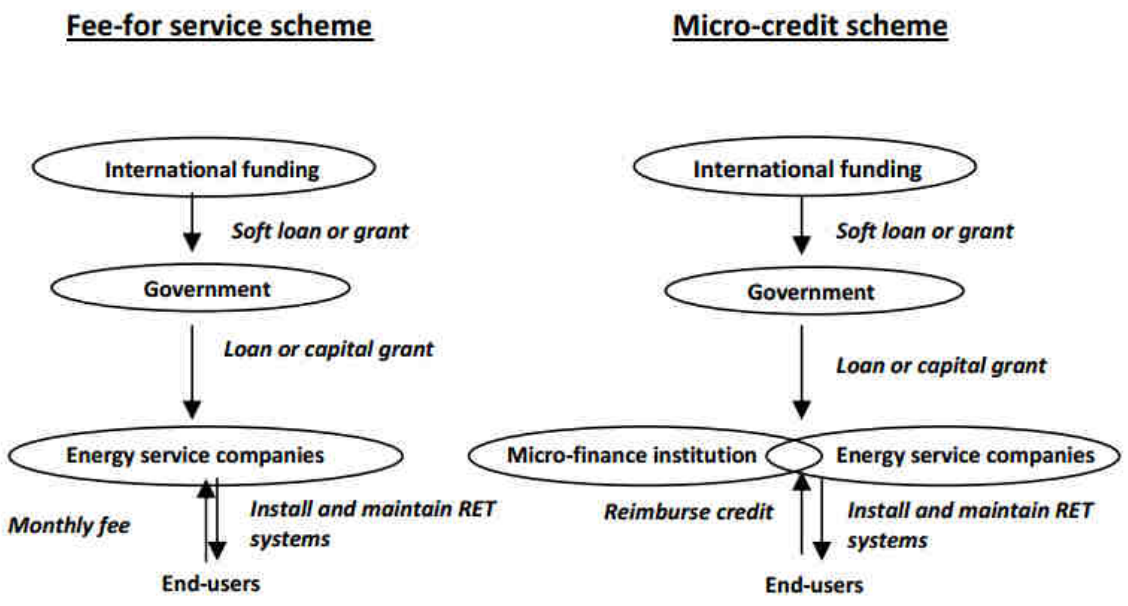
3.1 The advantages of main business models

Most models developed for electricity services could be well-suited to improving access for the rural and peri-urban poor, such as hire-purchasing/leasing, micro-credit models and fee-for-service business models.

Micro-credit models have been proven to work as a means for increasing access to energy services for the rural and peri-urban poor. Initial financing can be a significant barrier to setting up new micro-finance institutions due to the perceived inherent risk in providing credit to poorer consumers; however once this barrier is overcome, either through risk mitigation or simply waiving the consideration in light of the social benefit, the provision of credit to consumers without access to mainstream financial facilities can have an immense impact on the affordability and accessibility of energy products and services.

Fee-for-service business models in are applicable to servicing the rural poor, due to the model having the lowest initial capital requirements for the consumer. However, the establishment and provision of a fee-for-service business model through an organisation, for example and energy service company, is often contingent on outside financing, for example donor funding, due to the higher initial capital requirements for the company, and the necessity for financial sustainability over a longer period whilst service payments are made. The reliance on service payments as a revenue stream behoves the supplier to maintain the system at a suitable service level, maintaining customer satisfaction and willingness to pay as a result.

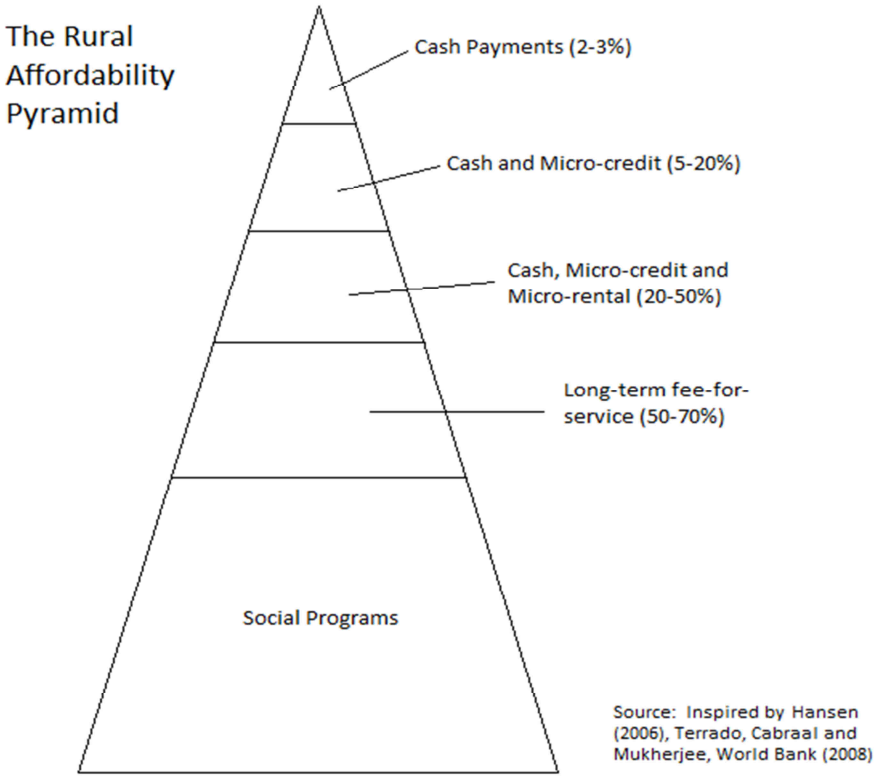
Graph 1: Comparing Fee-for-Service and Micro-credit Scheme



Source: Lemaire, X. (2014) Increasing energy access in off-grid rural areas of developing countries. Section 4. Chap 15. In Sustainable Energy Solutions in Agriculture. Ed. Jochen Bundschuh and Guangnan Chen. New York: CRC Press – Taylor and Francis Group.

