Document of the Inter-American Development Bank

**Colombia**

**CTF Renewal Energy Financing Program for the Non-Interconnected Zones**

**(CO-L1161)**

**Economic Analysis Annex**

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1. **Introduction**
   1. In the current context of global climate change, governments in emerging economies have to face the important challenge of responding to increasing demands for energy while maximizing their system’s supply reliability, efficiency and sustainability. Investments in power generation from clean sources play a big role in this process, contributing to diversifying the countries’ energy matrixes and mitigating the negative environmental impacts of conventional power technologies.
   2. While Colombia has a high average electricity coverage index (96.1% ), it has about 60% of its territory not inter-connected to the electricity grid, with about 1.8 million inhabitants relying on limited dispersed energy services generated mainly with diesel technology (96.3% of generation) corresponding to emissions of about 375,650 tons of CO2e a year.
   3. The current delivery of electricity services in the ZNIs is based on a subsidized business model[[1]](#footnote-1). In most cases operators depend on subsidies that cover the difference between the lower tariffs charged to strata 1 to 3 end users in the ZNIs and the tariff paid by end-users of the same strata (socio-economic conditions and productive activity) in the SIN. Investments in generation, maintenance and distribution are often not commercially viable, with subsidies covering 30% to 80% of costs. The value of these subsidies paid by the government in 2008-2012 to strata 1-3 in the ZNIs and SIN is estimated at US$381 million[[2]](#footnote-2).
   4. The proposed program will provide Bancóldex, Colombia’s second tier public bank in charge of supporting entrepreneurial development, with additional long term finance to enhance access to long term finance by private sector investors on terms and conditions needed to cover investment costs and payback requirements of RE projects in the ZNIs through on-lending to IFIs that should in turn provide sub-loans in adequate terms to these investors.
2. **Assumptions and Methodology**
3. **Methodology**
   1. Evidence of the economic viability of the proposed program is presented below, based on a cost-benefit analysis focused on the objective of the program, namely, the increase in renewable energy production in the ZNIs and the reduction in greenhouse gas emissions.
   2. The economic analysis for the proposed intervention presents two main results:
      1. A unit abatement cost, comparing the total investment of the program per CO2 unit abated to diesel-based electricity generation in Colombia’s ZNIs.
      2. A value of the net benefits obtained by comparing the costs savings of investing in RE instead of diesel plants and by calculating the net present value of CO2 emissions reduced by RE generation. These benefits are measured during a period of 25 years (which is the estimated lifetime of projects financed by the program) and discounted at a rate of 12%.
   3. The main elements of the analysis are the following:
      1. **Cost Savings**. One of the benefits of the program will come from the costs savings that the investment in renewable energy will represent in the long run. The Colombia government has designed a subsidies scheme that will compensate the energy operators for their generation costs using diesel as a reference. This means that whether an operator produces with diesel or with other sources of energy, it will be compensated as if the electricity was generated with diesel. This opens the possibility for the operators to look for alternative technologies with lesser generation costs that will allow them to increase their profits in the long run.

For the purpose of this evaluation, this implies that the private benefits of the program will not come from an increase in revenues from using renewable energy sources, but for a decrease in the operational costs that in the long run will make this option more attractive. This is because whether the operators produce with diesel or renewable energy, they will always be compensated in the same amount by the government. This implies that the projected flows of income in the scenario without project will be the same as in the scenario with project[[3]](#footnote-3). For this reason this analysis will focus on the difference between the projected cost of the scenario without project and the scenario with project.

The costs are classified in this analysis as investment costs and operation and management (O&M) costs. The investment costs include all the expenses necessary to construct and start operating a power plant meanwhile O&M are the annual costs incurred by the plants for operations and management expenses.

* + 1. **Emissions reductions.** The environmental benefits of the project will come from the reduction in Greenhouse gas emissions that the project will originate. Considering that 97% of actual electricity production comes from diesel engines[[4]](#footnote-4), the new renewable energy installed capacity will partially replace either current or planned diesel generation for the ZNIs for the life span of the project.

