Energy Service Companies (ESCOs) and S³IDF's Social Merchant Bank Approach[SM] (SMBA)

Economic Innovation in the Service of Bottom of the Pyramid Entities

Russell J. deLucia, President and Executive Director, S³IDF
Nikhil Desai, Pro Bono Advisor, S³IDF
delucia@s3idf.org and ndesai@alum.mit.edu

Abstract

There are huge potentials in increasing energy efficiency and reducing climate pollutants at the "Bottom of the Pyramid" (BOP) – the more than three billion people still dependent on traditional unprocessed solid fuels (biomass, coal) and the micro- and small-scale enterprises (MSMEs) they engage in. These "ecosystems of energy poverty" have two avenues of efficiency improvements: via transition to modern energy and then, using them more efficiently. The transformative impacts of modern energy come primarily from the changes in the "productive" sphere. These MSMEs frequently are "informal" entities, i.e., outside the reach of formal financial and administrative networks and have limited access to information. Therefore, proactive interventions covering various elements of technical and financial intermediation are needed for their transformation via cleaner, more efficient energy use. We build on three main premises: i) productive uses of modern fuels require equipment investments at the end user level; ii) BOP entities of which the poor are variously owners, employees, and customers, have structural difficulties investing in such productive uses; and, iii) this leaves them dependent on inefficient energy use and limits their growth potential. Promotion of modern energy transition and efficient use also leads to significant climate protection benefits via sharp declines in non-CO_2 greenhouse gases (GHGs) and black carbon. We provide illustrations of explicitly pro-poor interventions that help achieve these efficiency potentials and related reductions in emissions of climate pollutants, and outline the non-profit, the Small-Scale Sustainable Infrastructure Development Fund, Inc. (S³IDF), and its paradigm-shifting Social Merchant Bank Approach[SM] (SMBA) for addressing "energy poverty" challenges. Finally, we discuss options for applying the "Energy Service Company" (ESCO) concept for productive transformations of BOP enterprises, an area where ESCOs have largely been absent. We present this innovation in the context of adding a for-profit (albeit limited profit) ESCO into the SMBA toolkit.

Introduction[1]

Impressive gains have been made in extending modern energy (see definition) services to the masses in the developing countries (see definition) – some 4.5 billion people now have access to grid electricity, and some 2.6 billion people have, more or less, stopped using unprocessed solid fuels, compared to fewer than 0.5 billion people at the end of the Second World War under each category. However, about 1.3 billion people still lack access to grid electricity, another 1.3 billion have such access only on an intermittent and unpredictable basis, and some

[1] Paper for the ECEEE (European Council for an Energy Efficient Economy) Summer Study on energy efficiency in industry, Arnhem, 11-14 September 2012. It draws on the authors' experiences with energy projects and dialogues on energy/poverty nexus since deLucia (1990), *The Energy Dimensions of Poverty*. *Paper for the IFAD World Rural Poverty Study*. It also draws on discussions with colleagues at SELCO India, the Asian Development Bank, the Blue Moon Fund and USAID's South Asia Regional Initiative for Energy.

3.2 billion people still primarily rely on traditional energy for cooking and space/water heating.

Traditional energy use is inefficient in three ways:

i) the mix of fuels and energy conversion (combustion) devices is such that the useful energy extracted is a small fraction of the primary energy supplied (e.g., traditional wood fires, kerosene lighting);

ii) the services provided are more limited in application terms (compared to electric lighting, telecommunications or motorized transport) and limit human productivity; and,

iii) traditional heat and lighting combustion practices are hazardous in terms of safety or drudgery, produce emissions injurious to human health and leads to *additional* efficiency gains in productive processes and makes possible a wide range of activities that are just beyond the reach of traditional energy. (Note: It is important to keep the nexus of fuels and appliances together).

Consequently, the cleanliness, efficiency gains, and versatility of modern energy contribute to economic growth and healthier, more comfortable lives, as has happened for many people and communities in the developing countries.

Yet, evaluations of electrification programs repeatedly demonstrate that poorer people have enjoyed much less of these benefits. Similar observations hold for natural gas networks and the supply networks for LPG (liquefied petroleum gases) present in so many developing countries, not to mention networks of motor fuels (gasoline and diesel). Even where modern energy is available from a geographical standpoint, many people continue to rely on traditional energy or limit their consumption of modern energy.

To a significant extent, this is because even as the poor households make a transition to modern energy and enjoy the small amounts of electricity they can afford for final consumption, they have not been able to make such a transition for non-household activities that help generate incomes and investments in human capital. These activities include small-scale industrial and commercial enterprises and physical (transport, water supply) and social (health, education, administration) infrastructure services – collectively referred to as "BOP entities" in this paper (see definition).

The limits to modern energy transition and/or efficient use for these "BOP entities" are primarily due to scarcity of investment funds in the use of modern energy – e.g., the public investments in social or physical infrastructure are scarce, and/or the private sector entities are not "bankable." Non-economic barriers also play a part, but whereas subsidies are often available for new household access – grid or service connection – and even small amounts of household consumption, this is often not the case for the MSMEs or providers of other infrastructure services since they are assumed to run on commercial principles.

That is, the BOP "ecosystem" is comprised not just of households surviving on their own expenditures of US$1-2 per capita each day (see definition of BOP population), but also of BOP entities that have exceptional potential for transformation that can lead to incomes of $3-4 a day per capita and more.

Unless and until the transformational potential of modern energy – enhancing efficiency and productivity of all resources – is widely realized, the poor will continue to suffer energy inefficiency in two ways: as owners/employees in the BOP enterprises and as consumers of lower-quality goods and services from those enterprises. "Energy poverty" (see definition) at the household level is compounded by the "ecosystem of energy poverty" (see definition).

This characterization of energy efficiency (EE), where gains come from fuel switching, is consistent with the generally accepted concept of EE – reduction in unit energy requirements for a product or a service. It is just that in the developed countries, EE refers exclusively to reduction in modern energy requirements, including switching *among* modern fuels.

There has been little explicitly pro-poor attention to EE potentials and gains, perhaps due to plausible notions that the existing modern energy consumption at the BOP is insignificant and that EE investments are unaffordable. The minor exceptions are "improved" woodstoves or replacement of incandescent lamps by Compact Fluorescent Lamps.

An alternative perspective we subscribe to is seeing the poor as reservoirs of unrealized potential, and recognizing that EE gains to them from the transition to modern energy as well as *after* the transition, could help them afford the transformative benefits of modern energy. Such recognition, and the removal of the knowledge and financing barriers to EE not just from newer technologies for established purposes – e.g. cooking or lighting – but also from new uses the poor can adapt, is the starting point for this paper.

