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Paraguay

**Promoting Private Sector Investments in Energy Efficiency in the Industrial Sector in Paraguay**

**(PR-L1146)**

**Economic Analysis**

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1. Introduction
   1. The general objective of the program is to promote energy efficiency (EE) investments by SMEs in Paraguay, improving their productivity in the long-term. The specific objectives are:
2. to increase access to medium and long-term finance for EE investment projects by SMEs
3. to reduce greenhouse gas (GHG) emissions, supporting the achievement of the country’s climate change goals.
   1. As described in the Proposal for Operation Development (POD), one particular type of investment that is relevant to SMEs is associated to the implementation of EE measures, which can have a significant impact in the firm’s energy consumption, contributing toward reducing company expenses and increasing productivity and competitiveness[[1]](#footnote-1). However, EE investments in Paraguay are hindered by credit constraints, which in the case of SMEs are heightened by extra collateral requirements, lack of credit history and documentation, and high transaction costs that translate into high interest rates. EE technologies involve high up-front costs and long payback periods[[2]](#footnote-2), and there is usually very little information on the performance of new equipment and availability of reliable service for its installation and maintenance. As a result, firms lack the capacity to develop bankable business plans and Local Financial Intermediation Institutions (IFI) use traditional asset-based lending (future cash flows generated by EE investment projects are not included in the risk analysis), limiting financial flows to these projects[[3]](#footnote-3).
   2. In this context, unlocking Paraguay’s full EE potential requires a well-designed financial strategy that coordinates all relevant actors (including government institutions, technology and service providers, IFIs and SMEs) to incentivize private investment. The problem that the program intends to address is the lack of adequate financing for SMEs operating in energy-consuming industrial sub sectors in Paraguay, where a significant potential for implementing EE measures has been identified[[4]](#footnote-4).
   3. By increasing access by SMEs to medium and long-term financing, the program will enable the development of increased investment in EE in the short to medium term[[5]](#footnote-5). In the longer term, with the effective implementation of a diversified portfolio of subprojects, the program aims to encourage a transformation in SME industrial practices, by demonstrating EE economic and financial viability for the private sector, while further reducing consumption of non-sustainable biomass and avoiding GHG emissions and forest degradation. Also, the financial intermediation design of the program aims to generate a demonstration effect with IFIs that can contribute to transforming the local climate finance market in the long term
   4. The program consists of a global credit loan operation under a single component to be executed by *Agencia Financiera de Desarrollo* (AFD), development bank of Paraguay. AFD will use Green Climate Fund (GCF)[[6]](#footnote-6) reimbursable resources (US$20 million), channeled by the IDB, along with its own resources (US$20 million) to provide long-term finance via its network of accredited IFIs. IFIs will on-lend funds to EE projects by SMEs[[7]](#footnote-7) through second tier sub-loans. Additional US$3 million non-reimbursable resources from the GCF will be used for technical cooperation (TC) activities ([PR-T1249](https://idbg.sharepoint.com/teams/EZ-PR-TCP/PR-T1249/_layouts/15/DocIdRedir.aspx?ID=EZSHARE-784093375-2)) to: (i) reduce SMEs and IFI perceived risks associated to EE investments; (ii) support SMEs and technology providers in developing bankable sub-projects; and (iii) promote energy policy enabling environment for EE investments.
   5. Sub-loans will be provided to end borrowers through AFD accredited IFIs, seeking to encourage their participation in financing these investments in the future. Sub‑projects to be financed will be deemed eligible based on conditions established in the operating regulations (OR), to be agreed between IDB and AFD, consistent with AFD’s operational policies and with IDB policies and procedures, including legal, financial, environmental, social and technical requirements for each individual subproject, following local norms and legislation. Although the program does not preestablish specific amounts to be allocated for each type of project (by subsector or technology), it is expected that the majority of the resources (around 85%) will be used in efficiency measures in equipment without changing the energy source (mainly firewood) while the remaining funds (15%) will go to modernization by technologies involving substitution of biomass energy source with electricity. From a demand perspective, appetite for investing in EE is determined not only by the cost of energy, but also potential productivity gains that SMEs expect to obtain from these technological changes.
   6. Owing to the highly concessional terms of GCF resources, the program shall provide a financial instrument that is adequate to the characteristics of the projects. By using GCF resources[[8]](#footnote-8), AFD will increase its ability to provide a longer tenor consistent with eligible projects’ costs, risks and cash flow profiles, contributing to the achievement of expected returns to make these ventures successful. The total amount of program resources will be channeled to end borrowers (SMEs investing in EE projects)[[9]](#footnote-9) by AFD through its network of accredited first-tier IFIs.
   7. The purpose of this document is to present evidence of the economic viability of the Promoting Private Sector Investments in Energy Efficiency in the Industrial Sector in Paraguay program (PR-L1146), based on a Cost Benefit Analysis (CBA). The analysis quantifies ex ante a monetary value for the net economic benefits of the program, based on a series of assumptions to be described in detail in the sections to follow. From an economic perspective, project analysis requires assessing changes in costs and benefits that would result from carrying out a particular investment. In the case of EE projects, such costs and benefits have to further consider the existence of externalities, the most significant being an overall reduction of CO2 emissions. The negative effects of GHG emissions on the environment is one of the reasons why governments in general promote the implementation of EE measures in firms and households. In the case of Paraguay, and due to the potential negative effects of a highly inefficient and unsustainable use of biomass, reducing its consumption becomes also crucial to protect their forests. To the extent possible, a valuation of the externalities associated with the development of such projects is included.
   8. Section II will elaborate on methodology and assumptions used for this analysis. Section III includes any other relevant considerations in relation to the development of the analysis, including any restrictions on its scope such as quantification of co-benefits and indirect beneficiaries. Section IV presents the results of the analysis in terms of Net Present Value (NPV) and internal rate of return (IRR), considered valid indicators for demonstrating the economic viability of the program. For these calculations, the standard IDB discount rate of 12% is used. Section V tests the robustness of the analysis, by stressing some important variables in the sensitivity tests. Finally, Section VI offers some brief conclusions.
4. Methodology and Assumptions

