Social Return on Investment: Developing Power

Just a small amount of electricity can change the lives of poor people. Because the basis of Developing Power's value proposition is breaking the cycles of poverty through electricity and capacity building, quantifying and continuing to measure the social and environmental impacts of Developing Power projects are a significant component of the organization.

The primary benefits from access to electricity include improved education, human health, communication and entertainment, comfort, protection, convenience, and productivity. Until recently, the magnitude of these benefits has not been well documented. The goal of this Social Impact Analysis is to develop a methodology for quantifying these benefits from access to electricity. This methodology will then be applied to estimate the benefits from Developing Power projects in Bahia, Brazil.

In summary, Developing Power expects to electrify **91,000 households** over 15 years, resulting in a net present value of **$93 million in social benefits**. And for every $1 invested in a Developing Power project there is an average of $3.2 in social benefits.

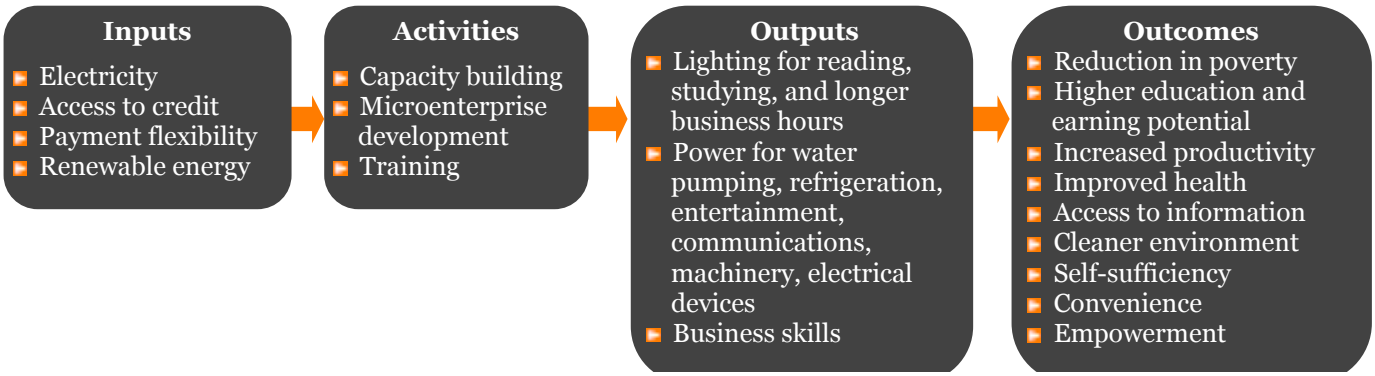
1. Assumptions

- The benefits assessed in the analysis are grouped into education and earning potential, productivity, the environment, communications and entertainment, and human health. To avoid double-counting of the benefits from access to lower-cost lighting, it is assumed that lighting benefits are reflected in the above measures.
- The estimates presented are for villages that previously did not have electricity, where the benefits represent the incremental benefits of acquiring access to electricity compared to the baseline of kerosene and batteries.
- Many of the benefits are based on a groundbreaking study from the World Bank entitled, "*Rural Electrification and Development in the Philippines: Measuring the Social and Economic Benefits* (Barnes 2002), which quantifies the social benefits to households with electricity versus those without electricity, based on a survey of 2,000 households in the Philippines. In the Social Impact Analysis for Developing Power, average income is used as a proxy to adjust the benefits in the Philippines study to the potential benefits of electricity in Bahia, Brazil. The average monthly income in rural areas of Bahia, Brazil is $110, and the average monthly income of the households in the Philippines study is $177; therefore, the benefits presented in this analysis are scaled down 62% (110/177) to better approximate the probable benefits in Bahia.
- The benefits are quantified for 15 years because the expectation is that the villages electrified through Developing Power will not likely receive grid connection over that time period.
- Social and environmental benefits are discounted at the weighted average cost of capital, reflecting the opportunity cost of the projects not being undertaken.

2. Social Benefits

Electricity in rural villages is used for various applications, the foremost being to power electric light bulbs for illumination. The intermediate outputs from the use of electricity are improved services, which are predicted to result in the intended social benefits of the electricity system, such as improved education and productivity. Figure 1 shows the relationship between electricity access and the services it can provide to increase social welfare.

Figure 1: Potential Outcomes of Improved Energy Services in Alleviating Poverty



3. Education and Earning Potential
One of the most effective ways to improve education and earning potential is to utilize electric light to increase the ability to study or read at night. In the Philippines study, households with electricity believe that their children study more during the evening hours than do households without electricity, and 97.7% of all households either agreed or strongly agreed with the statement, "having electricity is important for children's education." Surprisingly, more than 70% of the surveyed households with electricity also expect their children to attain a college education.

The dominant source of lighting in the developing world is a kerosene lamp, which provides one-tenth to one-fiftieth of the light from a light bulb. Of the 2,000 households surveyed, 91% believed that reading was easier with electric light compared to kerosene.