This emphasis on EE becomes more urgent as modern energy access is sought to be expanded to poorer geographical (urban and rural) locations, which are increasingly more remote and costlier to serve. Compared to the goals of EE at the "Top of the Pyramid" (TOP), which seek to reduce total energy consumption and related emissions, not just unit requirements, EE goals at the BOP need to explicitly allow for an *increase* in aggregate energy use for that segment, after the reduction achieved due to transition to modern energy use, because of the promise of a sharp increase in human benefits.

Scope of the Problem: Access and Efficiency

The UN has declared 2012 as the International Year of Sustainable Energy for All and discussions are underway to meet the goal of "universal access" by 2030. This is meant to cover electricity as well as non-electric fuels, and will require both deepening of access within the geographic areas where modern energy access is at least theoretically available, if not reliable, as well as geographic expansion of such access. Indicative estimates of the current status of modern energy access are provided in Table 1, based on UN and IEA data and adjustment using authors' familiarity with other sources of varying vintages. To meet universal access targets, the incremental population to be served by 2030 can then be calculated as below in Table 2 (UN population

Table 1: Developing Countries: Indicative Estimates of Modern Energy Access 2012

Billion population	Urban	Rural	Total
Electricity – reliable grid access	2.0	1.2	3.2
Electricity – unreliable grid access	0.5	0.8	1.3
Electricity – no grid access	0.2	1.1	1.3[b/]
Primary cooking fuel "modern"	2.2	0.4	2.6
Primary cooking fuel "traditional"	0.5	2.7	3.2[b/]
Total[a/]	*2.7*	*3.1*	*5.8*

Sources: a/ Based on UN World Urbanization Prospects 2011, with *interpolation to 2012*, http://esa.un.org/unpd/wup/CD-ROM/Urban-Rural-Population.htm. *b/ Based on IEA (2011) Energy for All: Financing Access for All*, adjusting 2009 estimates to 2012 and also covering non-biomass traditional cooking fuel use, http://www.iea.org/Papers/2011/weo2011_energy_for_all.pdf.

projections, subtracting current numbers).

While allowing that some population growth would occur in the households already served reliably, the pace of modern energy access would have to be accelerated several times beyond that observed in the past.

Table 2 Developing Countries – Modern Energy for All by 2030			
Billion population	Urban	Rural	Total
Total, 2030	3.9	3.1	7.0
Increment (from 2012)			
Reliable grid electricity	1.9	1.8	3.7
Other modern fuels	1.7	2.7	4.4
Source: *Aggregate population projection and urban/rural distribution from the UN as in Table 1 a/; other numbers derived on the basis of Table 1*			

In effect, what was achieved in the forty years between 1970 and 2010 will have to be achieved in twenty years, even though this would require i) serving increasingly remote locations with small, sparsely distributed, and unpredictable electricity and fuel demands, thus substantially increasing the costs of at least the network approaches (electricity grids, and fuel networks that cover the entire country), and ii) reaching progressively poorer households and locations of lower productive potential, thus diminishing the prospects for commercial viability.

To achieve these targets, UN has called upon the international community to provide about $1 trillion in capital finance. This does not include the investments required to upgrade the existing networks to meet the currently unmet demand or the growth in demand from the current customers.

While the financial requirements are debatable and certainly unrealistic, it is appropriate to ask why they appear unrealistic. To us, the basic answer is straightforward and can be explained in two parts:

i) the financing strategies generally employed so far for extending electricity access to the poorer segments have already led to huge subsidy bills and/or accumulated losses in the power sectors in many developing countries, with no money to meet the existing demands, let alone extend service to wider geographies and 20-50% more customers; and,

ii) while inappropriate subsidies are difficult to revoke, the underlying reason for their persistence is that electricity access has not adequately sparked the transformative process of economic growth and advances in human productivity that can, over time, reduce the need for consumption subsidies.

A similar argument can also be made about non-electric modern fuels, though the subsidy level and patterns vary a lot more, principally according to whether a country is a low-income oil producer and has public sector oil companies. In many countries, at least some of the petroleum products are taxed heavily, thus lowering the overall burden of cross-subsidy.

Indeed, it is perhaps reflective of the disappointment with productive uses of modern energy (see definition) among the poor that the UN calculations of investment requirements for access address *only* household access and consumption. This neglect of non-household consumption is a big dark spot in the effort to bring light.

Why has electrification failed to spark income growth and advances in human productivity in a broad-based fashion? We do not by any means wish to suggest that electrification has "failed" and divert attention away from the issue of why supplier revenues have not increased commensurate with the increases in supply costs or in customers' incomes, which is, at least in part, attributable to electricity and electricity-enabled services. The question is, simply, why is the "success" not more uniform?

The answer lies in examining "access" not simply in terms of households – as the UN and many other agencies advocating "energy for all" seem to be doing – but looking also at non-household consumption. The benefits of modern energy access extend far beyond substitution of basic household consumption from traditional energy. Except for some household BOP enterprises (see Photo #1), household electricity for the poor does not address productivity increases needed for poverty alleviation; it merely illuminates their poverty at night.

Photo #1: Household enterprise silk worm feeding and cocoon production access and financing for PV-based lighting system supported by S[3]IDF.

In order for electrification – or infrastructure service deliveries generally – to realize the fullest development potential of poor people who are subject to multiple other constraints (that electricity and modern fuels do not automatically relax) and "productive" activities (normally, but not necessarily outside the household), two key aspects must be considered:

i) With electricity-based income growth, it is possible to finance a larger, and steadier, quantum of consumption, thus making supply economics less risky and even achieve economies of scale, and,

ii) Electricity-based productive activities generate demand for labor services, often at steady rates and with higher skill requirements, providing an incentive for human capital investments (health, education) and administrative/ commercial support networks (communications, financial services).

But then the question becomes: why do productive activities not grow spontaneously across all groups and regions? Casual observation suggests that electrification in the urban and "connected" areas – in transport, commerce, administration, and communication – has sparked income and consumption growth. However, these benefits have occurred disproportionately to those among the "haves" who were the first to be able to pay for connection and to be *able to invest in appliances and equipment*. In other words, the users' capacity to match the supply investments determines whether productive activities are generated.

The poor lack these investment resources. Moreover, this inability frustrates the policy of subsidized tariffs. Sometimes the investment per unit of energy consumed is high – e.g., getting the basic electricity connection and internal wiring for a few lights. Sometimes it is quite the opposite – e.g., once having obtained an electrical connection (often because of liberal connection policies) and investing in a pump or a motor. As a result, even if the electricity tariffs are subsidized, the inability to invest in a pump or a motor limits benefits to the poor from such subsidies. Even when the tariffs – or LPG prices, for example – are not subsidized for commercial connections, the inability to make the commercially justifiable transition to modern energy defeats the intent in extending access. If electrification means more capital-intensive options such as pico-hydro or PV-based systems, the transitions to modern energy mean that the financial constraint is even still greater and there is still the matter of appliances or equipment.