1. A. Proposed methodology
   1. Following standard practice, the economic evaluation of the program compares estimated costs and benefits for scenarios “with” and “without” program, making assumptions on a simulated portfolio of sub projects financed by the program. This model serves as a practical tool to quantify ex ante the economic value of the aggregated incremental benefits of the program.
   2. **Definition of scenarios:** 
      1. In the scenario A (“with” program), GCF funding and co-financing from AFD for the program provides financing to investments by SMEs in a number of EE sub projects. This will result in the implementation of specific EE measures in a subset of industrial sub sectors. Investment costs occur during the investment phase, while Operation and Maintenance (O&M) costs occur throughout the life of the sub projects. Additional costs corresponding to the complementary TC activities, although not part of this proposal, are included, as they are considered essential for the investments to be deployed effectively. In this scenario, energy consumption and emissions are reduced.
      2. In the alternative scenario B (“without” program), it is assumed that none of the EE sub projects in scenario A is implemented –without financing from the program, SMEs do not have the capacity to finance 100% of these investments by themselves and other sources of financing are not currently available at terms adequate to match their projects’ profiles. In this scenario, there are no investment costs and O&M costs over the period of analysis correspond to those incurred by the use of old equipment currently in operation. No energy savings from EE projects are produced, maintenance costs remain high and there are no CO2 emission reductions.
   3. **Program cash flows:** The cash flows in both scenarios are built from the following main elements: (i) investments costs of new equipment (incorporating all sources of financing, including third-party leveraged equity); (ii) O&M, based on the average production/use of equipment (old and new); and (iii) average energy consumption of equipment (old and new). Based on the expected lifetime of sub projects to be financed, and the projected schedule of disbursements throughout the execution, the horizon for the analysis is 15 years.
   4. **Assumed portfolio:** An indicative portfolio of projects to be deployed with support from the program[[10]](#footnote-10) is developed based on a thorough assessment of available references and reports from the sector in Paraguay, in particular a market study[[11]](#footnote-11) carried out specifically to support the design of a program of this kind in the country (see ¶1.3). The referred study identified a significant potential for EE measures in the Paraguayan industrial sector, mainly linked to technological modernization (replacement of equipment that is outdated, obsolete and inefficient), as well as the substitution of energy sources, incorporating electricity as a replacement for non-renewable biomass.
   5. It should be emphasized that the construction of an assumed portfolio, although based on expectations on future demand, is a method used exclusively for quantification of the benefits and costs of the program and should be take only as indicative. There is no formal pre-determined allocation of funds to be disbursed by sub sector or technology, and sub projects will be financed upon demand, on a first-come-first-served basis. Therefore, possible combinations of actual sub projects participating in the program could be infinite, and aggregated values may be more or less impacted by differences between the assumed and real portfolio[[12]](#footnote-12). For this reason, the analysis is tested for a variety of individual and combined key criteria that can affect not only the assumed mix of sub projects, but also the characteristics of the expected impacts of each type of investment in the portfolio. A sensitivity analysis is included to address this issue, which is expected to strengthen the conclusions of the assessment of the program’s economic value.
   6. **Program benefits:** The main principles pertaining the accounting of benefits and costs for each scenario include the following:
      1. Economic benefits for the program derive from: (i) the difference of expected firm’s energy costs between the scenario with program (with new or retrofitted equipment installed and operating) and the scenario without program (no change in current equipment); (ii) the difference of O&M costs of equipment between the scenario with program (with new or retrofitted equipment installed and operating) and the scenario without program (no changes to equipment); and (iii) a monetized value of CO2 emissions avoided, as a representation of the externalities associated with the reduction of GHG emissions.
      2. Benefits are mainly represented by the foregone costs that are implied by saving an amount of energy (mainly biomass-sourced) as a result of the EE measures implemented in the sub projects financed by the program. The value of these foregone costs in the scenario without program shall be zero, as no savings in energy are expected in the absence of an EE technology in place.
   7. **Results:** The program NPV is calculated by projecting the net economic flows over the estimated useful life of sub projects, discounting them at a rate of 12%.[[13]](#footnote-13) The IRR is also obtained as key indicator to determine its economic viability.
   8. **Sensitivity analysis:** The main calculation parameters used in the core analysis are altered in order to test the sensitivity of the values obtained to variations in the assumptions, and the adjusted economic values (NPV and IRR) under each different sensitivity scenario are presented. Sensitivity scenarios are determined based on relevant risks on changing conditions.
2. B. Main assumptions
   1. **Sub project mix and schedule**: It is assumed that the sum of funds (US$40 million) will be used entirely to finance 300 small to mid-sized EE sub projects.[[14]](#footnote-14) Such investments will be developed gradually throughout the 5-year execution period of the program, based on an assumed schedule of project readiness and closing of deals by participating IFIs.
   2. Although the program does not preestablish specific amounts to be allocated by subsector or technology, it is assumed that the majority of the resources (around 85%) will be used in efficiency measures in equipment without changing the energy source (mainly firewood) while the remaining funds (15%) will go to modernization by technologies involving substitution of biomass energy source with electricity[[15]](#footnote-15). From a demand perspective, appetite for investing in EE is determined not only by the cost of energy, but also potential productivity gains that SMEs expect to obtain from these technological changes.