The emissions are measured in metric tons of CO2 equivalent utilizing electricity generation data, emissions factor for diesel generators, and the market price for carbon.

* + 1. **Counterfactual scenario**. As a counterfactual, we define an scenario in which the projected electricity demand[[5]](#footnote-5) in ZNIs will be met by investments in power generation that will maintain the current distribution of generation technologies: 97% diesel 3% renewable. Hence, the costs and emissions associated with this distribution of technologies will be the benchmark against which we will compare the costs and emissions of the program.
  1. The cash flows of costs savings and emissions reduced, as detailed above, are then discounted at a rate of 12% (standard for IDB programs) in order to obtain their Net Present Value (NPV).
  2. Finally, this document includes a sensitivity analysis. This analysis is performed considering independent variations in two criteria: (i) O&M costs for diesel and renewable generation plants, and (iii) distribution of renewable energies in the project.

1. **Assumptions**
   1. The main assumptions for the estimation of the cost-benefit of this project are:

***Energy Demand Assumptions***

The projected energy demand is the basis of the estimation of investments required, projected costs and projected emissions for the scenario with project and without project. For the estimation of the demand of energy the following assumptions are considered:

* + 1. **Feasible Beneficiaries**. This analysis follows the target group defined in the Energy Demand Study[[6]](#footnote-6). This study considers as most likely of being eligible for financing, a group of energy operators that currently possess more than 0.5 MW of installed capacity each one in ZNIs. The projected demand of energy is based on data reported for this group.
    2. **Current Installed Capacity**. The energy demand estimation starts from the reported total installed capacity of 158 MW for the feasible group in the ZNIs in 2014.[[7]](#footnote-7)
    3. **Demand Growth**. The demand of installed capacity needed to satisfy energy consumption in the ZNIs is assumed to grow at the same rate as Colombia’s GDP[[8]](#footnote-8). Hence, the projected GDP growth is used to estimate the demand growth.
    4. **RE Participation in New Investments**. We follow the assumption made for the estimation of projected renewable energy investments in the ZNIs[[9]](#footnote-9) that sets in 70% the share of new investments that goes to renewable energy every year in the ZNIs. This assumption would yield (if investments on RE occur every year beyond the programs life spam) a participation of 30% for renewable energy generation in ZNIs by 2040, which is in line with Colombia’s Government plans[[10]](#footnote-10).
    5. **Distribution of investments by RE technologies**. Following the consultations and surveys with energy authorities, energy operators and technology providers we follow the assumption[[11]](#footnote-11) that the yearly investments in RE in the ZNIs will be distributed as follows: 30% for Hybrid Plants (Diesel + Solar), 30% for Solar, 20% for SHP and 20% for Biomass.

**Table 2.1 Distribution of Investments by RE Technology**

|  |  |  |  |
| --- | --- | --- | --- |
| **Hybrid** | **Solar** | **SHP** | **Biomass** |
| 30% | 30% | 20% | 20% |

Source: Analysis of Demand for Credit for Investments in Renewable Energy in ZNI

**Technology Assumptions**

* + 1. **Current distribution of Technologies.** According to data from IPSE[[12]](#footnote-12) the current distribution of generation technologies is 97% diesel and 3% energy generated from renewable sources.
    2. **Renewable Technologies.** Based on consultation with energy experts and operators and energy providers we assume the renewable technologies to be considered for the analysis are: photovoltaic (solar), hybrid (solar + diesel), small hydropower (SHP) and biomass. These technologies produce no GHG emissions, unless we are in the case of an hybrid plant, where emissions are produced by the diesel component of the plant.
    3. **Stages of Development and Calendar**. Following information on standard construction times, we assume that all types of plants considered in this analysis can start operating in the first year of investment. Hence, the flows of costs and emissions begin in year one.
    4. **Load Capacity Factor**. The load capacity factor of a [power plant](http://en.wikipedia.org/wiki/Power_plant) is the ratio of its actual output over a period of time, to its potential output if it were possible for it to operate at full [nameplate capacity](http://en.wikipedia.org/wiki/Nameplate_capacity) indefinitely. This factor can vary depending of the design of the plant and fuel that powers it. Following information from IPSE, reported in the Analysis for Demand of Credit for our target group, we assume that the average load factor of current plants is 64%.[[13]](#footnote-13)
    5. **New RE capacity**. Following the calculations in the Analysis for Demand of Credit, we assume that every financed project will invest, on average, in 0.7 MW of renewable energy installed capacity. This assumption comes from the discussions and surveys with the executing agency, energy operators and technology providers that concluded that for this first stage of RE investments in ZNIs, the current plants will add RE to their generation in an amount equivalent, on average, to 20% of their current average installed capacity (3.67 MW).