In other words, energy poverty perpetuates income and other forms of poverty. When “BOP entities” – food/beverage processing, brick-making, stone-crushing, small metal and woodworking, small retail, solid waste management, drinking water and sanitation, local transport, schools, health posts and clinics – cannot transition to modern energy or cannot expand the use of modern energy, poverty continues, and so do pressures for price subsidies for consumption. In turn, these limit the investments in access expansion. A confluence of overlapping vicious circles means the poorest fall farther behind.

As the supply costs to new connections increase, and even more so with the frequently higher unit capital cost of clean electricity options using renewable energy, either higher price subsidies will be required to afford even small amounts of consumption or the price will be so high that anything much beyond the basic survival needs (for electricity, lighting) will be uneconomical. The answer lies in efficiency enhancements in modern energy use at both the household and non-household levels, taking into account not only the “first round” effects of unit cost reductions but the “second round” effects of economic growth and improvement in the stock and productivity of human capital (including labor conditions).

It has so far been implicitly assumed that non-household customers make the transition once the geographic area has been provided with grid electricity or petroleum fuel depots, for example. This is a severely limiting assumption, and the results show in the disproportionate distribution of modern energy benefits so far. Just because the secondary users are nominally for-profit does not mean they have the technical and financial resources to adopt modern energy services. The same applies to non-profit institutions.

Continuing with the assumption will only mean that the poor will remain poor because their “eco-systems” will also remain poor – high-cost, low reliability, low-quality products and services that also contribute to low-productivity human capital.

Recent data (Table 3) from the 2011 Census of India can be used to make some more specific observations. India is large and has a unique set of attributes in terms of overall financial and institutional strengths and weaknesses, but it is also diverse enough, especially at the BOP level, to represent many of the same characteristics found at the BOP level in other countries.

Using additional data from Census 2001 and other sources, we observe the following:

Our main observation is that the poor are stuck in the past on traditional energy. Some 167 million households with more than 800 million people, overwhelmingly (~88%) in rural areas, rely on traditional energy for cooking and heating. Some 80 million households or 400 million people, similarly rely on traditional energy for lighting.

Our second observation (based on other data; can be provided upon request) is that, despite some impressive gains in the last ten years in extending modern energy access, *the “haves” enjoy massive implicit subsidies, accruing mostly to the non-poor among them.* The resultant financial imbalances in the supply systems have jeopardized further expansion of access and also the reliability of service, hitting the poor more and/or more frequently.

Our third observation from this table is that household and housing conditions are changing. The proportion of "smaller" households has been increasing; housing stock and quality have grown rapidly and access to "safe water" has increased. Smaller families imply an increase in women's available time for activities other than child rearing. The housing changes imply growth in construction materials and labor demand, income growth, acquisition of household appliances, *in turn fueling the growth in energy demand from those who can afford it*.

Table 3: India 2011 Census – Household energy use patterns and other characteristics

Total no. of households (million)			Rural	167.8	Urban	78.9
	Household size			**Main source of drinking water**		
	= < 5	6 – 8	8+	Tap	Hand pump	Other
Rural	66%	27%	7%	31%	44%	26%
Urban	74%	21%	5%	71%	12%	18%
	Condition of housing units (m)			**Main source of lighting**		
	Good	Livable	Dilapidated	Grid electric	Kerosene	Other 2/
Rural	77	80	11	55.3%	43.2%	1.5%
Urban	54	23	2	92.7%	6.5%	0.8%
	Wall material 1/			**Main fuel for cooking**		
	Hard	Soft	Other	LPG/PNG	Other modern 3/	Biomass/coal 4/
Rural	55%	43%	1%	11%	1%	87%
Urban	86%	13%	2%	65%	8%	26%
	Waste water drainage			**Assets**		
	Closed	Open	None	Television	Mobile phone	Internet
Rural	6%	31%	63%	33%	94%	1%
Urban	45%	37%	18%	77%	93%	8%
1/ Wall material: Hard: Burnt brick, stone, concrete; Soft: Grass/thatch/bamboo, mud/unburnt brick, wood; Other: plastic/polythene, metal/asbestos sheets, other. 2/ "Other" lighting: Includes 0.5 % in rural and 0.2% in urban areas by solar, and also 0.5% in rural and 0.3% in rural with no lighting at all. 3/ Cooking: "Other modern" includes kerosene electricity,, and biogas 4/ Cooking: Includes firewood, crop residue, dungcake, coal, lignite, charcoal, and all other. LPG=Liquefied Petroleum Gases. PNG = Piped Natural Gas.						

Source: Census of India: http://www.censusindia.gov.in/2011census/hlo/hlo_highlights.html. Although for reasons of brevity, 2001 numbers are not shown here, they are available at the same website.

Our fourth and final observation is that technical opportunities exist to promote efficiency for BOP entities even at current prices – especially in productive situations and where electricity tariffs or LPG prices are not subsidized – and in the face of worsening shortages. And there are additional large opportunities for EE improvements in the "non-connected" world – *by transition to modern energy and making this transition affordable, especially where electricity supply – self-generation via isolated renewable resources or diesel – may be higher cost.*

Together, these changes show a complex interplay of the sources of modern energy demand and the impact of household and non-household consumption. The modern energy Indian "have-nots" – those without access and those suffering from electricity or fuel shortages – comprise about a third of the global household energy poverty. These "energy poor" of 21st century differ from those of fifty or even twenty years ago in that they are more numerous, less secure in farm activities, and more challenged by global competition. Conversely, their human capital development can benefit from "modern" education and health services – in turn enabled by modern energy services.

Energy Efficiency at the Bottom of the Pyramid

We note without further discussion that *some* areas of the developing world do have very little commercial activity or inter-household commercial transactions other than small trade in produce, occasional services of priests and midwives, or hired help in farms or homes. While infrastructure connectivity – transport and telecommunications – can and does grow commercial activities, we are concerned here more with those low-income areas that already have such connectivity, but where all or some of the households and non-household activities are without modern energy access or suffer from inefficient use of modern energy that limits their growth potential.

These "ecosystem" activities typically include small-scale or artisanal manufacturing, construction, retail commerce, waste management, as well as social services such as health, education, and law-and-order or other administrative services. These BOP entities can be publicly or privately owned, and are often significant employers of the BOP individuals (including, unfortunately, minors). If public, their finances are nearly always unstable; the situation is no different if they are private and nominally for-profit. Some of these entities have "upward" linkages in the value-added chain – for instance, manufacturing timber, bricks, or breaking stones for use in large-scale construction programs, drying crops to sell to larger agro/food processing enterprises, or feeding students in the higher education system. Some of the other hand-produced goods and services largely for local consumption include preparation of meals and beverages, and construction and maintenance of poor people's dwellings or water supply.