**Table 2.1. Disbursement schedule**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Y1 | Y2 | Y3 | Y4 | Y5 | Total |
| Financing from program (USD) | 1.7 | 3.4 | 9.7 | 12.6 | 12.6 | 40 |
| Beneficiary sub projects (number) | 14 | 27 | 73 | 93 | 93 | 300 |

* 1. It should be noted that the assumption is that financing from the program will cover 90% of total investment required for these projects, the remaining portion (10%) being equity committed by the investing firms. Hence, the total investment for the 300 expected beneficiary projects will be roughly US$44 million (US$40 million from the program, plus US$4.4 million from equity).[[16]](#footnote-16)
  2. Based on information collected from technology service providers, local and international experts on the field and relevant studies available[[17]](#footnote-17), parameters have been established for a typical sub project (in average terms) in a set of indicative technologies and subsectors to be financed under the program (assumed portfolio, see ¶2.4-2.5). The data is presented in Table 2.2.

**Table 2.2. Parameters for a typical project by technology/subsector[[18]](#footnote-18)**

|  | Modernization of equipment (same energy source) | | | | Substitution by electric equipment |
| --- | --- | --- | --- | --- | --- |
| TECHNOLOGY | Ovens (direct heat) | | Boilers (steam) | | Dryers (direct heat) |
| SUBSECTOR | Nonmetallic (bricks) | Casting | Food other (sugar) | Cold storage | Grains |
| Energy consumption (toe) | 1,797.4 | 209.9 | 3,566.7 | 982.2 | 323.8 |
| Efficiency factor (new versus old equipment) | 78 vs. 70 | -12% | 91 vs. 83 | 91 vs. 86 | 81 vs. 37 |
| Expected lifetime (years) | 10 | | | | |
| Timeframe for implementation (years) | 1 | | | | |

* 1. For statistical comparative purposes, energy consumption for both firewood‑sourced and electric equipment has been converted into tons of oil equivalent (toe)[[19]](#footnote-19). Simple conversion factors are needed to compare wood fuels with other fuels. These comparisons are important especially when a decision regarding fuel change has to be taken. Conversion factors used for these conversions are shown in Table 2.3.

**Table 2.3. Most common energy conversions**

|  |
| --- |
| 1 toe = 41.87 GJ = 11.63 MWh |
| Firewood Net Caloric Value = 14.4 MJ/kg = 4.0 kWh/kg |
| 1 kWh electricity Caloric Value = 3.6 MJ = 1 kWh |
| 1 GWh = 1,000 MWh = 1,000,000 kWh |
| 1 TJ = 1,000 GJ = 1,000,000 MJ = 1,000,000,000 kJ |
| 1 ton = 1,000 kg |

Source: [Wood Fuels Handbook](http://www.fao.org/3/a-i4441e.pdf), Food and Agriculture Organization of the United Nations, 2015

* 1. **Investment and O&M costs:** Investment costs are assumed to be fully covered by financing from the program (including AFD counterpart) plus the private funding complementing this financing (equity and/or additional financing from sources other than AFD). Investment costs are accounted for entirely at the time of start of implementation of each project; the assumption is that these will cover the initial costs of starting up and deployment of EE technologies. Projects are expected to start operations and produce benefits (associated to the production and/or savings of energy) after the end of the installation of the system is completed.[[20]](#footnote-20) Likewise, O&M costs will be included yearly starting from the year in which each sub project begins operations. From then on, lifetime of projects is assumed to be equal to 10 years, regardless of the type of technology and usage.

**Table 2.5. Costs of a typical project by technology/subsector[[21]](#footnote-21)**

|  | Modernization of equipment (same energy source) | | | | Substitution by electric equipment |
| --- | --- | --- | --- | --- | --- |
| TECHNOLOGY | Ovens (direct heat) | | Boilers (steam) | | Dryers (direct heat) |
| SUBSECTOR | Nonmetallic (bricks) | Casting | Food other (sugar) | Cold storage | Grains |
| Investment costs (USD) | 150,000 | 110,000 | 250,000 | 150,000 | 250,000 |
| O&M costs - new equip, as a share of investment costs | 0.2 | | | | |
| Ratio of O&M costs - old vs. new equip | 2 | | | | |

* 1. **Energy source prices**: At present, electricity remains more expensive than firewood. Hence, sub projects involving substitution by electricity-sourced equipment are assumed to become financially viable (and attractive for investment) only once firewood and electricity prices converge. Using current prices from 2017 (baseline) and based on our own projections for both firewood and electricity prices (see Annex I), it is assumed that this convergence will take place around the third year of implementation of the program. This aspect is considered when proposing an indicative schedule of disbursements of funds, as shown in Table 2.1.