Collaboration between micro-finance institutions and ESCOs allows the end-user access to the energy service provided by the company, with the company installing and maintaining the system from the initial payment by the end-user (as financed by the MFI). Under a fee-for-service scheme, the periodic payment (monthly fee) above is used to finance maintenance of the system, with the ESCO installing the system up-front for a significantly lower down-payment. Both schemes, however, are most often dependent on some form of government loan or capital grant to establish.

Graph 2: The Rural Affordability Pyramid



Fee-for-service programmes tend to have a wider reach than other forms of financing schemes for renewable energy access: payment by end-users tend to be lower when they are spread over a longer period than micro-credit (often 1-3 years)

3.2 Model and technology lessons for thermal energy services

There are a number of lessons to be drawn from the experience in sustainable electricity service business models for thermal energy services.

First, electricity and thermal energy services delivery can be combined to reinforce the sustainability of a rural energy service company, like in the case of the concession in Kwazulu-Natal (see 2.1). The Nuon-RAPS off-grid electricity concession in South Africa, as of its inception in 1998 has been offering LPG services to its off-grid electricity customers, and has diversified this portfolio of thermal energy products to include LPG equipment, LPG fuel, improved cookstoves and bioethanol gel fuels for cookstoves.

The fee-for-service business model that NuRa operates for its off-grid solar home system business is complemented by the provision of LPG services to its existing consumer base: customers have to visit a NuRa energy store regularly in order to pay for the electricity services used, and being able to purchase LPG fuel or equipment at the energy stores improves convenience for the customer, as well as ensuring a greater degree of cost recovery for the electricity service component of their business. Giving consumers an incentive to visit the point-of-payment for electricity service provision assists in cutting down on late payment and default rates, and providing LPG fuel at the energy stores, which act as the central point-of-payment for NuRa's electricity service business, gives an additional incentive for customers to visit the energy store.

In both electricity service equipment and thermal energy service equipment, servicing and maintenance provision in contracts between energy service companies and consumers has a large effect on success and failure. Providing a servicing and maintenance regime as part of a fee-for-service scheme can greatly improve system performance, whether that requires changing a photovoltaic system battery or maintaining a bio-digester.

Given the challenges already present in establishing rural electricity service companies, for example a lack of appropriate financing for company or consumer, and a lack of capacity/experience with technologies and local expertise, in designing business models for thermal energy access these factors need to be addressed.

Capacity-building, useful information provision to consumers on equipment operation, and a financing model that takes consumers' income levels into account whilst maintaining profitability (for example, a micro-credit/fee-for-service model) will all contribute to the success and sustainability of a rural energy services company.

Finally, project and business success rates in rural communities of developing countries have been demonstrably higher if public-private partnerships are implemented, and if government agencies are willing to partner with the private sector in the sphere of energy services delivery. The successes of the Bangladeshi IDCOL program (see section 2.4) highlight the progress that can be achieved through utilising both localised solutions from the private sector and the economies of scale the public sector can provide.

3.3 Extension of off-grid business to include thermal energy activities

Existing off-grid business in many differing country contexts have also experimented with the addition of thermal energy services to their operations, either as an alternative revenue stream, or as a mandated government service cross-subsidised through existing off-grid electricity provision activities. There are a number of reasons why a company or organisation may choose to diversify their operational portfolio to include thermal energy services.

If the market exists for providing a thermal energy service in the company or organisation's current operational area, then adding thermal energy services such as LPG equipment and fuel provision to an existing off-grid electricity business can increase the robustness of the business, with both revenue streams able to cross-subsidise each other, as well as incentivising more people to utilise the services of the company/organisation, through catering to many different needs in a centralised fashion. Services can also be provided on a lifeline-tariff basis to bottom-of-the-pyramid users, cross-subsidised by the existing off-grid electricity business of the company/organisation.

Some thermal energy services are more suited to integration with off-grid electricity activities than others. This can be due to the cost of the thermal energy service equipment, fuel costs, or installation and maintenance costs for the equipment. For example, both improved cookstoves and LPG use for cooking and heating are well-suited to integration with off-grid solar business; improved cookstoves due to the low costs of equipment, and therefore easy addition to a business model through a direct purchasing scheme, and LPG due to its moderate equipment costs, as well as the service relationship that it creates through fuel purchases, reinforcing the consumer/company relationship and ensuring regular contact to follow up on the operational status and payment schedule for both systems.

Other technologies, such as biogas systems or to a lesser extent solar water heaters require a larger investment from the end user, and if to be combined with an off-grid electricity business, would require a higher degree of complexity in business and operational models to ensure the success of both streams of the business. However, these larger and more complex/expensive systems are also in general more profitable to the company than smaller thermal energy equipment, such as improved cookstoves.

3.4 Possible thermal energy/electricity service combinations

Table 2. Possible Thermal Energy/Electricity Service Combinations

IMPACT	Capital Cost / Income Generation	Logistic / Operations / Installation and Maintenance	Relations with End-Users / Marketing
Solar	Low/Medium	Installation costs high, fee-for-service or micro-credit business model for spreading costs for poorest, maintenance costs low.	Consistent engagement with end-user possible through fee-for-service, capital cost level lends itself to service arrangement.
Solar PV + LPG	Medium/High	Little extra installation costs when using LPG cooking, equipment and installation costs lower than other thermal technologies, incentivises repeat visits to company for fuels.	Consistent relations with end-users for fuel sales and equipment maintenance/refitting, in addition to solar business.
Solar PV + biogas	High/Medium	Installation costs very high, long-term commitment to company from user required due to lack of recourse in event of non-payment, payback periods however low.	Maintenance regime extremely important for biogas installations to maintain high functionality, long-term service arrangement preferable.
Solar PV + cookstoves	Medium/Medium	Easy to integrate thermal energy service, low-cost option but also lower returns than other sources. Little in terms of service arrangement potential, direct purchase/subsidised purchase model more common.	If fuelled through purchased fuel from company then regular service contact, however, obligation is not inherent. Easy to market, proven benefits.
Solar PV + SWH	High/Medium	High capital cost of equipment but effective thermal energy intervention, transferrable skills in installation leads to easier integration, maintenance contracting possible for extending customer interaction.	Mature technology with maintenance arrangement possibility, transferable marketing opportunities with existing solar business.