Many of these BOP entities are outside the reach of, or covered only in a limited way, by the formal finance and administrative service networks. Some of them are owner-employees (individual or family) and linked only to other similar informal enterprises (see definition). Their information and communication networks also tend to be weak and limited to local "word-of-mouth" practices or reception of radio and television. If they operate in remote regions and/or in areas vulnerable to extreme weather conditions (monsoon, winter), their market integration is further limited. It is not an exaggeration to say that access to, and consumption of, infrastructure services by these BOP entities is a binding constraint to the economic growth and human capital formation of the BOP households.

BOP entities are frequently trapped in a "low-level equilibrium" of inefficient technologies with high operating costs and low quality output because they do not have the knowledge and/or the financing capability to invest in new technologies that would be more efficient and improve output quality. Not all traps have to do with inefficient energy use, of course, but the transformation potential is particularly high with electricity because of its versatility and precise controllability which leads to a number of economic benefits, including better control of production quality and schedules (also for irrigation), product loss reduction (refrigeration), customer service (air-conditioning in a restaurant), removal of extreme drudgery, and, sometimes, a reduction in the need for or desirability of child labor. Even when there is a cost increase, the attendant benefits are extremely high-value – e.g., nighttime deliveries in presence of adequate lighting. Some benefits occur via use of information and communication technologies (ICTs) in education and health delivery. There is frequently a "snowball" effect of continuous expansion of electricity use, dependent only on reliable access and the users' investment capacity for electricity-enabled appliance use. In all these cases, end-use EE improves the growth potential and sometimes also the product/service quality.

Just as an electric light or a gas stove transforms the household dynamics of time use and gains in human capital, modern energy transition in BOP entities can change the product and labor market dynamics outside the home. Some new products are emerging to ease this transition.

For example, 'pico-solar' (with PV panels of 1-5 W) lanterns of various shapes, sizes, and capacity offer low-cost, convenient charging for LED (light emitting diodes) lights and mobile phones or other electronic devices. Mobile phones, in turn, are in turn used for entertainment (radio, audio, video), text communication, and internet access, including for financial transactions. Thus, not only do the pico-solar products improve the overall reliability and efficiency of lighting and mobile phone charging that can reach practically everybody who can afford kerosene and commercial phone charging, the use of mobile phones or other ICTs can have significant economic impacts. Financing the capital costs of high-quality pico-solar products – about $40-50 apiece ex-factory, though much less in bulk – and awareness about the products and suppliers are the major constraint, now that mobile telephony and internet access are getting much cheaper in many parts of the world.

A similar efficiency potential lies in the use of modern thermal energy technologies substituting for traditional combustion fuels and technologies – e.g., solar water heating, biogas, or emerging modern biomass technologies, stoves and cookers for commercial and institutional users in combination with processed solid biomass fuels such as pellets and briquettes that ensure cleaner combustion.

Even when electric lighting is from efficient fossil fuel generation and thermal energy use is from LPG or natural gas, the net GHG emissions per unit of useful energy obtained can be substantially lower than traditional energy generally regarded as "renewable." This is because traditional combustion of solid biomass – especially low-quality fuels used by the poor in uncontrolled fires – emits not just CO_2 but various non-CO_2 GHGs and black carbon, products of incomplete combustion (PICs), that are highly potent warming agents[2]. These same PICs are also dangerous health pollutants, by direct exposure or as precursors of ground level ozone. In other words, "renewable" biomass is not "GHG-neutral" and is certainly a health and safety hazard when combusted in traditional manner.

Crude "back of the envelope" estimates suggest that the likely total gross emissions of climate pollutants (including black carbon) from traditional fuel use are between 6 and 10 billion tons CO_2-equivalent (btCO_2-e) per year, using 20-year Global Warming Potentials or GWPs (more appropriate for short-lived species that have most of their warming impact within days and months and also because the health benefits are in the user's lifetime, not for their

[2] See for example USAID 2010, Black Carbon Emissions in Asia: Sources, Impacts, and Abatement Opportunities. Available at http://www.pciaonline.org/files/Black%20Carbon%20Emissions%20in%20Asia.pdf. Also see Kirk R. Smith and Kalpana Balakrishnan, *Mitigating climate, meeting MDGs, and moderating chronic disease: the health co-benefits landscape*. Chapter 4 in Commonwealth Health Ministers' Update 2009. Commonwealth Secretariat, London. Some unpublished research suggests that the unit GHG emissions from inefficient kerosene lighting are similarly severe, though the total volumes are not as high.

grandchildren a hundred years hence)[3]. At the lower end of the range, the estimates include only household use of woody fuels (at least 2 billion tons of wood equivalent per year). At the upper end of the range, they include guesses for non-woody biomass (e.g. dung), direct use of coal (mostly in Asia), and non-household uses (10-30% of the household use, depending on the region) of all such fuels, but exclude emissions of climate pollutants from traditional lighting or animal traction. (We note that the choice of period for GWPs is allowed by the international conventions. Similarly, treating gross carbon emissions from wood as sequestrable is a matter of empirical validation; IPCC guidelines require only that unsustainable wood extraction at the national level be reported under "land use changes." The non-CO_2 warming effect is so much more powerful that ignoring wood CO_2 emissions and using 100-year GWP still favors LPG substantially. Also, black carbon is not recognized as a warming agent in the UNFCCC, since uncertainties about the direction and magnitude of its effects were resolved only in recent years.)

By way of comparison, the total CO_2 emissions from fossil fuel use currently run at about 6 billion tons for the US and 9 billion tons for China[4]. Eliminating the poor people's traditional energy use entirely by zero-carbon fuels or electricity is not a viable option, any more than it is so for the other half of humanity or even the richest. Rather, substitution by fossil fuels – e.g., LPG or natural gas – and electricity, even if partially based on fossil fuels, leads to *net* reduction in GHG loadings because of the dramatic efficiency gains in the delivery chain or use. Again, crude estimates suggest that, for example, substituting LPG for open-fire wood combustion could reduce climate pollutant emissions by more than 95%; using 100-year GWPs, the decline is quite similar, a little more than 90%.

If the poor were left entirely to fend for themselves, reliance on traditional energy will continue, and emissions will grow along with population, from 6-10 btCO_2e to perhaps 10-12 btCO_2e by 2030, allowing for some efficiency improvements in traditional energy and resource constraints. Merely providing household access to the poor would not do much either because it would reduce their energy poverty, but not the income poverty, which can only come from increasing their productivity and employment in higher-value occupations which, in turn, require alleviating the energy poverty of the BOP entities. For both these transitions to occur on a sustainable basis, it is critical that modern energy use also be highly efficient at the BOP – in households and the ecosystems surrounding them.