**Table 2.4. Projected prices of firewood and electricity (USD/toe) (5-year horizon)**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Baseline | Y1 | Y2 | Y3 | Y4 | Y5 |
| Electricity | 345 | 359 | 374 | 389 | 404 | 420 |
| Firewood | 112 | 159 | 226 | 321 | 456 | 647 |

* 1. From the fifth year onwards, the analysis assumes, conservatively, that price increases for both firewood and electricity will remain in line with (consumer price index (CPI) levels, at an average of 4%.
  2. **Emission factors and price of CO2**: In order to obtain an estimate amount of emissions reduced by the projects financed, the analysis uses: (i) the default emission factor for stationary combustion of wood/wood waste in manufacturing industries and construction from the [2006 IPCC Guidelines for National Greenhouse Gas Inventories](http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_2_Ch2_Stationary_Combustion.pdf) (112,000 kg of CO2 per TJ), which considers emissions from combustion of fuels in industry, including combustion for the generation of electricity and heat for own use in these industries; and (ii) Latin America’s average conversion factor for electricity (0.188 kg CO2 per kWh) from the [List of international emission conversion factors for electricity](https://ig-tools.com/files/CF_for_IG_Tools.pdf), which uses data from the Guidelines for DEFRA/DECC's GHG Conversion Factors for Company Reporting (2014). These values, although not specific to Paraguay, provide us with an approximation of the emissions displaced by reducing the amount of firewood and/or electricity used in the firms financed by the program.[[22]](#footnote-22)
  3. Emission reductions are calculated by multiplying the energy savings produced by the sub projects financed, by its corresponding conversion factor:

CO2 displaced = Conversion factor x Energy saved

1. C. Identification and quantification of economic benefits
   1. Economic benefits include three main elements: (i) foregone energy costs (energy savings) by EE; (ii) reduced O&M costs by more modern and efficient equipment; and (iii) abated costs derived from the avoided future GHG emissions of a "without" program scenario (see ¶2.2).

Economic benefits (USD) = Foregone energy costs from EE + Savings from O&M + Abated costs of emissions

* 1. The first measure of benefits is obtained by calculating the difference between energy costs associated to equipment currently in operation, and the energy costs generated by the new/efficient equipment (i.e. the costs that will be avoided by covering the same energy needs with the new efficient systems). The calculation is made using projected prices of energy and average consumption of each technology and subsector under analysis, over a period of 20 years, minimum expected lifetime of the sub projects financed.

Foregone energy costs = Cost of energy consumed with old equipment (USD) – Cost of energy consumed with new/efficient equipment (USD)

* 1. Benefits from O&M savings are determined by the difference between O&M costs associated to equipment currently in operation, and those generated by the new/efficient equipment. Old equipment normally requires more frequent revisions and repairs, including parts replacement. Costs associated to these may vary widely depending on the type of equipment, availability of parts, hours of operations and operation practices. For practical purposes, a simplification is made on the estimation of these costs, calculated as a percentage increase on O&M costs of new equipment (see ¶2.13).

Savings O&M = O&M old equipment (USD) – O&M new/efficient equipment (USD)

* 1. A third portion of benefits (abated costs of emissions) uses a monetary value of GHG emissions reduced by the projects financed, determined by the unit price of a metric ton of CO2 in the international market. This value is based on information about carbon pricing around the world (emissions trading systems, ETS, and carbon taxes), which has been substantially increasing since 2012. The existing carbon prices vary significantly—from less than US$1 per tCO2e to US$130 per tCO2e, with the majority of emissions (85%) priced at less than US$10 per tCO2e. The analysis will use a unit price of US$5 per tCO2e, conservatively and along the lines of existing or potential instruments in other emerging economies (including Korea, China, Mexico and Chile)[[23]](#footnote-23). The use of this reference price is an interpretation of the evaluation exercise of the various economic, local and global, current and future costs of negative externalities associated to emissions. International carbon pricing provides us with a publicly available resource for monetization of this aspect of the analysis.

Abated costs of emissions = TM CO2 displaced x Price per TM CO2 (USD)

1. Other Considerations
   1. It is assumed that the country will maintain a fairly stable macroeconomic framework and conditions conducive to sustaining growth and investment.[[24]](#footnote-24) The program is not expected to generate a crowding out effect, since it is assumed that the potential demand for financing exceeds supply and the intervention of AFD responds to the need to fill this financing gap.
   2. With regards to the overall energy sector, it is expected that electricity prices will remain competitive in comparison to other sources, as opposed to firewood, which will be impacted by increasingly restrictive measures to reduce deforestation in larger regions of Paraguay.
   3. Voluntary participation of the private sector under market conditions is indicative that the expected value of these projects will result in net financial profits (i.e. financial costs are lower than financial benefits from a private perspective). In this sense, the financial viability of the program is guaranteed[[25]](#footnote-25).
   4. The implementation of activities under the proposed program is part of a more comprehensive solution to broader institutional and structural problems that hinder the development of EE investments in Paraguay. The program’s scope is limited to the provision of loans but it will be supported by a complementary TC program, PR-T1249, to be approved separately (see ¶1.5), deemed essential to the achievement of results as proposed by the program and this analysis. In that sense, an assumption is made that complementary TC activities will be successfully deployed and effective in raising awareness among the industrial sector on the convenience, opportunity and need to introduce EE improvements.[[26]](#footnote-26)
   5. The analysis is regarded as conservative, as it leaves out some additional positive externalities (co-benefits), such as direct and indirect job generation and contribution to the competitiveness of the country’s economy. The program will also contribute to reducing vulnerability of forests, as demand for firewood is expected to be reduced. In the absence of more sophisticated mechanisms, these elements are not possible to quantify accurately. Hence, the presented values should be considered as a lower-bound estimate.
2. Results of the Analysis
   1. Using the model and assumptions described in the sections above, the net present value of the program comes at US$54.9 million. A table with detailed calculations for the period of analysis is shown in Annex II.