**Cost Assumptions**

We follow the cost estimations presented in the Analysis for Demand of Credit, which is based on information provided by UPME, IPSE and specific projects in Colombia and LAC region. These costs consider the additional transportation and logistics requirements that producing in the ZNIs demands.

* + 1. **Investment Costs**. For the diesel plants, we assume an investment cost of 530 USD$ per installed kW. For hybrid (diesel + solar) we assume 3,291 USD/kW, for solar 3,192 USD/kW, for SHP 3,448 USD/kW and for biomass 2,906 USD/kW.
    2. **Operation and Management Costs**. We assume an operational cost of 0.22 USD/kWh for diesel plants, 0.2 USD/kWh for hybrid plants, 0.024 USD/kWh for solar plants, 0.02 USD/kWh for SHP and 0.068 USD/kWh for biomass.

**Table 2.2 Comparison of Investment and O&M for diesel and alternative renewable energies in the ZNI**

|  |  |  |
| --- | --- | --- |
| **Technologies** | **CAPEX (US$/kW)** | **OPEX (US$/kWh)** |
| **Diesel** | 530 | 0.22 |
| **Hybrid Diesel + Photovoltaic** | 3,291 | 0.20 |
| **Photovoltaic** | 3,192 | 0.024 |
| **SHPs** | 3,448 | 0.021 |
| **Biomass** | 2,906 | 0.068 |

Source: IDB estimations of average expenses based on data from Unit for Mining and Energy Planning (UPME). IPSE and exiting projects in the ZNI.

**Assumptions Regarding CO2 Emissions**

* + 1. **Emissions factor for Colombia’s ZNIs.** We follow the information reported from UPME in the Analysis for Demand that provides an estimated emission factor of 10.16 CO2 Kg per gallon, which in turn implies a factor of 0.83 Kg CO2/kWh using generation data from the ZNIs diesel plants.
    2. **Price of CO2 Emissions.** We assume a carbon price of USD 8 based on the current value on the European Energy Exchange for EU Emissions Allowance[[14]](#footnote-14). Furthermore, we assume that the projected carbon prices during the life span of the project will follow the estimations made by 2015 Carbon Dioxide Price Forecast from Synapse Energy Economics[[15]](#footnote-15).

**Assumptions regarding the implementation of the program**

* + 1. **Disbursement of funds**. We assume that the disbursement of the investment will be made during the four years of the program according to the investments required to satisfy the calculated energy demand for each year, given the programs budget.
    2. **Life span of power plants**. The timespan to analyze the benefits will be 25 years, which is a conservative estimate of the life of solar, SHP and biomass plants[[16]](#footnote-16). The reinvestment cost for diesel plants are incorporated in the investment and operational costs.
    3. **Macroeconomic Framework**. For the benefits estimated in this analysis to be accomplished, it is assumed that the economy of the country will keep a framework that ensures appropriate conditions for consumption and investment, both public and private.
    4. **Regulatory Framework**. This analysis assumes that the new regulatory framework that favors RE investment has already taken place for all localities since year one of the analysis.

1. **Results of the Analysis**

**A. Cost-Effectiveness Analysis**

* 1. Table 3.1 below presents the results of the cost-effectiveness analysis. It is expected that the RE plants financed by the program will deliver an annual average production of 55,973 GWh and 1.07 MMT of CO2 emissions reductions over the 25 years of life of the project.
  2. Given this information on emissions reductions over 25 years, the unit abatement cost is US$9.08 per tCO2 considering total CTF investment and US$26.2 when the total project investment costs are considered.