S³IDF and its Social Merchant Banking Approach℠ (SMBA): a De-Facto Energy/Infrastructure Service Company for Alleviating "Energy Poverty"

S³IDF was formed by a group of development professionals in 2001 in response to the limitations of major development entities' paradigms for dealing with the challenges of providing energy and other infrastructure services to poor people. S³IDF's founders developed an investment-focused method to address these challenges, taking note that:

i. The vast majority of the poor are working poor with willingness and some ability and to pay for energy and other infrastructure services, provided that the services meet their priority

[3] See draft note "Household LPG Stoves Energy Efficiency and Climate Change Mitigation" (available from the authors).
[4] Adjusting the 2010 CO_2 estimates in the BP Statistical Review 2011 for 2012 – slightly lower for the US, higher for China.

needs;

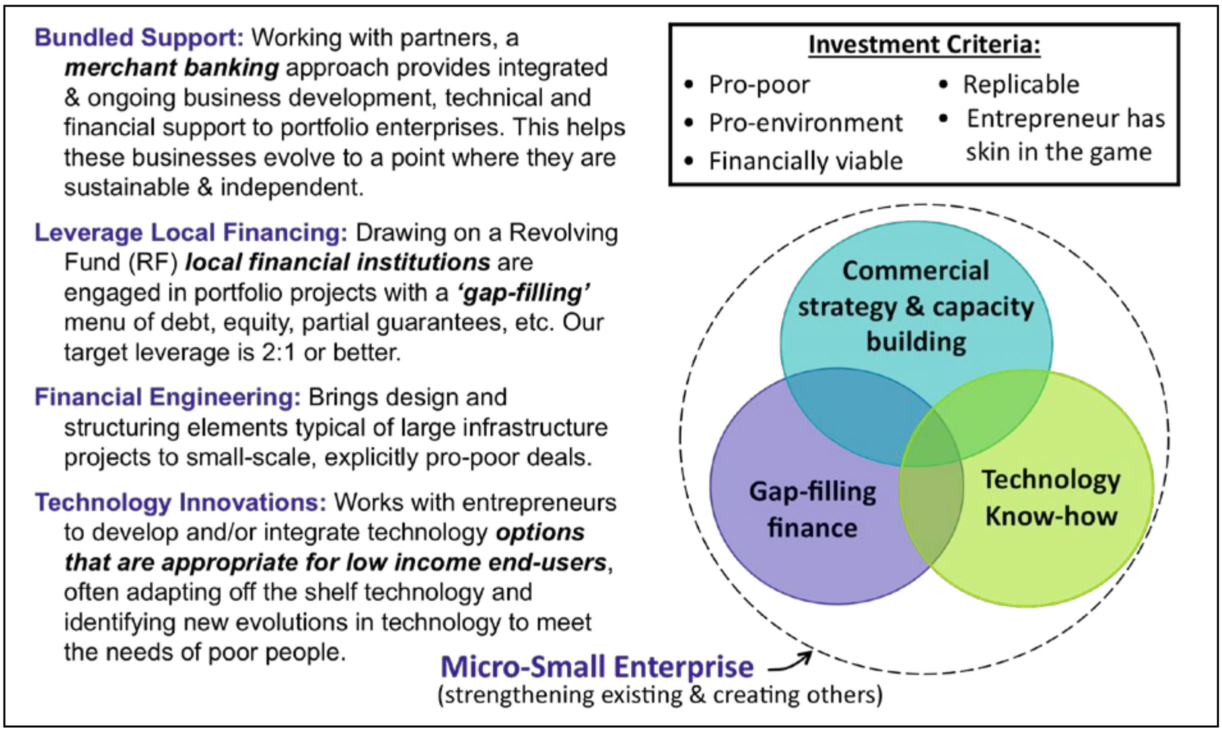
ii. For poverty alleviation to happen, simply supplying modern energy is insufficient; there must also be investments in productive use appliances and equipment;

iii. The materials and technology evolutions over the last generation have made small-scale and distributed energy and other infrastructure options much more cost-effective; and,

iv. The problem of the poor is more than the lack of access to adequate infrastructure services; they often lack access to financing, technology, and know-how (including business know-how) to organize and implement cost-effective and financially viable infrastructure and productive-use solutions.

The resulting method is a paradigm-shifting approach known as the Social Merchant Bank Approach^{SM} (SMBA). The SMBA addresses the problems facing poor people by simultaneously overcoming their lack of access to financing, technology and know-how. Together with its local partners**,** it fosters small, explicitly pro-poor investments and their associated micro and small enterprises (see definition) by bringing a bundle of technical, financial and business organizational innovations that are common in medium and large infrastructure investments to the development of a portfolio of explicitly pro-poor small-scale investments.

Figure 1: S^{3}IDF's Social Merchant Bank Approach^{SM} (SMBA).



The SMBA is summarized in graphic form in Figure 1. The characteristics of many of S^{3}IDF's interventions are analogous with those of various Energy Service Company (ESCO, see definition) business models operating in the US and elsewhere.

Such an approach, and the interventions it is applied to, is rare in small infrastructure projects that are *explicitly pro-poor in their intent as well as impact*. The investments S^{3}IDF supports must explicitly benefit the poor in one or more ways (for example, as customers, employees, asset owners), be environmentally responsible in their construct and operation, and operate in a financially sustainable fashion, including payment of loans of other forms of financing support (e.g. leases), from implementation onwards. Working with local partners (e.g., financial institutions and technology and know-how providers), S^{3}IDF creates and/or strengthens MSMEs that are *designed to be private and for-profit*. For the SMBA to be explicitly pro-poor, it needs to secure philanthropic or other non-commercial support, and therefore S^{3}IDF-US and its affiliate, S^{3}IDF-India, both have charity status. They do not earn profits to distribute; they are non-profit corporations operated like investment transaction-oriented businesses.

S^{3}IDF's SMBA provides "gap-filling" financing of needed types (debt, equity, partial guarantees) that makes viable, but often "non-bankable," small, pro-poor, energy and other infrastructure investments "bankable," leading to commercial co-financing by local financial institutions.

S^{3}IDF's SMBA was consciously designed to be widely applicable in pursuit of two mission objectives:

i. To employ its SMBA in India to build a pro-poor MSME investment portfolio with environmental benefits;
ii. To promote, disseminate and transfer its SMBA to achieve a broader and greater impact by enabling other sources to leverage philanthropic or development capital for local commercial co-financing for similar MSMEs

The characteristics of S^{3}IDF's SMBA include: involvement of local small private players (as opposed to large or international players); use of varying financial structuring; business and organizational approaches to ensure financial sustainability – just like those often employed by ESCOs elsewhere – but with a focus on other infrastructure services as well as energy services; engagement of financial markets and other development agents; investments all along the supply chain, from technology and know-how through to end-user investments and linked productive-use investments (e.g. grain mills); and, via clean energy investments, promotion of pro-poor environmental benefits.