**Table 4.1.- Summary of results**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  |  |  | Value |
| Net Present Value (millions of US$) |  |  |  | **54.9** |
| Internal Rate of Return (%) |  |  |  | **40.6** |

1. Sensitivity Analysis
   1. For the sensitivity analysis presented in this section, deviations on key variables used for the base analysis are simulated in order to determine their impact with regards to the economic value obtained for the program. In other words, assumptions are modified in order to test the tolerance of the program to variations on the conditions that may have an impact on the results established above.
   2. While all variables used in this analysis (and assumptions related to them) may be affected by factors out of the control of the program execution, the selection of parameters included in this section was determined on account of their criticalness in the quantification of results, both overall and at the sub project level. Following is a list of the parameters analyzed and a brief description of the tested scenario. In all cases, extreme values for the parameters have been used in order to make the analysis more robust:
      1. O&M costs are not reduced with the installation of new equipment. A reference value for the ratio between old and new equipment O&M costs is difficult to determine, as these costs vary widely among different industries, technologies and depending on the age and obsolescence of equipment. Normally, the older the equipment, the more frequent revisions and repairs it needs to operate properly. Each of these repairs involves at least the cost of labor, but may require also replacement of parts and can lead to losses due to interruptions in operations for several days[[27]](#footnote-27). Hence, it is not likely that O&M costs will become higher once a new technology is put in place and a ratio of 1:1 is considered suitable for this test.
      2. Firewood prices are replaced by low growth projection scenario (see Annex I). This reduces the energy savings benefit, as the foregone costs of consuming this energy will be lower. It may also produce a change in the mix of sub projects, postponing (or eventually displacing) those that involve a transition to electric equipment (a change to electricity as energy source strongly depends on a ratio between firewood and electricity price that makes investments viable and attractive). This possibility is analyzed in scenario d (see below). Nonetheless, based on recent trends (see Annex I), along with upcoming restrictions of biomass supply to be further imposed by the Zero Deforestation Law ([Law 2524/04](http://www.infona.gov.py/application/files/1714/2902/4900/Ley_N_2524_-_Deforestacion_cero.pdf)) that are bound to produce more formal biomass markets, firewood prices are expected to increase considerably and this risk is considered low.
      3. Projects that may not evolve successfully and are not implemented (for instance, due to default or breach of contract from the ESTP) are considered for the last scenario. This implies an assumption that after the investment is made and the financing is approved, some of these projects do not become operative and enter into default. The scenario assumes a 10% of project failure, which is considered extreme as AFD is characterized by its high-quality credit portfolio, and complementary TC activities from PR-T1249 will support a rigorous technical implementation of projects with all actors involved.
      4. Given that the demand for EE projects is not known ex-ante, the assumed allocation of funds (85% used in efficiency measures in equipment without changing the energy source, 15% used in technologies involving substitution of biomass energy source with electricity, see ¶2.10) is varied to test the impact of having a different mix. It is worth nothing that the behavior of the demand for financing, with regards to the share of projects involving a change to electricity, will depend on the evolution of firewood prices. If firewood prices grow faster than assumed, biomass will become more expensive than electricity earlier in the execution period of the program and investments on energy substitution will be more likely to occur. Conversely, if firewood price trends stagnate, investments are bound to be more focused on those technologies/subsectors in which efficiencies can be achieved without switching to electricity. The complementary TC includes activities related to monitoring pricing developments, in order to support the assessment of risks in each sub project and optimize the use of program funds.
   3. Table 5.1 presents a summary of the results of the sensitivity analysis. For each parameter the table shows the test value under the changed scenario, the adjusted NPV and the IRR under the modified scenario and the break-even value (the value of the parameter under which the NPV of the program becomes zero).[[28]](#footnote-28)

**Table 5.1: Summary of sensitivity analysis**

| Parameter | Initial value | Test value | NPV (MUSD) | IRR (%) | Break-even value |
| --- | --- | --- | --- | --- | --- |
| a. Ratio of O&M costs - old vs. new equipment | 2:1 | 1:1 | **51.4** | **39.0** | **-13.6:1** |
| b. Firewood price trends | High growth projection (42% annual increase) | Low growth projection (34% annual increase) | **34.6** | **31.7** | **13.46% annual increase** |
| c. Sub projects successfully implemented after closing of financing | 100% | 90% | **46.6** | **37.0** | **33.6%** |
| d. Sub project mix | 85% no change in energy source  15% firewood substitution with electricity | 100% no change in energy source  0% firewood substitution with electricity | **50.0** | **38.4** | **n.a.** |

* 1. In addition, by building a scenario in which several parameters are changed at the same time, the sensitivity analysis intends to test the impact of various aspects considered, combined. For example, by combining scenarios a, b and c, in Table 5.1, the NPV remains positive, at US$24.7 million, and the IRR is still significantly high (26.6%).
  2. The results of the sensitivity analysis show that the net economic benefit of the program is not particularly elastic to any of the main parameters:
     1. A change in the growth trends of firewood shows the most significant impact on the NPV. This is expected, as the bulk of the benefits is related to the reduction in energy costs resulting from the implementation of EE measures. If energy prices are lower, then the value of savings from the use of energy drops. And, if firewood prices grow at a slower pace, convergence with electricity prices will happen later in time, which has an impact in the economic value of projects involving substitution with electricity.
     2. A slightly lower effect is shown when assuming some of the projects do not materialize. In this scenario, investment costs are accounted for in full while no benefits are considered for the failed projects; still, the project retains a positive NPV.
     3. The impact of a change in the sub project mix is also minor. Although it is possible to construct other alternative scenarios of sub project mixes, which in turn would result in different economic values for the program, possible combinations could be infinite. A variation in the share of the two broad categories described (no change in energy source and firewood substitution with electricity technologies), mainly due to fluctuations in price trends of the energy sources under analysis, is considered an appropriate test with regards to the sub project mix, which was built based on country-specific analysis on the potential for implementation of EE measures in different subsectors. At any rate, it is considered unlikely that a particular mix of EE projects will show negative returns, when individually they are projected to produce positive results.
     4. Finally, the economic value of the program is least sensitive to not achieving savings in O&M costs with the technologies implemented. This is associated to the fact that O&M represents only a small portion of total costs, with investment costs representing the most important fraction.