4.0 Conclusions

In conclusion, the availability of options in terms of business models for thermal energy services is wide-ranging. There exist approaches towards the provision of thermal energy services, both with and without an integrated electricity supply component of a business/company, which will assist with both company and wider sectoral growth. More expensive (in terms of up-front costs) thermal energy technologies, such as biomass gasifiers or solar water heaters, are more suited to approaches that contain some degree of end-user financing, as defined in the above table.

Poorer end-users would not otherwise be able to afford the thermal energy service technologies, and a fee-for-service or micro-credit/dealer credit approach, allows these users access to technologies that would otherwise be out of reach, energising these consumers for future growth in income. Lower-cost thermal energy technologies, such as improved cookstoves, are more suited to direct purchase models, and face difficulties if trying to be implemented under a service arrangement, but can be cross-subsidised for poorest commuters from the electricity services business.

These more innovative approaches in terms of combining businesses and supplementing electricity service businesses with thermal energy technologies not only provide electricity service companies with an additional potential revenue stream, maximise the already not so limited impact of solar electrification (Lemaire, 2018), but also enable consumers readier and easier access to thermal energy services through existing companies, and existing service relationships.

Questions and Answers

What business models have been used in the sphere of electricity services which could be used for thermal energy services?

Thermal energy business model experiences that have achieved scale, to date, have predominantly revolved around three main models: the use of direct subsidies, provision of micro-credits, and establishment of fee-for-service contracts with the consumer. These models have inherent advantages and disadvantages, particularly when applied to certain thermal energy technology types.

As with electricity services, cash purchases are a basic form of model that can be applied in nearly any market circumstance, however these often need to be supported with direct subsidies for the consumer, as well as potentially for manufacturers, as ability-to-pay for developing country consumers, particularly in rural areas, is often low. This approach has been used in the Kenyan market case above, where local retailers act as providers for directly-purchased solar home system components.

Micro-finance has been a common route in countries such as India and Bangladesh to allow poorer consumers, including bottom-of-pyramid consumers, access to energy services and energy technologies on an affordable basis. This approach involves a financing institution offering small amounts of credit, typically ~US$100, to consumers for energy equipment purchases. This model has been used extensively by organisations such as the Grameen Bank in Bangladesh as detailed in section 2.4, as well as the Karnataka State, India case above in section 2.5. This approach allows consumers who may not be able to afford energy equipment such as solar home system, or a solar water heater, to defer the full cost of purchase with a loan, repayable on flexible terms of a long period.

Fee-for-service models typically involve the participation of an energy service company (ESCO), who is responsible for installing energy equipment for consumers, who then pay a monthly fee for the use of the equipment to the company. In some circumstances these companies are also responsible for maintenance of the system. These models have the greatest accessibility potential for the poorest consumers, as the monthly fees can be pitched to be significantly lower than loan repayments, allowing consumers to access energy service technologies on a much more affordable basis. Examples of fee-for-service models include the South African electricity concession case above in section 2.1, as well as solar water heating technology provision in Barbados.

What business models are most appropriate for thermal energy service technologies?

A wide variety of business models have been used successfully in the sphere of thermal energy services. Some technologies, however, are more appropriate to be used with some thermal energy service technologies than others. There are a few factors that affect this consideration, most notably the cost of the thermal energy service equipment.

Technologies such as solar water heating and LPG cooking or heating are more suited to a fee-for-service or micro-credit approach, spreading the relatively high cost of the systems or fuel over a longer-term basis, improving the affordability of the technology for poorer consumers.

Improved cookstoves, for example, are suited to a micro-credit or direct purchasing approach, possibly with small dealer-credit models to offset some cost for the poorest consumers, as these technologies are of lower cost, and more within reach of poorer consumers without having to address the affordability of systems. South African electricity concessions in rural areas of the country, such as the Nuon-RAPS case above in section 2.1, have integrated LPG cooking technology with their fee-for-service solar home systems concession, with the revenues from the LPG business helping to support the solar home systems business. Their business model involves regular trips to "energy stores", central payment points, to top up pre-paid electricity meter cards, and offering LPG fuel at these energy stores enables consumers to access the fuel more easily.

What support is necessary from a policy level for the growth of thermal energy markets on a business basis?

Policy-makers can assist with the development of thermal energy markets in a number of ways. In developing world contexts, market development is often constrained by the ability of consumers to pay for services and technologies. Governments can intervene in this sector through both direct and indirect subsidies for thermal energy equipment, as well as through capacity-building and training programs, and perhaps most importantly, public-private partnerships.

Direct subsidies to develop energy markets have been used extensively as a method to allow consumers access to technologies that are otherwise unaffordable to them, either at a subsidised price or entirely without cost to the consumer. Examples include state cookstove programs in India, as well as solar water heating provision in South Africa. Direct subsidies can be effective in diffusing technologies at a rapid pace, however, they often have the effect of distorting nascent markets for energy technologies, hampering their medium-term development.

Indirect subsidies can take the form of reductions in taxation for thermal energy service equipment, either on import duties or value added tax, and also guaranteed purchasing agreements, as have been used for LPG technology in Mozambique in collaboration with the VidaGas concession[1]. Indirect subsidies allow markets to develop more organically with less distortion in terms of pricing or supply from the government.

This indirect support for thermal energy technology markets can also come in capacity building and training, as has been used in Kenya for the training of entrepreneurs in the clean cookstoves market, also promoting the involvement of women in the energy business. Accreditation is another factor that government bodies can influence in the thermal energy sector, offering regulation and standards provision on thermal energy service equipment. This accreditation not only helps consumers make an informed choice about products, but also allows governments to regulate product quality on the thermal energy market.

What effect can public-private partnerships have on businesses and business models for thermal energy services?