Photo #2: A village-scale South Indian water purifications enterprise that S^{3}IDF helped open through financial, business development and technological services.

In its initial area of work in southern India (Karnataka and parts of adjacent states), S^{3}IDF implements its SMBA with two interrelated sets of operations. First, it undertakes (often with partners) the various pre-investment efforts in identifying and developing financially sustainable schemes that can meet its pro-poor criteria. Second, it operates a revolving fund (RF) that provides the "gap-filling" finance necessary to mobilize the necessary local finance, arranges the co-financing, and helps bring the investment to implementation. The pre-investment operations must be underwritten in whole or in large part with grants to meet the high transaction costs involved and the poor's inability to bear these costs. But as noted, from implementation on, the private investments supported are designed to be profitable, bearing all their costs, including financing costs, with the potential to accumulate and grow.

The SMBA generates its MSME deal flow by collaborating with local partners, activists, NGOs, academic groups, equipment suppliers, local banks and financial institutions. In India, this has resulted in a portfolio of more than 185 small investments deals and co-financing partnerships with more than a dozen banks and other financial institutions[5]. Similar collaborations are suggested when the SMBA is disseminated/transferred elsewhere.

The portfolio of 185-plus deals includes ones with hard investment costs ranging from a few hundred Euros to about tens of thousands Euros, many around five thousand Euros and a few in the many tens of thousands. The largest ones are for "last mile" grid electricity distribution franchisees.

The deals also vary in technology involved, complexity, and related gestation time. The household enterprise lighting for silk cocoon production shown above in Photo #1 is not complex and is straightforward in its replication. The deal shown in Photo #2 is more complex in multiple ways, including in technology sourcing, business model, and ownership and financing structuring. Another very different complexity is shown in Photo #3, which shows a cookshop for poor families located at a major urban hospital.[6] This investment combines a supply enterprise with one partner (the LPG supply company) and an organizational and operations enterprise partnership involving multiple partners (S^3IDF, the hospital, corporate and trust funders, and the operating micro-enterprise). While applicable to many other hospital settings, its complexity of partnering, deal structuring and fee-for service business model makes replication a significant challenge.

Finally, it warrants mentioning that an additional complexity is found when the technical solution for a particular infrastructure requirement utilizes a new variant/combination of existing technologies and equipment. For example, consider a new rural "multi-service center" that is powered by PVs or other renewable energy-based sources and provides ICT and other services to communities or groups of people. This "multi-service center" is a project type that is currently being developed by a S^3IDF partner. In going forward with "commercial"

Photo 3: S^3IDF worked with strategic partners, hospital administrators and other key players to implement this cookshop in the 2000-bed Osmania General Hospital. Families pay an hourly fee for use of the LPG connections

[5] S^3IDF's working hypothesis, verified in south India and elsewhere, is that financing small-scale infrastructure investments is within the capability of local banks and other financial institutions (for example, some credit and savings co-operatives and micro-finance institutions).

[6] Family members come from both the city and surrounding areas to visit family members in the hospital, often spending days. Prior to the cookshop, they cooked their meals over open fires in an area of the hospital compound. They would purchase fuel-wood and food from local vendors. Similar situations are common at other public hospitals and clinics serving the poor.

versions of this type of new project, the early business model and financial structuring must consider more aspects of risk mitigation than in investments already in "replication" mode. This generally will entail longer gestation periods and possible revision of the business model and financial structuring until the project type is ready for "replication" with only modest changes reflecting community site particulars.

In India, S^3IDF operates a revolving fund (RF) that provides the "gap-filling" finance necessary to mobilize local co-finance. In most other situations, however, it would be better if the RF were hosted by a complementary private financial institution; this has been the design in S^3IDF SMBA dissemination and transfer efforts in East Africa, Nepal and Sri Lanka and will likely be recommended for forthcoming efforts elsewhere.

Also, in India and elsewhere, other specialized partners operate under an "organizational umbrella" which can be helpful in various ways, including accessing capital. For example, a for-profit (albeit low profit) ESCO operating in partnership with the non-profit S^3IDF can allow access to other sources of entity capitalization. This capitalization could come from investors from the impact, social, development or philanthropic (program related investors) classes. Such investors should have an interest in S^3IDF's pro-poor mission, but want to support a for-profit business that will only return well below risk-adjusted market rates of return on investment.

The SMBA characteristic of mobilizing such local financing to leverage external or local philanthropic and/or development finance is a critically important dimension of this paradigm shifting approach. *There is simply not enough development and philanthropic capital to meet the challenges of providing energy and other infrastructure services and related linked productive-use investments necessary to escape from the vicious trap of poverty*. In order for local financial institution co-financing to happen, given the "business as usual" (BAU) mindset of banks and other financial institutions and the realities of the poor and their MSMEs employers, the necessary development finance (whether from S^3IDF or others) must include a menu of financing types: debt (primary and secondary), equity and partial guarantees or other credit conditioning instruments. Experience suggests that partial guarantees are the most useful of the financing types but should often be used in combination with other types.

This type of financing must be deployed in a "gap-filling" manner along with the type of investment financing and ownership and risk mitigation structuring that ESCOs make possible, along with documentation of the potential investment. This is taken to the banks/financial institutions for debt finance, making previously "non-bankable" investments into "bankable" ones. This part of the SMBA allows bank co-financing to flow either directly to the user or through the ESCO, with subsequent financing distributed under a workable arrangements such as lease financing.[7]

ESCOs for "Ecosystem Energy Poverty" Alleviation Using SMBA

A pro-poor ESCO (see definition) combines financing of physical investments with technical guidance and management services to achieve energy cost reductions, with an explicit target of a limited profit rate. While the ex ante target profit rate may not be realized due to a variety of uncertainties and risk factors, a for-profit designation is crucial for attracting social impact investors; qualifying, in India for instance, for depreciation benefits that enhance the cash

[7] In India, there are special accelerated depreciation benefits for clean energy investments. MSMEs in the informal sector cannot capture these depreciation benefits, but for-profit ESCOs or corporate partners can, under special structuring arrangements.

flows and allow ownership structures that transfer those benefits to corporate partners who have Corporate Social Responsibility (CSR) programs; and allowing monetization of benefits beyond the reduction in energy costs (e.g. carbon). A greater-than-expected profit rate – if risks fail to materialize – can be contractually returned to the user, or, subject to agreements with financing partners, ploughed back in the ESCO's RF.

An ESCO does not have to invest in physical assets; but BOP users rarely have the requisite financial resources for such investments (or to get debt finance) or are reluctant to invest for risks of failure with an unfamiliar technology. In principle, an ESCO, however, can get around that barrier by obtaining debt based on its balance sheet or with guarantees or other credit conditioning. Depending on the local social and legal context, a SMBA-type ESCO does not have the same legal standing of a bank and may be much constrained in enforcing finance contracts. It may thus lose not only equity but also debt (whether provided by itself, or acting as an intermediary) because, unlike banks, it cannot recover part of the unpaid debt by collecting on the collateral. These risks are all the greater in the case with BOP entities where legal re-possession of assets for non-payment is problematic in multiple aspects.