1. Conclusions
   1. The cost benefit analysis shows how the discounted benefits are greater than the discounted costs over the time of analysis, thus resulting in a positive Net Present Value (NPV) of US$54.9 million and an IRR of 40.6%. This assessment is conservative, as all the possible economic benefits of the program were not monetized.
   2. In addition, the sensitivity analysis shows that even when changing the value of the key parameters used for the calculations, the program remains viable for a wide range of values. The sensitivity analysis is relevant as it improves the reliability of the results obtained from the initial assumptions, allowing for more robustness of the conclusions. No significant risks are observed regarding the sustainability of the program in case reasonable changes occur that may affect the main variables on which the benefits are based.
   3. In general, the project team has used plausible and contrasted assumptions, with aims of a rather prudent and conservative approach for the analysis. Based on this, the project team recommends the IDB approves the financing of the proposed program.

**Annex I. Firewood and electricity price projections**

* + Projections of prices for electricity and firewood have been made for the next six years, based on latest trends and recent development related to policy and regulation in the sector. This includes: (i) data of firewood price increases over the last decade; (ii) an identified potential for firewood supply gap;[[29]](#footnote-29) (iii) an expected increase in transportation costs, owing to larger distances between regions where deforestation is not yet restricted and main industrial areas in the Eastern Paraguay; and (iv) recent surges in industrial electricity prices.
  + The *Administración Nacional de Electricidad* (ANDE) increased electricity prices by 50% in 2017, so additional significant increases are unlikely to happen in the near future. Electricity prices have been projected under three different scenarios of 4%, 6% and 8% annual growth. The baseline value (Y0) considers the referenced electric tariffs for the industrial sector (non-peak prices),[[30]](#footnote-30) as published in the country’s most recent *Pliego Tarifario* (March 2017) and using an exchange rate of 5,636.53 PYG per USD.[[31]](#footnote-31) Firewood price increases are extrapolated from 2008-2013 series. As a result of the implementation of the Zero Deforestation Law, it is expected that a supply-demand gap and transportation costs will drive up firewood prices. The increase in electricity prices is estimated to be below inflation on a yearly basis. Firewood commercialization is an unregulated market and its prices have shown increases of almost 50% annually between 2008-2013. Three scenarios have been projected for annual increases of 42%, 38%, and 34%.
  + Although firewood is still less expensive than electricity, biomass is primarily supplied by non-sustainable systems of production, instigating deforestation and making the system vulnerable. As a result, restrictions of biomass supply have been imposed by the Zero Deforestation Law ([Law 2524/04](http://www.infona.gov.py/application/files/1714/2902/4900/Ley_N_2524_-_Deforestacion_cero.pdf)). The objective of this Law is to protect and preserve native forests in the eastern region of Paraguay (*Region Oriental*), where most of the industrial activity is located[[32]](#footnote-32). Restrictions imposed by this law have produced a shift in deforestation to the Chaco region, affecting the supply of firewood, and increasing firewood prices[[33]](#footnote-33). As enforcement of this Law is strengthened and biomass markets become formal, biomass prices are expected to increase further.
  + As the price of firewood increases dependent on developments associated to its demand and supply, these trends will be reflected on the investment decisions of those firms willing to implement EE measures, especially those that involve substitution by electric equipment.
  + A simulation of firewood and electricity prices for the next six years provides the basis for the assumptions related to energy costs generated by these two sources in both “with” and “without” program scenarios. For comparison purposes, prices for both sources have been converted to US$/toe units.

**Table A1. Projections of firewood and electricity prices (USD/toe)**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Electricity | | | Firewood | | |
|  | Low growth (base) | Moderate growth | High growth | Low growth | Moderate growth | High growth (base) |
| Y0 | 345 | 345 | 345 | 112 | 112 | 112 |
| Y1 | 359 | 366 | 373 | 150 | 155 | 159 |
| Y2 | 374 | 388 | 403 | 201 | 214 | 226 |
| Y3 | 389 | 411 | 435 | 270 | 295 | 321 |
| Y4 | 404 | 436 | 470 | 362 | 407 | 456 |
| Y5 | 420 | 462 | 508 | 485 | 561 | 647 |
| Growth rate | 4% | 6% | 8% | 34% | 38% | 42% |

**Figure A1. Electricity vs. firewood prices in base scenario and projected convergence**

**Annex II. Detailed program cash flows (US$ million)**



Notes: Total investment includes financing from the program (US$40 million) plus equity provided by the investing beneficiary firms (up to US$13 million), based on an assumed loan-to-equity value of 75/25. The total amount of TC funding from PR-T1249 is included as a cost for the program, as activities included in this TC are considered essential to the successful implementation of the sub-projects financed. Technology/Subsector categories included are based on relevant information collected and recent studies related to the potential for EE in Paraguay, as explained in the assumptions in Section II.B. These were established for the purpose of this analysis and should only be taken as indicative (the number and type of sub-projects included do not constitute a committed portfolio for the program).