Public-private partnerships have a huge potential to grow markets for energy service technologies more generally in the developing world, but are particularly useful for thermal energy services. Diffusion of thermal energy technologies has been a barrier in a number of cases to market growth, for example the Kenyan and South African cases above, however countries such as Bangladesh with the Infrastructure Development Corporation (IDCOL) in section 2.4 above, and also Sri Lanka in the clean cookstoves sector in partnership with the Ceylon Electricity Board (CEB), have benefited from private sector organisations partnering with governmental or semi-governmental organisations. Both cases have allowed the private sector to access the scale of consumer base that state organisations can provide, in order to more effectively and more quickly grow market-based provision of energy service technologies, supporting market development.

[1] Please see Vidagas: Mozambique In Restio (2014) *Case studies on PPP frameworks based on energy sector experience in Sub-Saharan Africa*, STEPs. http://stepsproject.net/outputs/

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Andreas, J. et al., UNEP Frankfurt School Collaborating Centre (2011) *Feasibility study on access to financing for RE appliance for rural poor in Cambodia*. New York, United Nations Environment Program. Available at:
http://fs-unep-centre.org/sites/default/files/media/feasibilitystudyonaccesstofinancing.pdf

Focusing on the Cambodian context, this study gives recommendations for micro-finance innovation for RE appliance supply to the rural poor. The study focuses on solar PV and thermal technology supply, and gives recommendations to the existing MFI sector on loan product formulation, best practice and sales strategy.

Banovac, E., Gelo, T. and Šimurina, J. (2007) Analysis of economic characteristics of a tariff system for thermal energy activities. *Energy Policy*, vol. 35, pp. 5591 – 5600.

This paper analyses the construction of a tariff system for thermal energy activities in a Croatian context, based on existing electricity tariff structures in the country. The assessment is performed using a capital asset pricing model, with the weighted average cost of capital ensuring regulatory authorities facilitate returns equal to the opportunity cost of capital for thermal energy use.

Basu, A.K. et al. (2011) Micro-grids: Energy management by strategic deployment of DERs – A comprehensive survey. *Renewable and Sustainable Energy Reviews*, Vol. 15, pp. 4348 – 4356.

This paper assesses the benefits of micro-grids to sustainable energy management strategies through the utilisation of distributed energy resources. Primarily the paper focuses on the benefits micro-grid integration into energy strategy can have in terms of emissions reduction, reliability enhancement and deferral of costly grid infrastructure upgrades, but also assesses tariff structures and market strategy in a global context.

Bazilian, M. et al. (2012) Improving access to modern energy services: Insights from case studies. *The Electricity Journal*, Vol. 25, Issue 1, pp. 93 – 114.

Predominantly focusing on Sub-Saharan Africa, but also on cases from South America and South-East Asia, this overview paper offers a wide array of general principles for the sustainable design and implementation of energy service access projects. Remaining technology-neutral, the paper considers business development, financing, institutional structure and regulation for rural and urban contexts in developing countries.

Bertoldi, P., Rezessy, S. and Vine, E. (2006) Energy service companies in European countries: Current status and a strategy to foster their development. *Energy Policy*, Vol. 34, pp. 1818 – 1832.

This paper examines the role at the time of energy service companies in European Union and New Accession countries, and the factors affecting their market development. Financing recommendations solely focus on the supply-side, covering equity capital and leasing arrangements, as well as partnerships with suppliers and revolving funds, for example the Spanish energy efficiency revolving fund experience.

Bhattacharyya, S.C. (2013) Financing energy access and off-grid electrification: A review of status, opportunities and challenges. *Renewable and Sustainable Energy Reviews*, Vol. 20, pp. 462 – 472.

This paper analyses the government- and project-level financing options for off-grid electrification, covering the gamut of off-grid electrification options. Financing access on an end-user and supply-side level is also examined, covering micro-credits and small-scale lending, as well as leasing agreements and revolving funds at a community level, remaining on a global developing world context.

Bobinaite, V. and Tarvydas, D. (2014) Financing instruments and channels for the increasing production and consumption of renewable energy: Lithuanian case. *Renewable and Sustainable Energy Reviews*, Vol. 38, pp. 259 – 276.

This paper assessing the viability of increasing solar technology access in the Lithuanian context through improved financing instruments. Focusing on the financial sector, the paper examines the current feed-in tariff policy, as well as the existing commercial financial sector instruments for renewable energy project financing, and new routes to potential project financing. The paper also assesses the cost benefits of new financing on the electricity and heat sectors.

Business in Development/NCDO (2006) *Profiling business roles in rural energy access in developing countries*. Amsterdam, National Commission for International Cooperation Netherlands (NCDO)

This report profiles twelve separate rural energy access businesses in developing countries, covering South-East Asia, Sub-Saharan Africa and South America. Focusing on business development, in-depth interviews with managers and owners of these businesses examine their business and financing models, including direct donor financing, fee-for-service and micro-credit. The paper also offers a summary of energy funds for business development across the developing world.

Calderoni, M. et al. (2012) Solar thermal plants for industrial process heat in Tunisia: Economic feasibility analysis and ideas for a new policy. *Energy Procedia*, Vol. 30, pp. 1390 – 1400.

This paper predominantly analyses industrial process heat applications for solar thermal energy in the well-established Tunisian context, but also proposes an ESCO model for end-user thermal energy use in the country. The model revolves around on-bill financing for the consumer paid to the ESCO, which allows the ESCO to claim energy reduction certificate subsidies that exist under the government solar thermal scheme.

Centre for Resource Solutions (2001) *Financing off-grid PV*. San Francisco, Centre for Resource Solutions. Available at: http://resource-solutions.org/site/wp-content/uploads/2015/08/DistRural-FinancingoffgridPV.pdf

This report offers experiences from China, Indonesia, Kenya and other developing countries for off-grid photovoltaic financing, covering both user-owned and institution-owned models. User-owned models cover cash payments, micro-credit schemes, small scale dealer provision of sales/credit, and revolving loan funds. Institutional models include energy service companies and government-concessions, for example as used in the South African rural electrification program.

Chaurey, A. and Kandpal, T.C. (2009) Solar lanterns for domestic lighting in India: Viability of central charging station model. *Energy Policy*, Vol. 37, pp. 4910 – 4918.