These risks can be largely mitigated when the EE assets are held in the premises owned by the ESCO, and services are offered on a "tolling" or "fee-for-service" basis; or when the ESCO has a network of partnerships with the equipment providers and/or providers of ongoing inputs to the user (e.g., fuel or electricity but could be anyone who has the ability and an interest to terminate such supplies in case of payment default by the user). This will involve longer pre-investment periods and higher transaction costs but may be worth undertaking if setting a basis for a subsequent scale-up.

Consider some typical examples of productive uses of modern energy that improve energy use efficiency as animate or natural solar energy is substituted by grid electricity (whatever the generation source) or solar PV electricity or specially organized use of "passive solar," and also improve production values for poor farmers. These are *not* technical innovations – much of the equipment, including PV, is familiar in many rural areas; they are examples of institutional and economic innovations.[8]

a) Post-farming[9] operations with easy, reliable access to grid power: These can include crushing, grinding, juicing, milling of a variety of agricultural product. In turn, these 'modern' operations avoid produce loss, lower price realization of primary product when selling to middlemen at farm-gate or marketing centers, and open up the possibilities of on-site packaging, canning, bottling. Further value addition may also come from utilizing the waste as fuel or selling it as fuel.
b) Post-farming processing without grid power: Some mechanical operations can be done by people, but there may still be room for a quantum increase in product quality and marketable value by applying simple technologies such as covered air-drying with fans (powered by solar PV) or somewhat advanced ones such as the use of high-temperature heat (solar or advanced biomass or LPG) for drying or feed preparation.
c) Food and meals preparation: Despite the entry of large-scale food products production and retail commerce, small-scale home-based, collective, or commercial food/meal/beverage outfits have grown both in low-income urban neighborhoods and in

[8] For brevity, we ignore cases where users' investments in replacing existing equipment with more efficient one will reduce unit energy use and improve output quality. This approach – the conventional ESCO model – may also be used for the BOP entities.
[9] "Farming" is meant to include silviculture, horticulture, and other land and water-based organic production.

towns. At the BOP level, this is driven in part by the growth in migrant and transient labor – from cities and villages alike – in response to the growth in construction industry and other unskilled or low-skilled labor. Smaller families and greater labor force participation by women also means that – as in the developed countries – women in all income and family size groups have less time to cook full meals; however, at the BOP level, especially outside cities, cooking becomes an even more substantial domestic burden. In addition, commercial food/meal/beverage-making continues to rely on traditional energy, which is not only inefficient, increasingly uneconomical at the prices for commercial wood and charcoal.

At the BOP level, no single customer would have an initial scale of operation that would justify capital investments at high level of utilization. Aggregation of energy service at a single location – via a cooperative or other legal constructs – is then necessary; leasing to individual users is too risky. Transport alternatives would determine the economic radius for the service center, which can take the "fee-for-service" or "tolling" approach, with some or all payment possibly "in kind" and realized when the product is sold. Other contractual alternatives are possible.

EE promotion may also improve the supply economics – e.g., small village-level grids based on local hydropower or hybrids of renewable sources and diesel when the productive uses add to the daytime demands, and lighting efficiency improvements reduce the peak load. *If network extensions just for small power uses are not economical, battery charging for LED lighting and other small uses can also similarly improve the supply economics.*[10]

The conventional "supply side" literature of modern energy access – or clean energy promotion – typically ignores i) prior existence, or absence, of property and other wealth that is used for personal investments in the productive uses, ii) exposure to technologies and supply chains including those of finance, iii) a skill-base appropriate for the activity at hand, and iv) entrepreneurial preparedness (in turn influencing risk management options available and used). The non-poor do not suffer these handicaps; hence the disproportionate gain in benefits by the elite.

A SMBA ESCO can incubate and strengthen local commercial profitable entities. It often takes a combination of local and foreign expertise and experience to put together a web of partners – commercial and otherwise – to nurture such entities and capitalize on local knowledge of opportunities and constraints. Profitability is important for accumulation and resilience to risk; it facilitates engagement with local banks. And the deepening of financial services via such business development is, in the long run, perhaps the most significant contribution to development.

Assuming initial equity capitalization, the scenario for implementation of a SMBA ESCO can be envisioned. Suppose the necessary pre-investment work has been done for a set of *pioneering* commercially justifiable investments along the lines outlined above. This set can be the initial pipeline for the SMBA ESCO. This is not for a "project," it is the starting program for a new legal entity, the ESCO. And, depending on the particulars of the individual investments, additional new entities may be needed depending on how the ownership and

[10]There are also a variety of options not just for combining renewable energy options and EE options but also help achieve similar cost reductions by more efficient water use, irrigation or drinking water pumping, and innovations in transport and logistics, and that many such options promise better controls and revenue management via use of ICTs. The options for multi-service companies are as diverse and complex as the BOP. The poor are more diverse, and more connected to their immediate geographies and cultural traditions, than the rich.

operation structure is arranged (e.g., enterprise ownership by a BOP entity, asset provided on lease by the ESCO).

In addition to aforementioned lease financing, other investment-specific contractual arrangements can be made, including more complex ones where payments are based on "shared savings" in the case of energy cost savings. Dealing with BOP entities, the most useful structures will be those in which the ESCO arranges the financing and structures the ownership and operation for risk mitigation (as least for initial periods). A variety of financing instruments and risk mitigation techniques can be deployed, depending on the context and what is required to achieve financing leverage with local bank co-financing. If the returns are positive, the concept has been proven. And, if the same technology/equipment and partnership networks are used in the same market shed for a number of investments, banks and other financial institutions will be more willing to lend with progressively lower shares of debt covered by guarantees, and prepared to take the assets as collateral, the concept has been "mainstreamed" for scaling up.

Considering the diversity of the BOP – and allowing for the real possibility that, as modern energy access is expanded to wider areas with unsustainable subsidies, the poorer population will be increasingly marginalized and made to suffer the same deprivation it has for generations – the challenges are immense. Indicative analysis suggests that overall scale of finance for technical assistance and financial support for such a pro-poor ESCO scale-up are minuscule compared to large energy infrastructure projects.

The key idea is that the ESCO approach to BOP entities' productive use of modern energy achieves large efficiency and human development gains. Governments and external donor agencies have recognized the large untapped EE potentials in the informal sector and micro/small/medium enterprises (MSMEs). But they have struggled with the emerging "dualistic" pattern of energy technologies, where large enterprises have the knowledge and finance to exploit the most advanced EE options whereas the MSMEs continue to be squeezed by low-quality fuels, inefficient technologies, and sometimes even inferior quality labor, with resulting inferior quality products. This only contributes to persistent poverty and, at best, a dualistic pattern of development.