**Table 3.1 Results of Cost-Effectiveness Analysis**

|  |  |  |  |
| --- | --- | --- | --- |
| Electricity Generation | | Investment Costs (USD million) | |
| MW installed | 8.79 | **Total Program Investment** | 28 |
| Total Investment per MW installed (MUSD) | 3.18 | **CTF Investment** | 9.7 |
| Average Annual Generation (MWh) | 55,973 | **Leveraged Investment[[17]](#footnote-17)** | 18.3 |
|  | | | |
| Average annual CO2 emissions reduced (tCO2) | | **42,741** | |
| Total CO2 emissions reduced in 25 years (tCO2) | | **1,068,524** | |
| CTF cost per emission reduced (USD/tCO2) | | **9.08** | |
| Total investment per emission reduced (USD/tCO2) | | **26.2** | |

* 1. Both measures of abatement costs are below the maximum established by the CTF, which is US$200/tCO2. Following these criteria, the project is efficient in terms of maximizing environmental impact in a context of limited resources.

**B. Cost-Benefit Analysis**

* 1. **Definition of the counterfactual.** Since the objective of the project is to finance the development of renewable energy generation in the ZNIs, instead of recurring to the current contaminant technology that prevails, we assume a counterfactual that could represent an alternative scenario to this investment. We define this counterfactual as a scenario in which the projected demand of energy is met utilizing diesel plants.

**Planned Generation and Investments**

* 1. For the estimation of costs and emissions it is necessary first to estimate the investments required to partially satisfy the energy demand which in turn will define the new installed capacity of diesel and RE plants.
  2. Following the assumption that the energy demand will increase at the same rate as the GDP growth, for each of the four years of the program the required new capacity installed is estimated, starting from the current 158 MW installed. However, given that the generation will be limited by what is invested during the initial four years, we assume that the generation capacities of the plants will only growth until year 2025. Afterwards, the generation will remain constant, at its full capacity. The initial growth rate of generation is a combination of new investments and additional hours that growth in response energy demand. For the scenario with project, this new capacity is distributed as follows (following assumption (v)):30% is going to be met by investments in diesel plants and 70% by investments in RE plants. For the counterfactual scenario, we assume that all new investments will be made on diesel plants. Table 3.2 presents the evolution of the total cumulative electricity generation during the program’s lifespan. This generation includes diesel and renewable plants, which are distributed as presented in table 2.1.

**Table 3.2 Evolution of Cumulative New Generation in ZNI**

|  |  |  |  |
| --- | --- | --- | --- |
| **Year** | **kWhr/year** | **Year** | **kWhr/year** |
| **2016** | 13,442,592 | **2029** | 80,859,670 |
| **2017** | 26,885,185 | **2030** | 80,859,670 |
| **2018** | 46,028,002 | **2031** | 80,859,670 |
| **2019** | 66,055,749 | **2032** | 80,859,670 |
| **2020** | 68,081,672 | **2033** | 80,859,670 |
| **2021** | 70,464,531 | **2034** | 80,859,670 |
| **2022** | 72,930,789 | **2035** | 80,859,670 |
| **2023** | 75,483,367 | **2036** | 80,859,670 |
| **2024** | 78,125,285 | **2037** | 80,859,670 |
| **2025** | 80,859,670 | **2038** | 80,859,670 |
| **2026** | 80,859,670 | **2039** | 80,859,670 |
| **2027** | 80,859,670 | **2040** | 80,859,670 |
| **2028** | 80,859,670 |  |  |

**Source**: Estimations based on Analysis of Demand for Credit for Investments in Renewable Energy in ZNI

* 1. Following this, and the costs assumptions in Table 2.2 the distribution of the investments by number of projects, RE technology and installed capacity is as follows:

**Table 3.3 Distribution of Investments by Project and Installed Capacity**

|  |  |  |  |
| --- | --- | --- | --- |
| **Type of Plant** | **Number of Projects** | **Installed Capacity (MW)** | **Investment (USD million)** |
| **Hybrid** | 4 | 2.64 | 8.7 |
| **Solar** | 4 | 2.64 | 8.4 |
| **SHP** | 2 | 1.76 | 5.8 |
| **Biomass** | 2 | 1.76 | 5.1 |
| **Total** | **12** | **8.8** | **28** |