This paper examines the viability of the central charging station model for solar lighting in the Indian context. Several dissemination models for solar lanterns in the country are also analysed, most notably rentals and fee-for-service. The paper also studies the impact of kerosene price increases on the solar lighting industry in the country, and estimates subsidies to improve viability of the charging station model.

Chaurey, A. and Kandpal, T.C. (2010) Assessment and evaluation of PV based decentralized rural electrification: An overview. *Renewable and Sustainable Energy Reviews*, Vol. 14, pp. 2266 – 2278.

Focusing on photovoltaic mini-grids, but also decentralised standalone RE systems (covering micro-wind, micro-hydro and others), this paper produces a techno-economic and life-cycle analysis of decentralised rural electrification options for developing countries. Financing mechanisms analysed in the paper include fee-for-service through energy service companies, as well as community lending models from MFIs.

Chaurey, A. and Kandpal, T.C. (2010) A techno-economic comparison of rural electrification based on solar home systems and PV micro-grids. *Energy Policy*, Vol. 38, pp. 3118 – 3129.

This article examines the differing characteristics of solar home systems and PV micro-grids in a South Asian context, assessing the least-cost option for development in terms of life cycle costs. These assessments are made based on a fee-for-service and rental model for solar home systems, and an energy services company model for micro-grids.

Chaurey, A. et al. (2012) New partnerships and business models for facilitating energy access. *Energy Policy*, Vol. 47, pp. 48 – 55.

This paper examines new and innovative business models for energy access in the developing world, most notably public-private partnerships, and pro-poor public-private partnerships. Primarily focusing on solar home systems, the paper provides an overview at a global level of strategies for financing and institutional arrangements, as well as regulatory mechanisms, to support the development of partnership and business in order to facilitate energy access.

De Vries, M. et al. (n.d.) *Business models for energy access. Enabling Access to Sustainable Energy (EASE) Project report*. Available at: http://www.jatropha.pro/PDF%20bestanden/EASE-Business-models-for-energy-access-sm.pdf

This paper examines the project interventions of the EASE project in South-East Asia, South America and Sub-Saharan Africa. Thermal energy sources and products covered include improved cookstoves and biogas installations. The project summaries include a number of micro-finance initiatives, particularly in South Asia, and the challenges and responses for each.

Dei, T., Islam, A. and Khan, A.H. (2010) Current financial schemes of solar home system projects in Bangladesh and user's opinion. *Global Journal of Researches in Engineering*, Vol. 10, Iss. 6, pp. 51 – 55.

This paper analyses consumer opinion of three financing mechanisms for solar home systems and household biogas installations in Bangladesh. Financing mechanism covered are cash payments, micro-credits over a 24 or 36 months period, and monthly service charges (fee-for-service). Overwhelmingly, fee-for-service has the greatest positive opinion with users (70%), mostly for the public ownership retention of the system, with user opinion of forthcoming grid extension meaning a lack of will to be 'burdened' with a SHS when finally connected to the grid.

Friebe, C.A., von Flotow, P. and Täube, F.A. (2013) Exploring the link between products and services in low-income markets – evidence from solar home systems. *Energy Policy*, Vol. 52, pp. 760 – 769.

This article examines four Product Service Systems (PSS) for solar home systems in low-income markets: cash payments, micro-credits, leasing and fee-for-service. A key feature of this paper is highlighting the importance of service delivery in constructing sustainable business models, particularly in maintenance of the systems, and also the availability of consumer finance dependent on consumer income level. The paper remains focused on global low-income markets.

Glemarec, Y. (2012) Financing off-grid sustainable energy access for the poor. *Energy Policy*, Vol. 47, pp. 87 – 93.

This paper investigates off-grid sustainable energy financing from a global and technology-neutral perspective. Improved access to financing for the poorest consumers, as well as public-private partnerships to reduce the burden on the public purse for scaling of renewable energy access, are examined, as well as new financing sources, for example climate funding in the form of carbon finance.

Gujba, H. et al (2012) Financing low carbon energy access in Africa. *Energy Policy*, Vol. 47, pp. 71 – 78.

This paper predominantly focuses on supply-side financing mechanisms for developing low-carbon energy sources in Sub-Saharan Africa. Sources such as venture capital, equity capital, multilateral and bilateral funding agencies are examined, as well as consumer financing for bottom-of-pyramid users, highlighting the vibrant culture for micro-finance in Sub-Saharan Africa and its applicability to low-carbon energy technologies, citing solar home systems as an example.

Harish, S.M. et al. (2013) Adoption of solar home lighting systems in India: What might we learn from Karnataka? *Energy Policy*, Vol. 62, pp. 697 – 706.

The Karnataka case study examined in this article used micro-credit for solar home lighting systems, and also the role that micro-credit institutions play in solar home system management over and above the immediate financing, including ensuring operation and maintenance quality, focusing on the Indian state of Karnataka's context. The paper also describes methods of ensuring replicability of the success of the Karnataka model through program design, including matching the needs of business, financial institutions and consumers in design considerations.

IEA World Energy Outlook (2011) *Energy for all – Financing access for the poor. Special early excerpt of the World Energy Outlook 2011*. Paris, International Energy Agency. Available at: http://www.iea.org/papers/2011/weo2011_energy_for_all.pdf

This report examines a wide range of technology options for on- and off-grid electrification in developing countries, as well as LPG stoves, biogas systems, and improved cookstoves, in a global context. Specific financing approaches are examined for each sector and technology choice, and sources of financing are also examined, covering government, multilateral/bilateral development groups, and the role of the private sector.

International Energy Agency (2003) *Summary of models for the implementation of solar home systems in developing countries*. IEA Photovoltaic Power Systems Group, March 2003. Paris, International Energy Agency. Available at: http://iea-pvps.org/index.php?id=155andeID=dam_frontend_pushanddocID=206

This report provides a comprehensive summary of the state of solar home system (PV) financing in developing countries at the time, covering cash sales, credit schemes and fee-for-service models, and the advantages, disadvantages and risks of each. Examples are provided from Sub-Saharan Africa, South-East Asia and South America.