After controlling for factors such as income, housing type, and price of energy, the Philippines study estimates that a child in an electrified household reads or studies *48 minutes longer per day* than a child in an unelectrified household. And electric light increased reading by adults an average of *15 minutes per day*. The study also indicates that members of electrified households attain about two years more formal education than their non-electrified counterparts.

The most direct benefit of a higher education is the ability to earn a greater income. In this analysis, the benefits are not expected to be fully realized until *five years* from the installation of the system, because the effects of increased education and earning potential do not accrue immediately. The actual timing of the benefits should be determined based on the specific age profiles of the households, but five years represents a realistic average. Scaling the benefits to Bahia wage earners in households with electricity are estimated to earn between **$26 per month per household** more than their counterparts without electricity.

4. Productivity
Approximately 20% to 30% of people in the developing world operate a business from their home, and the use of electricity for electric lighting and mechanical devices can significantly enhance the productivity of home businesses or microenterprises. The Philippines study indicates that with electricity, small businesses typically operate *two more hours per day* compared to businesses without electricity. Scaling the estimated benefits to Bahia, Brazil, a business in a non-electrified household could potentially increase its income by **$21 per month per household** with access to electricity.

Electricity also saves time spent on cooking, cleaning, collecting firewood, fetching drinking water, and various family chores. The Philippines study estimates that households save approximately one hour of time per day through the use of electricity. Assuming that the opportunity cost for time used for these purposes is income generation, the value of the time saved per household is approximately **$14 per month per household**.

5. Environment
The benefits to the environment from Developing Power projects are from two main sources: 1) reduction in CO_2 from the use of renewable energy, and 2) reduction in the improper disposal of batteries.

A Developing Power hybrid system can provide approximately 66% of the total generated power for a village from renewable energy. The other 34% of the power generated is from the diesel genset, which results in 8.41 tons carbon per year (from HOMER output). This is equivalent to 30.8 tons CO_2 (8.41*44/12 = 30.8). The average annual CO2 emissions from kerosene lighting in most rural households is 0.3 tons of CO2 per household (Nieuwenhout 2000). Assuming that the electrical system displaces all of the kerosene use in the village, then approximately 60 tons CO_2 from kerosene would be avoided (0.3*200 households). On net, a Developing Power system would then reduce CO_2 emissions in half from the baseline of kerosene, and would avoid a total of 30 tons CO_2 per year. There is a wide range of estimates for the marginal damage of a unit of CO_2, but most estimates fall between $3 and $7 per ton CO_2 per year (Tol 1996). Assuming $5 marginal damage per ton CO_2, a Developing Power project would **avoid $150 of environmental damages (climate change) per year**.

Approximately 10% of unelectrified areas of developing countries use car batteries to power small electrical appliances such as lights, television, and radio. Because this type of battery was not designed for small discharges, these activities reduce the useful life to about 1.5 years. Consequently, there are high rates of battery disposal, which often means dumping them in the local river. The assumption is that car batteries and improper disposal will be avoided with electricity from Developing Power; however, the discrete benefits to the environment need to be determined on a village-by-village basis.

6. Communications and Entertainment

People's desire for information is reflected through the high demand in the developing world for radio, television, and the Internet. Because there is already use of these devices in the developing world through batteries, which are extremely expensive on a kWh basis, it is possible to estimate the value of expanded and lower cost electricity from a hybrid system in place of batteries. Table 1 shows that households with electricity from a Developing Power hybrid system receive expected communications and entertainment benefits of **$5 per month per household,** through the use of cheaper electricity. These benefits are likely to be *underestimated* because they do not capture the excess consumer surplus under the demand curve that is expected from increased demand from cheaper access to electricity.

Table 1: Communications and Entertainment Benefits from Cheaper Electricity

Electrification Status	Hours of radio listening per month (10W radio)	Hours of TV viewing per month (50W TV)	Total cost per month (radio and TV)	Total benefits for having electricity
Household with electricity	60	30	$1.26[1]	**$5 per month per household**
Household without electricity	60	30	$6.30[2]	

1 Sum of radio and TV use assuming $0.50 per kWh; (60*0.01*0.60)+(30*0.05*0.60)=$1.30
2 Sum of ratio and TV use assuming $3 per kWh; (60*0.01*3)+(30*0.05*3)=$6.30

7. Human Health

The provision of electricity to rural villages in developing countries can result in multiple benefits to the health of community members. The main health benefits include 1) the avoidance of diseases or death from the ability to store vaccines through 24-hour refrigeration, 2) the ability to pump and purify water for drinking and use in medical clinics, 3) improved lighting and use of equipment (i.e. microscopes) in medical clinics, and 4) reduced incidents of injury from explosions of kerosene lanterns. Although some of the most important energy-related health benefits occur through improved cookstove design which reduces indoor fume inhalation, Developing Power does not specifically provide this option as part of the original business proposition of electricity service. There is the potential for households that are using these options to upgrade to small two-ring electric stoves, but it is unclear whether this option will be realized.