Source: Analysis of Demand for Credit for Investments in Renewable Energy in ZNI

**Cost Savings**

* 1. **Costs calculations.** For the project and counterfactual scenario we calculate costs as follows:
     1. *Scenario With project*. For each of the four years of the program, following the energy demand growth, we have the installed capacity in kW that is going to be installed in diesel and RE plants. For the RE fraction of production (70%). The investment costs are calculated by dividing the required capacity for each year by the weighted investment cost reported in Table 2.2. We then calculate the generation for these plants by multiplying the average expected number of hours of use per day by 365 days. Finally we multiply the annual generation by the weighted average O&M costs reported on Table 2.2. The weights used for these calculations correspond to the assumed participation of RE technologies (Table 2.1). For the diesel fraction of production (30%) the investment costs are calculated by dividing the required diesel capacity for each year by the investment costs reported in Table 2.2. We then calculate the generation for these plants by multiplying the average expected number of hours of use per day by 365 days. Finally we multiply the annual generation by the diesel O&M costs reported on Table 2.2.
     2. *Scenario without project*. The investment costs are calculated by dividing the required diesel capacity for each year by the investment costs reported in Table 2.2. We then calculate the generation for these plants by multiplying the average expected number of hours of use per day by 365 days. Finally we multiply the annual generation by the diesel O&M costs reported on Table 2.2.

The cost savings will be the difference between the total costs (investment plus O&M) of these two scenarios.

**Emissions Reductions**

* 1. First, we calculate the emissions level that each scenario produces.
     1. *Scenario with project.*We multiply the generation of the diesel share of production (30%) by the emissions factor assumed for diesel (assumption xiii).
     2. *Scenario without project.* We multiply the total generation by the emissions factor assumed for diesel.
  2. Then, the emissions reduced by the project are the difference between the emissions in the scenario without project and the emissions in the scenario with project
  3. The economic value of the emissions reductions is calculated by multiplying the reduced emissions for each year of the life span of the plants by the carbon price assumed for that year (assumption xiv).

**C. Economic Returns**

* 1. The net benefits of the program are constituted by the sum of the value of the costs savings and the emissions reduced for each year
  2. **Net Present Value**. Based on the cost savings and emissions reduced detailed above, the net benefits, discounted at a rate of 12%, produce a net present value (NPV) for the program of US$27.92 million. A detailed chart with the calculations is annexed at the end of this document.

**Table 3.3 Summary of Cost-Benefit Analysis**

|  |  |
| --- | --- |
| NPV per concept | (MUS$) |
| Cost Savings | 27.98 |
| Total CO2 reductions | 5.29 |
| Program NPV | **33.27** |

* 1. As it can be seen, the price incentives devised by the Energy Authorities of Colombia allow the existence of a business model that is profitable for the prospective investors in renewable energy. The low O&M costs of RE offset in the long run the high investment costs compared to diesel generation. This speaks to the importance of easing the credit barriers that are currently present in Colombia for this type of investments.
  2. On the other hand the social/environmental benefits have a NPV of USD 5.3 million, which account for the important reduction in emissions that the use of the planned renewable energies generates.
  3. It is also important to mention that, in addition to the benefits considered in this analysis, the project is expected to have a substantial demonstration effect on the private sector investors and developers that can increase the social benefits for the lifespan of the project.

1. **Sensitivity Analysis**
   1. Complementary to these results, a sensitivity analysis is included in this section, where variations on key parameters (O&M costs for renewable energy and participation of technologies) are simulated to gauge their impact on the benefits. In other words, values are stressed in order to verify the tolerance of the program to variations on the conditions that may have an impact on the results established above.
   2. The parameters that were changed for the sensitivity analysis and each of their corresponding private NPV and total NPV values are shown in the table below.

