**Colombia**

**Renewable Energy Financing Program for the Non Interconnected Zones**

**CO-L1161**

**Program Fit with CTF Investment Criteria**

**Program Fit with Colombia’s Investment Plan and Dedicated Private Sector Program - Phase II**

In 2010, the CTF Trust-Fund Committee (TFC) endorsed an IP for Colombia that outlines the strategy, sectors, and objectives to be implemented by the IDB, the World Bank and the IFC in leveraging additional resources to support climate change mitigation measures in the country. The non-conventional renewable energy (RE) sector was presented in the original CTF IP as a priority sector for a possible second phase of the IP. In 2013, the original IP was revised, adding a Non-conventional RE Program with an indicative CTF allocation of USD 10 million for implementation by IDB, even though the total indicative allocation after the revisions remained at USD 150 million in CTF funding (funds from the Energy Efficiency Program in the original plan were reallocated, decreasing from USD 50 million in the original plan to USD 39 million in the revised plan). The CTF TFC endorsed these revisions (see [Revised CTF IP for Colombia](https://www.climateinvestmentfunds.org/cif/sites/climateinvestmentfunds.org/files/CTF_TFC.11_4_Revised_CTF_Investment_Plan_for_Colombia.pdf)).

In October 2013, the TFC endorsed a [proposal](https://www.climateinvestmentfunds.org/cif/sites/climateinvestmentfunds.org/files/CTF_TFC.12_4_Dedicated_Private_Sector_Programs.pdf) for funding to be deployed for Dedicated Private Sector Programs (DPSP). A [proposal for a Phase II of the DPSP](https://www.climateinvestmentfunds.org/cif/sites/climateinvestmentfunds.org/files/CTF_13_5_DPSP_Proposal_for_Phase_II_.pdf), endorsed in June 2014, includes a RE Mini-Grids and Distributed Power Generation Program, which aims to leverage private investment to fill financing gaps and to promote the widespread development of RE mini-grids to serve rural and under-served off-grid communities. The proposed IDB Program, “RE Financing Program for the Non Interconnected Zones” (ZNIs by its acronym in Spanish) was presented as part of the proposal for Phase II.[[1]](#footnote-1)

The objective of the proposed Program is to promote and increase private investments in RE generation in the ZNIs of Colombia, while reducing GHG emissions. RE investment projects to be funded with CTF resources will be complemented by financing of similar investment projects funded with IDB resources (up to USD 10 million) from the third loan operation (2949/OC-CO, USD 200 million) of an existing Conditional Credit Line for Investment Projects (CCLIP) with Bancóldex.

The Program’s long-term financing would be complemented with technical cooperation activities to address non-financial barriers to the investments and to provide regulatory support.

The Program will be also accompanied by monitoring and evaluation components, seeking not only to assess the Program’s impact but also its replicability. In addition, it will include a system to ensure continuous environmental and social (E&S) risk management, including avoidance of GHG leakage.[[2]](#footnote-2)

**1. Potential for GHG Emissions Savings**

The Program is expected to finance about 12 projects with an average capacity of 735 kW each, for a total RE installed capacity of 8.79 MW (see Annex 10. [Analysis of the Colombian Framework for Concessions in the ZNIs](http://idbdocs.iadb.org/wsdocs/getDocument.aspx?DOCNUM=39851003)). This should result in total emissions reduction of about **42,700 tons of CO2e per year**,[[3]](#footnote-3) or about 1.07 M tCO2e over the lifetime of the projects (around 25 years), from approximately 16.08 million liters of diesel displaced per year, and reducing the cost of electricity by an annual average of 52%[[4]](#footnote-4).

The average potential savings of fuel and GHG emissions by each project to be supported by the Program is 1.34 million liter of diesel/project/year (approx. 3,561 tCO2e/project/year).

Emission reductions were estimated based on savings on liquid fuel (diesel) from specific scenarios of technological changes, potential number of projects to benefit from a USD 19.265 million credit line and an estimated leverage of 30% in financing from intermediary financial institutions (IFIs) and private equity.

Replication potential. Even though the magnitude of the resources for the proposed program limits its scope, if successful the Program could be replicated in more than 100 projects of more than 500KW (an estimate based on the Colombian Government’s ambition to increase the share of RE in the ZNIs to 30%; see below section 4, Demonstration Potential at Scale). This would represent a total of 1.31 million liters of fuel savings, GHG emissions reductions of 130,000 tCO2 per year and 3.5 M tCO2e over 25 years.