1. [Industrial EE and competitiveness](https://www.unido.org/fileadmin/user_media/Services/Research_and_Statistics/WP052011_Ebook.pdf), Working Paper 05/2011, United Nations Industrial Development Organization (UNIDO), 2011. [↑](#footnote-ref-1)
2. The average payback period of these projects is 3.6 years, which is incompatible with the conditions offered by the banking system, generating mismatches in loan amortization periods. [↑](#footnote-ref-2)
3. [Carlino, H. 2017.](https://idbg.sharepoint.com/teams/EZ-PR-LON/PR-L1146/_layouts/15/DocIdRedir.aspx?ID=EZSHARE-1067953801-2) [*Guía para la estructuración de instrumentos financieros para la promoción de la eficiencia energética - Estudio de caso de la Agencia Financiera de Desarrollo de Paraguay*](https://publications.iadb.org/bitstream/handle/11319/8241/Guia-para-la-estructuracion-de-instrumentos-financieros-para-la-promocion-de-la-eficiencia-energetica-Estudio-de-caso-de-la-Agencia-Financiera-de-Desarrollo-de-Paraguay.pdf?sequence=1&isAllowed=y). [↑](#footnote-ref-3)
4. A market study [(Carlino, H., 2017)](https://idbg.sharepoint.com/teams/EZ-PR-LON/PR-L1146/_layouts/15/DocIdRedir.aspx?ID=EZSHARE-1067953801-2) has shown potential demand for credit for EE improvements in SMEs, in sub-sectors such as brick fabrication, sugar mills and agroindustry. In selecting the target sectors for the study, several factors were taken into account, including participation in GDP, relevant value chains for Paraguay, impact on generating positive foreign trade and job creation. See also [*Producción y Consumo de Biomasa Solida en Paraguay*](http://www.ssme.gov.py/vmme/pdf/biomasa/base/37.%20Produccion%20y%20Consumo%20Biomasa%20(1).pdf), Vice Ministry of Mines and Energy (VMME) and GIZ, 2013. [↑](#footnote-ref-4)
5. Non-financial barriers such as lack of awareness of business opportunities, insufficient technical capacity, and entrenched behavioral patterns will be addressed through complementary technical cooperation (TC) activities (see PR-T1249). [↑](#footnote-ref-5)
6. The GCF is a UNFCCC’s financial mechanism that provides funding to promote mitigation and adaptation to climate change. The IDB is accredited by the GCF to manage these resources. The framework for this relationship is established in the AMA approved by the IDB Board (GN‑2895, Resolution DE-31/17). In addition, the FAA to be agreed between the IDB and GCF will establish terms and conditions specific to this program, and shall be signed prior to the signing of the loan contract. [↑](#footnote-ref-6)
7. Eligible EE projects are expected to be related to efficiency improvements in industrial processes, including equipment replacement, energy substitution and co-generation. [↑](#footnote-ref-7)
8. AFD will use GCF resources to diversify and lengthen its funding sources, blending them with its own resources to better respond to the financing needs of eligible firms. [↑](#footnote-ref-8)
9. The program will use firm size definition as per the definition of economic unit under the framework of the *Censo Económico Nacional*. In this sense, SMEs under the program are firms with less than 50 employees and income equal to or less than PYG 2,000 million. In some particular subsectors with high potential, such as the sugar industry subsector, eligible firms may be larger in size. Whereas the analyses related to the potential demand and results of the program are based on an indicative set of SMEs and technologies, the program remains open to other EE technologies and industrial SMEs subsectors. The origination of innovative financial and non-financial instruments will allow for the introduction of various EE technologies (boilers, furnaces, electric motors, and ancillary equipment). [↑](#footnote-ref-9)
10. For practical purposes, the analysis uses aggregated data for the accounting of benefits over time, based on the construction of a portfolio of projects and the characteristics of a representative beneficiary firm for each type of project. [↑](#footnote-ref-10)
11. [Carlino, H. 2017.](https://idbg.sharepoint.com/teams/EZ-PR-LON/PR-L1146/_layouts/15/DocIdRedir.aspx?ID=EZSHARE-1067953801-2) [*Guía para la estructuración de instrumentos financieros para la promoción de la eficiencia energética - Estudio de caso de la Agencia Financiera de Desarrollo de Paraguay*](https://publications.iadb.org/bitstream/handle/11319/8241/Guia-para-la-estructuracion-de-instrumentos-financieros-para-la-promocion-de-la-eficiencia-energetica-Estudio-de-caso-de-la-Agencia-Financiera-de-Desarrollo-de-Paraguay.pdf?sequence=1&isAllowed=y). [↑](#footnote-ref-11)
12. The ex-post evaluation will be based on actual EE sub projects implemented, when program execution is completed. [↑](#footnote-ref-12)
13. Following IDB guidelines for economic analysis of programs financed by the IDB, it is recommended to use a discount rate of 12% for all IDB operations. [↑](#footnote-ref-13)
14. The typical sub project likely to receive financing corresponds to a small-sized retrofit or replacement of equipment (boilers, ovens, dryers). However, potential has been identified also for mid-sized cogeneration projects (in particular, in the sugar production industry), and these will also be eligible for financing. Typical loan size for these projects is US$15 million and finances around 70% of total investment. [↑](#footnote-ref-14)
15. A change to electricity as energy source strongly depends on the ratio between firewood and electricity prices, which in the short to medium-term (2-3 years) may remain unfavorable to electricity. Given that sub-loans will be subject to the financial viability of each sub-project, it is expected that earlier stages of the program will see financing focused on firewood equipment improvements without changing the energy source. All the same, the program will seek to facilitate a transition to electric equipment later during its execution and in the longer term. [↑](#footnote-ref-15)