**Table 4.1: Summary of Sensitivity Analysis**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Scenario |  O. Costs |  Solar |  Hybrid |  SHP |  Biomass |  CO2 Price |  RE Inv. Costs | NPV Private | NPV Program |
| **Base** | 0.00 | 0.30 | 0.30 | 0.20 | 0.20 | 0.00 | 0.00 | 27.98 | 33.27 |
| 1 | 0.15 | 0.30 | 0.30 | 0.20 | 0.20 | 0.00 | 0.00 | 24.94 | 31.54 |
| 2 | 0.30 | 0.30 | 0.30 | 0.20 | 0.20 | 0.00 | 0.00 | 22.29 | 27.69 |
| 3 | 0.00 | 0.45 | 0.25 | 0.15 | 0.15 | 0.00 | 0.00 | 29.94 | 35.34 |
| 4 | 0.00 | 0.60 | 0.20 | 0.10 | 0.10 | 0.00 | 0.00 | 32.30 | 37.70 |
| 5 | 0.00 | 0.25 | 0.45 | 0.15 | 0.15 | 0.00 | 0.00 | 21.69 | 27.09 |
| 6 | 0.00 | 0.20 | 0.60 | 0.10 | 0.10 | 0.00 | 0.00 | 15.79 | 21.19 |
| 7 | 0.00 | 0.25 | 0.25 | 0.35 | 0.15 | 0.00 | 0.00 | 29.85 | 35.25 |
| 8 | 0.00 | 0.20 | 0.20 | 0.50 | 0.10 | 0.00 | 0.00 | 32.13 | 37.53 |
| 9 | 0.00 | 0.25 | 0.25 | 0.15 | 0.35 | 0.00 | 0.00 | 28.84 | 34.24 |
| 10 | 0.00 | 0.20 | 0.20 | 0.10 | 0.50 | 0.00 | 0.00 | 30.10 | 35.50 |
| 11 | 0.00 | 0.30 | 0.30 | 0.20 | 0.20 | -0.15 | 0.00 | 27.58 | 32.08 |
| 12 | 0.00 | 0.30 | 0.30 | 0.20 | 0.20 | 0.15 | 0.00 | 27.58 | 33.66 |
| 13 | 0.00 | 0.30 | 0.30 | 0.20 | 0.20 | 0.00 | 0.15 | 27.00 | 32.10 |
| 14 | 0.00 | 0.30 | 0.30 | 0.20 | 0.20 | 0.00 | 0.30 | 26.80 | 31.87 |
| 15 | 0.30 | 0.20 | 0.60 | 0.10 | 0.10 | 0.00 | 0.00 | 7.06 | 12.46 |

* 1. The analysis highlights the importance of two of the main characteristics of the profitability of RE investments under this model. First, it shows that an increase in the share of the hybrid participation in the mix of RE generation yields the second lowest private NPV of the simulated scenarios. This is explained by the increased participation of diesel generation in the RE mix (because a hybrid plant combines diesel generation and solar generation). Hence, the cost savings are significantly reduced. Furthermore, this increments the emissions under the project. We also see that variations in carbon price have small impact on the overall NPV since the most important component of program benefits are due to cost savings. Furthermore, we observe than an increase in the investment cost of renewable energy has a negative effect over the program´s NPV due to the reduction in RE investment and hence, in an increase in operational costs and a decrease in emissions reductions.
  2. On the other hand, we observe that a combined scenario of 30% increase in RE operational costs plus an increase in hybrid participation to 60% yield the lowest private and total NPV of the simulated scenarios. This reflects the fact that the low O&M of renewable technologies is an important component of the profitability of the business model.
  3. **Additional Scenario.** An additional scenario was simulated for the sensitivity analysis. In this case, we considered a counterfactual scenario in which there is private investment in RE funded from sources other than the Program. This departs from our baseline scenario in which all new investments are made in diesel generation. We consider two variations for this analysis: In the first one, 7% of new energy generation is produced by RE energy, while in the second one 15% is destined to RE energy. Table 4.1.1 summarizes the results of this analysis. We observe that when the counterfactual presents 7% of RE generation both private and social benefits NPV decrease. The reason for this is that the presence of RE generation in the counterfactual reduces its overall O&M costs. Furthermore, this RE generation reduces the total amount of CO2 emissions. As a consequence, the comparison with the scenario with project yields smaller savings in costs and emissions reductions. Finally, it is shown that these effects are larger when we consider a counterfactual scenario in which 15% in new generation is allocated to RE.