Kariuki, P. and Rai, K. (2010), *Market survey on possibly co-operation with finance institutions for energy financing in Kenya, Uganda and Tanzania*. GVEP International/USAID. Available at: http://www.gvepinternational.org/sites/default/files/financial_institutions_market_study_in_east_africa_2010_gvep_international.pdf

This report presents case studies from three Sub-Saharan African countries: Kenya, Uganda and Tanzania, of micro-finance institutions and their experiences in energy product financing. The majority of cases focus on solar technology (mostly PV), but biogas and micro-hydro cases are also included. A discussion of the PRET model in Tanzania as an innovative lending model is also included.

Krithika, P.R. and Palit, D. (2011) *Review of alternative participatory business models for off-grid electricity services. OASYS South Asia Project Working Paper 9*. Available at: http://oasyssouthasia.dmu.ac.uk/docs/oasyssouthasia-wp9-mar2011.pdf

This working paper offers a review of business models for off-grid electricity services, focusing on solar home systems in the Sub-Saharan African and South Asian markets. Models covered include electricity distribution franchises and concessions, fee-for-service/ESCO models, community-managed off-grid systems, and public-private/purely private models. Country contexts include India, Nepal, Zambia and Sri Lanka.

Lemaire, X. (2009) Fee-for-service Companies for Rural Electrification with Photovoltaic Systems: the Case of Zambia, *Energy for Sustainable Development*, 13, pp. 18-23.

The paper surveys three small Energy Service Companies (ESCOs) that have been established in the Eastern Province of Zambia in 1999 and managed at that time each 100-150solar home systems. This case, even with its limitations, showed that a well-articulated public-private partnership can deliver a cost-effective energy service in rural areas.

Lemaire, X. (2011) Off-grid electrification with solar home systems: The experience of a fee-for-service concession in South Africa, *Energy for Sustainable Development* (special issue on Rural Electrification), 15, pp. 277-283.

South Africa launched in 1999 an ambitious off-grid solar electrification programme with fee-for-service concessions. This paper focuses on operational and design issues linked to the implementation of fee-for-service concessions. Even in a challenging institutional context, some South African operators seem almost able to reach their break-even point. The case of one concessionaire is detailed and serves as a basis for a discussion on the benefits and difficulties linked to the fee-for-service model and on the potential for replication.

Lemaire, X. (2014) Increasing energy access in off-grid rural areas of developing countries**.** Section 4. Chap 15. In *Sustainable Energy Solutions in Agriculture*. Ed. Jochen Bundschuh and Guangnan Chen. New York: CRC Press – Taylor and Francis Group.

This chapter focuses on the way to deliver energy services in rural areas of developing countries in the most cost-effective way, focusing on the policies, regulation and business models needed for the large-scale implementation of now mature small-scale electricity generating RETs; it also briefly introduce energy generation as by-product of farming activities.

Lemaire, X. (2018) Solar home systems and solar lanterns in rural areas of the Global South: What impact? In WIREs Energy and Environment, Vol 7 (5), September/October, pp. 1-22

Relying on a review and the analysis of 98 surveys, this paper shows that the research on the impact of small solar systems contradicts the commonly accepted idea that small solar systems—due to their limited capacity—cannot have an impact in terms of development.

Lighting Africa – Women Initiative (2013) *Financial institutions role in the uptake of solar lighting in Kenya – models, challenges, recommendations*. Washington D.C., Lighting Africa. Available at: http://lightingafrica.org/wp-content/uploads/2014/03/The-Role-of-Financial-Institutions-in-Uptake-of-Solar-Lighting-by-Women-in-Kenya.pdf

This report primarily assesses the key challenges faced by financial institutions in increasing access to solar lighting products and services in the Kenyan context. Of particular interest is the provision of 15 case studies and business profiles for MFIs operating in the Kenyan solar lighting market.

Lighting Africa (2010) *Solar lighting for the base of the pyramid – Overview of an emerging market*. Washington D.C, Lighting Africa. Available at: http://www.ifc.org/wps/wcm/connect/a68a120048fd175eb8dcbc849537832d/SolarLightingBasePyramid.pdf?MOD=AJPERES

This report examines the global market for bottom-of-pyramid user solar lighting use, covering the current state of the market, expansion forecasts, product ranges, and expansion challenges. While not directly assessing financing models, a key barrier identified is the high up-front cost of solar lighting products for a large proportion of users, and also on the distribution side, a lack of credit for business expansion activities.

Mills, B.F. and Schleich, J. (2009) Profits or preferences? Assessing the adoption of residential solar thermal technologies. *Energy Policy*, Vol. 37, pp. 4145 – 4154.

The considerations in residential adoption of solar thermal systems in Germany are examined in this paper. Geographic, residence and household characteristics, including demographics and settlement morphology are assessed, as well as potential differential adoption by various socio-economic groups. The relative impact of household energy expenditures is also assessed with and without solar thermal technologies.

Monroy, C.R. and Hernandez, A. (2008) Strengthening financial innovation in energy supply projects for rural exploitations in developing countries. *Renewable and Sustainable Energy Reviews*, Vol. 12, pp. 1928 – 1943.

This paper takes a global, technology-neutral overview of financing mechanisms for renewable energy supply to rural areas, focusing on project-level financing. A global survey of critical factors in renewable energy project success is followed by recommendations for strengthening capacity for innovative financing mechanisms across all economic sectors, as well as an assessment of barriers to uptake.

Morris, E. et al. (2007), USAID. *Using microfinance to expand access to energy services: Summary of findings*. Washington D.C., USAID. Available at: http://pdf.usaid.gov/pdf_docs/PNADM641.pdf

This report analyses the role of microfinance in a global developing world context for energy service access, covering Asia, Africa and Latin America and the Caribbean. The context for microfinance in each region is examined, and major findings for each region are presented, including assessments of the most relevant business/financial models and microfinance products for each region.