Measuring health benefits is difficult for rural villages in the developing world, and it does not appear that a thorough evaluation has been completed to estimate the discrete benefits from access to electricity. The Philippines study was also not able to estimate specific health benefits, although it noted marginal differences between the number of days missed from work and self-reported illnesses between electrified and unelectrified households. However, to capture some sense of the possible health benefits that might result from a Developing Power project, estimates are taken from a World Health Organization (WHO) study, *Addressing the Impact of Household Energy and Indoor Air Pollution on the Health of the Poor* (2002), which shows the predicted benefits from an improved cookstove program in Guatemala. Benefits from the WHO study are used as a proxy for the benefits to households from access to electricity. This assumption is supported by the statistic that there are about the same number of premature deaths from indoor air pollution as there are from unsafe drinking water, on a global basis. The expectation is that villages electrified by Developing Power will acquire water purification systems, but on average, they will not be operational until *three years* after the system is installed. Because income data was not presented in the study, the assumption is that the benefits achieved in Guatemala are the same as would be achieved in Bahia and are approximately **$75 per household per month**. It should be noted that these estimates

are a best approximation of the health benefits from access to electricity, and Developing Power will attempt to measure discrete benefits once power systems are in operation

8. Qualitative Benefits

Other benefits of electricity, which are more difficult to quantify but result from rural electrification projects, include greater levels of comfort, protection, and convenience. Access to credit through microfinance institutions has also shown to improve knowledge of health and nutrition, empower women, and institute financial skills among customers. Whether realized within the home or in the community, these qualitative benefits may result in higher levels of confidence and peace and should not be disregarded. However, contingent valuation studies could not reveal a discrete willingness-to-pay for these benefits.

9. Evaluation of Social Benefits and Costs

Evaluation of the social impacts of Developing Power projects is grounded in traditional cost-benefit analysis (CBA) to calculate a Benefit-Cost Ratio and a Blended Value. The total benefits are defined as the incremental social and environmental benefits over the next best alternative: in this case, the benefits of having electricity from a reliable source (hybrid system) versus the use of kerosene and batteries for energy. The total costs are represented as the sum of the total operating expenses and capital costs to implement Developing Power projects (taken from the income statement). A ratio of the net present value of the social and environmental benefits to the net present value of the project costs determines a benefit-cost ratio. A value greater than one reflects a net increase in the overall benefits to society from undertaking the projects. The discount rate assumed in the analysis is 11.7%, or the weighted average cost of capital. The results from the estimated benefits indicate that for every $1 invested in a Developing Power project there are an average of $3.2 in social benefits.

Social Return on Investment

(in $1,000 USD)

	Year 1	Year 2	Year 3	Year 4	Year 5	...	Year 15
Number of Projects	1	2	3	5	8	...	85
Cumulative Number of Projects	1	3	6	11	19	...	456
Cumulative Number of Households Served	200	600	1,200	2,200	3,800	...	91,200
Social and Environmental Benefits							
Education and earning potential	$0	$0	$0	$0	$62	...	$11,294
Communication and entertainment	$12	$36	$72	$132	$228	...	$5,472
Productivity in home businesses	$15	$45	$91	$166	$287	...	$6,895
Productivity in households	$34	$101	$202	$370	$638	...	$15,322
Human health benefits	$0	$0	$180	$540	$1,080	...	$53,460
Environmental benefits	$0	$0	$1	$2	$3	...	$68
Total Social and Environmental Benefits	$61	$182	$544	$1,208	$2,296	...	$92,443
Operating and Capital Costs	$0	$0	$0	$0	$0	...	$0
Total operating expenses	($143)	($190)	($240)	($314)	($413)	...	($15,328)
Capital expenditures	($175)	($350)	($446)	($744)	($1,050)	...	($11,156)
Total Operating and Capital Costs	($318)	($540)	($687)	($1,058)	($1,463)	...	($26,484)
Social Purpose Benefit Flow	($257)	($358)	($142)	$150	$833	...	$65,959

Discount rate	11.71%
NPV of Social and Environmental Benefits	**$93,454,572**
NPV of Project Costs	**$29,164,411**
Benefit-Cost Ratio	**3.2**
Social Purpose Value	**$64,290,161**

Blended Value, a metric developed by the Roberts Enterprise Development Fund, is also useful for comparing social and environmental performance to the financial performance of Developing Power. Blended Value is calculated as the Enterprise Value (based on free cash flows) plus the Social Purpose Value less the total long-term debt. Table 2 shows that Developing Power projects will result in $76,964,564 of Blended Value.

Table 2: Blended Value	
Enterprise Value	$14,224,403
Social Purpose Value	$64,290,161
Less: Long-Term Debt	$1,550,000
Blended Value	**$76,964,564**