16. A minimum level of equity to co-finance these projects is a normal practice in the financial sector. The 90/10 loan to equity value has been assumed based on previous experience from AFD and IFIs with similar types of SMEs investments. [↑](#footnote-ref-16)
17. *Guía para la estructuración de instrumentos financieros para la promoción de la eficiencia energética - Estudio de caso de la Agencia Financiera de Desarrollo de Paraguay,* Carlino, H. 2015; Informe nacional de monitoreo de la eficiencia energética de la República del Paraguay, CEPAL, 2016; *Producción y Consumo de Biomasa Solida en Paraguay*, VMEE and GIZ, 2013; Estado de la eficiencia energética en Paraguay: identificación de oportunidades, CAF 2016. [↑](#footnote-ref-17)
18. The cold storage subsector combines establishments working with meat and milk. Sugar industry consumption is largely sourced by bagasse from their own processes; the values of consumption for this analysis consider only the firewood additional to any self-sourced biomass. Grain industry includes soy, corn and wheat. Energy consumption values by sub sector are expressed as an average per productive unit. The value for the efficiency factor of ovens in casting is presented differently (shown as negative percentage), because the way in which the source estimates this factor is as a reduction in consumption. [↑](#footnote-ref-18)
19. A toe is a conventional unit of measurement used which corresponds to the amount of energy released by burning one ton of crude oil. [↑](#footnote-ref-19)
20. It is important to differentiate a period when a sub project is financed from that when a project begins operating. In the detailed cash flows (see Annex II) disbursements of loans and co-financing (including equity) will precede the accounting of benefits. [↑](#footnote-ref-20)
21. Investment and O&M costs have been obtained from interviews with technology service providers, local and international experts on the field and relevant studies available. The values provided vary widely among the different sources and real values will depend on the size and type of the firms installing these technologies. A rough approximation had to be made using a wide range of values for each type of equipment and subsector. [↑](#footnote-ref-21)
22. See also [CO2 emissions from Fuel Combustion online data service 2017 Edition](http://www.iea.org/statistics/relateddatabases/co2emissionsfromfuelcombustion/) (International Energy Agency). [↑](#footnote-ref-22)
23. In the European Union Emissions Trading System (EU ETS), which remains the single largest international carbon pricing instrument, the average price in 2014 was €6/tCO2 (US$7/tCO2). As of August, 2015, this price stood at some US$9/tCO2. For governments, carbon pricing is an instrument to achieve emissions mitigation but also a source of revenue. (see [State and Trends of Carbon Pricing](http://www.worldbank.org/content/dam/Worldbank/document/Climate/State-and-Trend-Report-2015.pdf), World Bank and Ecofys, 2015. [↑](#footnote-ref-23)
24. The latest projections of growth for Paraguay estimate positive values of 4.2% for 2017, 3.9% for 2018 and 3.8% growth from 2019 to 2022. See [Paraguay: 2017 Article IV Consultation-Press Release and Staff Report](http://www.imf.org/en/Publications/CR/Issues/2017/07/24/Paraguay-2017-Article-IV-Consultation-Press-Release-and-Staff-Report-45119), International Monetary Fund, Country Report No. 17/233, July, 2017. [↑](#footnote-ref-24)
25. Before implementation of the program, any existing portfolio is indicative. Information on specific sub projects is not available until it is presented by participants when applying to credits by IFIs and, when required, this information should be treated with confidentiality. [↑](#footnote-ref-25)
26. Costs associated to this TC are included in the cash flows of the program (see Annex II). [↑](#footnote-ref-26)
27. The potential for EE feasible investment in the industrial sector of Paraguay identified in Carlino H. et al. (2015) was related to outdated (most of it over 10 years old) and inefficient equipment. [↑](#footnote-ref-27)
28. The break-even value analysis serves as a practical tool to demonstrate that such changes in parameters observed would be highly unlikely. [↑](#footnote-ref-28)
29. Rios et al (2016) Solid biomass within the energy system of Eastern Paraguay—status and consequences. [↑](#footnote-ref-29)
30. This tariff corresponds to the medium voltage category delivered at the transmission line. The tariff is composed by two components represented by the amount charged per capacity and the amount charged per use, both corresponding to the service provided to this particular consumption group. The values for this category are 304.27 PYG/kWh (peak) and 167.68 PYG/kWh (non-peak). [↑](#footnote-ref-30)
31. Based on live mid-market rates, accessed on January 21, 2018. [↑](#footnote-ref-31)
32. The law includes a prohibition to issue permits, licenses, authorizations and/or any other legal document authorizing the transformation or conversion of native forest areas. Furthermore, [Law 515/94](http://www.infona.gov.py/application/files/2714/2902/2692/ley_515.pdf) prohibits exports and trafficking of wood rolls, lumps and beams. In addition, it prohibits the installation and operation of wood processing industries less than 20 kilometers from the Brazilian border. [↑](#footnote-ref-32)
33. The price of firewood has increased by 580% between 2008 and 2017, reaching US$33 per ton of firewood in March 2017. In some regions of the country, especially those which encompass the Atlantic Forest (such as Alto Parana), firewood price has shown slightly higher increases, due mainly to the lack of supply in those regions and the increased demand from others, such as el Chaco. [↑](#footnote-ref-33)