Mukherjee, A. (2004) *Engaging communities in public-private partnerships in the delivery of basic services to the poor: Inter-country models and perspectives*. Bangkok, U.N. E.S.C. Asia/Pacific. Available at: https://publications.qld.gov.au/storage/f/2014-02-05T05%3A31%3A28.296Z/mukherjee-dr-amitava-final.pdf

This report analyses pro-poor public-private partnership models across the energy, biodiversity and water sectors, as well as in the provision of anti-retroviral drugs, in the South and South-East Asian context. Community engagement is the key factor assessed in the report, and findings indicate that combining the authority and credibility of the public sector, with the human capital of consumers and the financial/entrepreneurial expertise of the private sector, can lead to greatly improved service provision.

Nfah, E.M. and Ngundam, J.M. (2012) Identification of stakeholders for sustainable renewable energy applications in Cameroon. *Renewable and Sustainable Energy Reviews*, Vol. 16, pp. 4661 – 4666.

Examining the Cameroonian context for off-grid sustainable energy applications, this paper analyses several previous wind, micro-hydro and solar PV projects in the country, and identifies stakeholders in the renewable energy sector to target for improved project sustainability. The lack of fee-for-service options as well as financial weakness in existing MFIs, were identified as key barriers to off-grid RE system uptake. The paper also addresses capacity issues in government and implementing agencies, recommending technical training and capacity building measures.

Palit, D. and Chaurey, A. (2011) Off-grid rural electrification experiences from South Asia: Status and best practices. *Energy for Sustainable Development*, Vol. 15, pp. 266 – 276.

Examining the experiences in off-grid electrification in South Asia, the authors provide a comparative analysis of mini-grid and stand-alone system uptake, sustainability and financing. Micro-lending at the household level is the main financial mechanism examined, but the paper also suggests best practices in tariff regulation for mini-grids and cross-subsidising to ensure financial sustainability. Technology options examined are solar PV mini-grids and SHS, as well as micro-hydro mini-grids.

Palit, D., Malhotra, R. and Kumar, A. (2011) Sustainable model for financial viability of decentralized biomass gasifier power projects. *Energy Policy*, Vol. 39, pp. 4893 – 4901.

This report focuses on constructing a sustainable model for biomass gasifier power projects, predominantly in the Indian context. Financial viability of micro-enterprise is the primary goal of the model, and the paper suggests extending tariff fixation in a regulatory context to off-grid systems in India, enabling micro-enterprise to operate on a more financially sustainable basis by regulating electricity pricing.

Palit, D. (2013) Solar energy programs for rural electrification: Experiences and lessons from South Asia. *Energy for Sustainable Development*, Vol. 17, pp. 270 – 279.

This paper examines rural electrification through SHS in the South Asian context, focusing on the IDCOL program in Bangladesh, the activities of TERI in India, the EASP program in Nepal and the RERED program in Sri Lanka. An in-depth analysis of service delivery models is provided for each case, as well as access to finance through micro-credit and fee-for-service models.

Palit, D. et al. (2013) The trials and tribulations of the Village Energy Security Programme (VESP) in India. *Energy Policy*, Vol. 57, pp. 407 – 417.

The Village Energy Security Programme in India covered a range of electrical and thermal energy options, including biomass gasification, biogas generation and improved cookstoves, as a method of creating integrated solutions to village energy needs. The difficulties faced by the program are assessed, and financing recommendations include promoting productive use of energy to increase consumer buy-in to the program, and setting tariffs at a rate to ensure the least-cost status of the sustainable option.

Pantaleo, A. et al. (2014) ESCO business models for biomass heating and CHP: Profitability of ESCO operations in Italy and key factors assessment. *Renewable and Sustainable Energy Reviews*, Vol. 30, pp. 237 – 253.

This paper presents several options for ESCO business models for biomass heating and combined heat and power operations in an Italian context. Various sectors of the economy are assessed and presented as case studies, including industrial use, the residential sector and the services/tertiary sector. The paper predominantly assesses BOOT (build-own-operate-transfer) contracts as a financial model.

Pode, R. (2013) Financing LED solar home systems in developing countries. *Renewable and Sustainable Energy Reviews*, Vol. 25, pp. 596 – 629.

This paper focuses on the experiences with micro-finance institutions and fee-for-service models in South-East Asia and Sub-Saharan Africa, considering solar home systems using LED lighting. The paper covers best practice for financing per-region, and examines cases across South-East Asia, and in Eastern, Western and Southern Africa, notably Kenya and Ghana.

Rai, K. and McDonald, J. (eds) (2009) *Cookstoves and markets: experiences, successes and opportunities*. London, Global Village Energy Partnership. Available at: http://www.hedon.info/docs/GVEP_Markets_and_Cookstoves__.pdf

This report from the Global Village Energy Partnership examines market opportunities for clean cookstoves in developing countries, and offers a range of case studies in the Sub-Saharan African and South Asian contexts. Scaling cookstove operations with carbon finance, creating indigenous production capacity in developing countries for clean cookstoves, and LPG stove accessibility for bottom-of-pyramid users are all assessed in the case studies presented.

Rao, P.S.C. et al. (2009) Energy-microfinance intervention for below poverty line households in India. *Energy Policy*, Vol. 37, pp. 1694 – 1712.

Proposing a new structure for microfinance interventions for bottom-of-pyramid users in the Indian context, this paper examines a two-fold structure for new MFIs – an energy-expertise organisation, and a financial-expertise organisation, collaborating on project implementation. Technologies targeted for these interventions are solar lighting charging points, solar lighting home systems, and improved cookstoves.

Roshchanka, V. and Evans, M. (2016) Scaling up the energy service company business: market status and company feedback in the Russian Federation. *Journal of Cleaner Production*, Vol. 112, Part 5, pp. 3905 – 3914.

This paper presents the Russian experience with using Energy Performance Contracts (EPCs) to enable ESCOs to operate in the public sector to improve energy efficiency. The Russian case is unique given the huge energy savings potential in the public sector, along with rapidly-increasing energy prices. The paper focuses on the policy environment that ESCOs operate under in the country, as well as examining the reasoning behind the awarding of multiple, smaller contracts to multiple ESCOs, rather than large, long-term contracts, for energy efficiency improvements in public buildings.