**Table 4.1.1 Additional Scenarios Simulated for the Counterfactual**

|  |  |  |
| --- | --- | --- |
|  | 7% of Renewable Energy | 15% of Renewable Energy |
| **Private NPV** | 23.46 | 18.23 |
| **Social NPV** | 4.76 | 4.16 |
| **Total NPV** | 28.22 | 22.38 |

1. **Conclusions**
   1. The cost benefit analysis shows how the discounted net benefits of the program is composed by significant net present values for the private as well as for the environmental component of the program.
   2. With regards to the private benefits of the program, the NPV of costs savings is equal to 27.98 million. On the other hand, the environmental benefit of the program is valued in USD 5.29 million. In addition, the sensitivity analysis shows the importance of the low O&M costs for RE plants and the sensitivity to the participation of hybrid plants in the RE composite.
   3. There is an expected demonstration effect that has not been considered for this analysis, which has likely underestimated the benefits of the program.
   4. In general, the project team has used plausible and contrasted assumptions, with aims of a conservative approach for the analysis. Based on this, the project team recommends the Bank to approve the financing of this program.

**Annex 1. Detailed Annual Cash Flows – Cost-Benefit Analysis**



1. The [CREG](http://www.creg.gov.co/phocadownload/publicaciones/propuesta%20para%20remunerar%20el%20servicio%20de%20energa%20elctrica%20en%20las%20zni.pdf) determines costs of service delivery for the operators, taking into account specific localities, energy losses, capacity and availability of installed plants, energy demand, and minimum costs to cover customer needs. [↑](#footnote-ref-1)
2. Ministry of Mines and Energy, 2015. [Statistics Report 2008-2012](http://www.upme.gov.co/Docs/Boletin_Estad_Minas_Energy_2008_2012.pdf). [↑](#footnote-ref-2)
3. In other words, for every given operator in the ZNIs, the price of energy will be the same for the scenario with program as well as for the scenario without program. [↑](#footnote-ref-3)
4. IDB (2015) Analysis of Credit Demand for Investments in Renewable Energy in ZNI ([link](http://idbdocs.iadb.org/wsdocs/getdocument.aspx?docnum=39861426)) [↑](#footnote-ref-4)
5. Ibid. [↑](#footnote-ref-5)
6. Ibid [↑](#footnote-ref-6)
7. Ibid [↑](#footnote-ref-7)
8. The projected GDP growth is comes from estimations made by [Bancolombia](http://investigaciones.bancolombia.com/inveconomicas/home/homeinfo.aspx). [↑](#footnote-ref-8)
9. IDB(2015). Op. Cit. [↑](#footnote-ref-9)
10. [UPME (2011). Plan de Acción Indicativo 2010-2015 PROURE](http://www.si3ea.gov.co/Portals/2/plan.pdf) [↑](#footnote-ref-10)
11. IDB(2015). Op. Cit [↑](#footnote-ref-11)
12. Ibid [↑](#footnote-ref-12)
13. Hence, we are assuming these load factors for every RE technology in the model as well. [↑](#footnote-ref-13)
14. [EEX. EU Emissions Allowance](https://www.eex.com/en/market-data/emission-allowances/spot-market/european-emission-allowances#!/2015/09/16). [↑](#footnote-ref-14)
15. [(2015) Synapse Energy Economics. *2015 Carbon Dioxide Price Forecast*](http://www.synapse-energy.com/sites/default/files/2015%20Carbon%20Dioxide%20Price%20Report.pdf)*.* We consider the mid case scenario. [↑](#footnote-ref-15)
16. IDB(2015). Analysis of Credit Demand for Investments in Renewable Energy in ZNI ([link](http://idbdocs.iadb.org/wsdocs/getdocument.aspx?docnum=39861426)) [↑](#footnote-ref-16)
17. Includes USD 10 million from Bancoldex. [↑](#footnote-ref-17)