Conclusion:

We hope to have conveyed several key points in the context of expansion of modern energy access to the BOP:

i) transition from traditional fuels to modern fuels is in and of itself efficient, both in the narrow sense of requiring less unit primary energy for the service performed, but also expanding the production possibility frontier – i.e., increasing total factor productivity, in part by using technologies not otherwise available; there is a huge potential for emission reductions;

ii) for modern energy transition to be sustainable and help realize its transformational role for the poor, its use should be efficient, improving not only affordability of consumption at the user level, but in many cases improving the economics of the supply system;

iii) such gains in affordability may increase the demand in useful energy services, whose environmental impacts are minimized by continuing efficiency improvements;

iv) efficient energy use employed in non-household activities not only contributes to human capital development and productivity increases, but also generates demand for more effective use of such human capital and, in turn, enables efficient use of local natural resources – e.g., for land and water – using the information and skills acquired; and, most critically,

v) all these necessary changes are hampered because of the lack of information, transactional and operational skills, and investment finance, for which the SMBA pioneered by S^3IDF is, to us, a viable and paradigm transforming approach.

The donor community has to recognize that the billions of euros of investment finance – commercial or grants (ex-ante or ex-post, intentionally or by default) – arranged for the supply systems are not enough and the benefits delivered to the customer accrue disproportionately to those who are capable of investing on the other side of the meter in appliances or information.

For modern energy access to be explicitly directed to the BOP, provision also has to be made not just for the usual project-based "technical assistance" and "capacity building" – which, in practice, often fails to deliver substantive results at the BOP – but rather for revolving funds that can be flexibly tapped into and sustained, thereby leveraging philanthropic, development or "socially responsible" capital to achieve local commercial finance and to underwrite the intermediation and risk management services offered under the SMBA. What S^3DIF has been able to achieve so far can be replicated thousands-fold with appropriate finance and training.

We have but only begun to understand the ecosystems of energy – or infrastructure – poverty in general.

We have had opportunities to observe not just the hardships suffered by, and limited opportunities available to, the people in the "unconnected" parts of the world. We have also seen how poor people in cities pay two euros per light-bulb (usually 60 Watts) per month for five hours of use at night to landlords who in turn pay a half or less on their meter. We have seen school children bringing to schools, or patients' families bringing to the hospitals, wood that the schools or hospitals can use for cooking or for heating water. We also know that there are places, not too far from home, where people dare not go or allow their children to go when dusk sets in.

At current costs and prices, it is entirely possible that access to modern energy – or other infrastructure services – will expand another 20-30% after which the remaining "have-nots" will be left to be essentially forgotten. Increasingly, the structural constraints to poverty reduction are infrastructural – not just the physical infrastructure but the social, commercial, administrative infrastructure it contributes to. This 21st century challenge is much different from that in the last century, and has to be met with 21st century technologies and institutions.

To develop programmable plans based on the key messages here, academic and applied research need to be directed to

i) defining the ecosystems of poverty and profiling the transactions, and the export/import chains of products and services with the surroundings;

ii) characterizing the efficiency/growth potentials and associated options for technical, social and financial intermediation; and,

iii) making evidence-based appeals for policy and legal changes that make pro-poor SMBs, such as S^3IDF, expand.

DEFINITIONS FOR THIS PAPER

Bottom of the Pyramid (BOP) Entities: For this paper, these are typically micro or small farm or off-farm enterprises – frequently "informal" and employing, as well as serving, the "bottom of the pyramid" populations – with fewer than 20 or 50 hired laborers (i.e., excluding own and family labor) depending on the context, low levels of capitalization (other than land, if any) and mechanization other than transport vehicles, water pumps, and small electricity generators for their own use.

Bottom of the Pyramid (BOP) Population: At the global level, the number of people with expenditure levels of US$2.50 or less per capita per day in PPP (Purchasing Power Parity) terms. As such, these are represented in the bottom 1, 2 or 3 quintiles of expenditure distribution in different countries.

Developing Countries: "Less Developed Regions" at http://esa.un.org/wpp/Excel-Data/definition-of-regions.htm.

Ecosystem of Energy Poverty: This refers to i) energy use in all the non-household activities with local employment with ii) significant degree of local exchange of assets, products and services, only weakly connected to the external transactions. Urban slums and villages with limited trade with the rest of the economy tend to constitute "ecosystems of energy poverty."

Energy poverty: Users' inability to transition to "modern energy" with minimal expenditure of time and energy in fuel collection or preparation. It can also be expanded to include transition to inanimate power. Energy poverty can be a result of a) lack of access to modern fuels, access defined as reliable door-step delivery of fuels and appliances; b) where such access exists, the lack of finance for the users' capital expenditure for the transition; or c) barriers to information, technological, or management capacity to enable the transition.

Energy service company (ESCO): A bankable entity that, via investments in a client's physical plant as well as other technical and management services, helps achieve energy cost reduction. Where legally permitted, the physical investments may include fuel production or power generation. A **pro-poor ESCO** is one that pursues, consistent with S^{3}IDF philosophy and operating principles, explicitly pro-poor interventions.

Explicitly pro-poor interventions: Poverty has multiple dimensions and is a matter of overlapping processes rather than absolute or relative rankings against scales (of income, vulnerability, human capital). We emphasize interventions that are designed exclusively from the criterion of accumulation of physical and human capital that contributes to the sustained improvement in the quality of life of the poor. Not all "access" interventions are explicitly pro-poor, though the poor may benefit even as the non-poor capture disproportionate gains.

Informal enterprises: Typically these are unregistered enterprises that may or may not be subject to some or any types of taxation and may not even be eligible for financial subsidies (although they may benefit from fuel or equipment subsidies that are generally available to others as well).

Micro/Small Enterprises: These are generally manufacturing, trade, or service enterprises with low levels of capitalization and employment per site. Their product composition, technical/economic features, and significance in the national economies vary significantly, and, as a result, so do formal definitions.

Modern energy: With minor exceptions, electricity and liquid/gaseous fuels combusted in a clean, convenient manner. Cleanliness and convenience are key; kerosene for lighting is no longer regarded as "modern energy." Processes and substances together – not just substances alone – define "modern energy." "Clean" or "convenient" are seen from the users' perspective, in comparison to the non-modern or *traditional energy* – e.g. uncontrolled combustion of solid fuels that emits hazardous pollutants, and may not apply to the entire fuel cycle.

Productive uses of modern energy: These refer to activities that have commercial value - i.e., where energy use is an intermediate input to a final product or service that earns revenue. These activities may be geographically located in a household, and may not always be distinguishable from the "final consumptive" use by the household – e.g., lighting in support of carpet-weaving or electric sewing machine for a tailor working from home.