Sovacool, B. (2013) Expanding renewable energy access with pro-poor public private partnerships in the developing world. *Energy Strategy Reviews*, Vol. 1, pp. 181 – 192.

Presenting eight case studies from a variety of developing world contexts, this paper makes the case for pro-poor public-private partnerships as a way to mobilise financing for renewable energy access. These case studies cover traditional cash payment models, fee-for-service schemes, as well as mixed-finance and donation models, where government/public sector institutions finance systems for energy service companies. The paper remains technology-neutral, but cases focus on solar home systems.

Srinivasan, S. (2005) Solar home systems – offering credit and ensuring recovery. *Refocus*, Vol. 6, Issue 1, pp. 38 – 41.

Focusing on the Indian context, particularly the Southern states, this paper examines the risks inherent to micro-finance institutions in offering credit to low-income consumers, and investigates pre-payment systems as a way to mitigate risks to financial institutions as a way to stimulate the solar home system market.

Thabet, I. (2014) Business model for solar water heaters development in the residential sector – Tunisian experience. *Presentation at IRENA Workshop on Business Models for Renewable Energy Deployment in Cities*, Abu Dhabi, United Arab Emirates, 22nd January 2014. Abu Dhabi, International Renewable Energy Agency. Available at: http://www.irena.org/documentdownloads/events/2014/march/12_Thabet.pdf

This presentation examines the PROSOL project in Tunisia and its role in increasing access to solar water heating. The PROSOL model uses on-bill financing through the state utility, or an energy service company operating on behalf of the state utility, as a loan to the user for solar water heating installation and use. This is complimented by a public investment subsidy to provide SWH systems to installers and suppliers. Quality assurance is a key aspect of the program, with investment subsidies only paid on accreditation of performance of the installed system.

Trivella, U. (2014) *Energy finance business model development – the Reduction Expense Energy Product Delivery Model (REEP-DEMO)*. Presentation at Fondazione Giordano Dell'Amore Green Microfinance Thematic Workshop, Milan, Italy, 8th July 2014. Available at: http://www.fgda.org/dati/ContentManager/files/Workshop/Green%20MF/Trivella-[Microfinanza-Srl].pdf

This presentation focuses on the EU New Financial Products for Sustainable Development program in Sub-Saharan Africa, which sought to strengthen the distribution of renewable energy technologies through MFIs. The REEP-DEMO model focuses on re-characterising microfinance as a reduction of expense on energy product, rather than a standard loan. Pricing for the loan is set at less than households' previous energy expenditure as an incentive, with a long instalment period to incentivise MFIs to disburse further products.

UNDP-GEF (2004) *Solar photovoltaics in Africa – Experiences with financing and delivery models*. New York, United Nations Development Program. Available at: http://www.undp.org/content/undp/en/home/librarypage/environment-energy/sustainable_energy/solar_photovoltaicsinafricaexperienceswithfinancinganddeliverymo/

In a pan-African context, this report offers experience with user financing, company financing and financial institution financing for solar photovoltaic projects. Consumer finance options covered include modular system purchase, hire purchase, consumer loans and revolving credit, and micro-finance initiatives, as well as more traditional subsidy models. Company-to-company credit lines and downstream financing for SMEs are also examined.

UNDP/UNCDF (2013) *CleanStart: Microfinance opportunities for a clean energy future. New York, United Nations Development Program*. Available at: http://www.uncdf.org/sites/default/files/Documents/cleanstart_publication.pdf

This report summarises the UNDP/UNCDF CleanStart program, offering US$26 million globally to promote microfinance institution creation and support for renewable energy programs. The paper goes into detail as to the implementation of sustainable microfinance from a global perspective, and in adding value to microfinance services, for example through carbon financing, as well as the co-benefits of renewable energy uptake in developing countries from a personal economics perspective (increased time availability, reduced household energy expenditure, and reduced healthcare expenditure for example).

United Nations Environment Programme, MacLean and Siegel (2007) *Financing mechanisms and public/private risk sharing instruments for financing small scale renewable energy equipment and projects*. New York, United Nations Environment Program. Available at: http://www.relwa.org/sites/default/files/Financing-Mechanisms-SSRE-UNEP-Report.pdf

This paper seeks to summarise experience in small-scale renewable energy finance, covering consumer, business and project financing. Focusing on the South Asian context with case studies of Indonesia, Bangladesh, India and China, the paper discusses financing for solar PV systems, solar home systems (both electric and thermal), household biogas and improved cookstoves, as well as thermal energy applications for agribusiness.

World Bank South Asia Energy Unit (2010) *Empowering rural India: Expanding electricity access by mobilizing local resources – analysis of models for improving rural electricity services in India through distributed generation and supply of renewable energy*. Washington D.C., World Bank. Available at: http://siteresources.worldbank.org/INDIAEXTN/Resources/empowering-rural-india-expanding-electricity-access-by-mobilizing-local-resources.pdf

This report examines the distributed generation and supply model for rural electricity access in India. Three approaches are examined – a feed-in tariff model, a rural distribution franchise, and a distribution and generation franchise (utility) model. Technologies assessed include biomass power and small-hydro, with an in-depth economic viability analysis for each technology option.

World Bank (2008) *Designing sustainable off-grid rural electrification projects: Principles and practices*. Washington D.C., World Bank. Available at: http://siteresources.worldbank.org/EXTENERGY2/Resources/OffgridGuidelines.pdf

This World Bank report offers guidelines for sustainable design of off-grid electrification projects in rural areas of developing countries. Business models covered are focused on solar PV micro-grids and home systems in a global developing world context, are consist of dealer models (direct purchase) and energy service companies operating on a fee-for-service basis.

Zerriffi, H. (2011) Innovative business models for the scale-up of energy access efforts for the poorest. *Current Options in Environmental Sustainability*, Vol. 3, Issue 4, pp. 272 – 278.

This article covers both supply-side and demand-side financing for the scale-up of energy access for the world's poorest. Methods covered include improved credit facilities and access to cross-subsidies on the supply-side, and leasing/rental models, third party financing and services delivery models (for example, fee-for-service/ESCO models) on the demand-side.

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