**2. Cost Effectiveness**

Based on GHG emission reductions of 1.07 M tCO2e for 25 years, the unit abatement cost of the Program is estimated at: (i) **USD 9.81** **per ton of CO2e** considering only CTF financing (USD 10.5 million); and (ii) **USD 27.3 per ton of CO2e**, when total project investment costs are considered (USD 10.5 million from CTF + USD 10 million co-finance by IDB/Bancóldex + USD 8.7 M in equity from private investors).

A Cost Benefit Analysis (CBA) (see Annex 5) undertaken for this Program indicates that the expected Net Present Value (NPV) of the Program is USD 33.27 million. The sensitivity analysis performed on key variables (participation of different types of renewable energies, increase in O&M costs) indicates that the Program’s NPV remains positive for a wide range of scenarios, base d on a discount rate of 12%.

**3. Demonstration Potential at Scale**

It is expected that the financing and business model proposed by the Program, as well as the selected technologies,[[5]](#footnote-5) could remove some important barriers to investment in RE projects in the ZNIs in Colombia, particularly in terms of increasing the attractiveness (reduced risk and efficient returns) of projects to engage private investors, reducing the risk perception of IFIs, and promoting good contractual practices and schemes.

The business models developed under the Program present a great opportunity to demonstrate the commercial viability of financing and structuring RE mini-grid projects, allowing for Colombian IFIs and potential private investors to reduce their investment risk perceptions and engage further in investing in RE solutions in the ZNIs in the long term. If the model is successful, it could be scaled up to support more RE generation projects for the ZNIs in Colombia. Moreover, the program has high potential for replication in other countries and regions, especially in Latin America and the Caribbean. This is so because the characteristics of the communities not connected to the grid in Colombia are very similar to others in the rest of Latin America and the Caribbean, where around 32 million people have no access to commercial electricity grids[[6]](#footnote-6), often living in remote areas with very low population density and where access to services is difficult and very costly.

Given the Colombian Government’s ambition to increase the share of RE in the ZNIs to 30%, the Program could be replicated to more than 100 projects (more than 500KW) and achieve a total of 1.31 million liters of fuel savings and GHG emissions reductions of 3.5 M tCO2e.

Transformation Potential. The proposed actions of the Program are expected to have a transformational impact as they would help overcoming some barriers such as lack of appropriate financing, lack of regulatory visibility and a better understanding of the business opportunity with RE in the ZNIs. The availability of appropriate financing will improve the RE project economics and in turn this would raise interest from additional private investors and technology suppliers[[7]](#footnote-7), [[8]](#footnote-8). (Figure1 at the end of this document illustrates the evolution of projected emissions for a scenario with and without the program, considering the potential impact of a transformation effect on RE investments by the CTF program, while Figure 2 shows the program’s potential to reduce the operational cost of generation).

The application of the proposed innovative financing model for RE investments (see Annex 10: Analysis of the Colombian Framework for Concessions in the ZNIs) should have important transformational impacts on the technology that is being used in ZNIs, as well as on subsidies, and hence on additional emissions reductions over the long term. Out of the 261.5 MW of installed electrical capacity in the ZNIs, 96.5% is provided by diesel technology, and only 3.5% from renewable energy technologies.[[9]](#footnote-9)

Finally, the Program may have a high potential for replication in other countries in the Latin American region where barriers to mini-grids and RE distributed generation in rural areas are similar, i.e. difficulty of access, little participation of IFIs due to high risk perceptions, and inadequate regulatory and risk management frameworks and instruments.

**4. Development Impact**

In addition to reducing GHG emissions, the development impact of the CTF RE Financing Program for ZNIs will be reflected not only in reductions in energy costs that have a direct impact on the subsidies provided by the government, but also in increasing productivity in the targeted communities given that the quality of electricity service will improve and the number of daily hours of electricity will rise[[10]](#footnote-10). In addition, it would attract new companies and create new jobs in the design, installation, and maintenance of these systems.

Contribution to the Millennium Development Goals (MDGs). The project aims to contribute to the following MDGs: (i) *MDG 1: Eradicate Extreme Hunger and Poverty:* Most (84%) of the users of the energy services in the ZNIs are classified by the statistics office of the Government of Colombia[[11]](#footnote-11) as living in the lowest socio-economic conditions (stratum 1), referring to the physical conditions of households and their productive capacity. Furthermore, within the ZNIs in Colombia, the percentage of unsatisfied basic needs (NBI) is 71%, whereas for the rest of the country it is 28%[[12]](#footnote-12). The proposed Program is expected to enhance the quality of energy service provided by increasing the reliability of the system and enhancing daily-hours of electricity. This is expected to increase productivity and economic benefits, as local businesses would be able to operate longer hours and connect new equipment to increase production and improve the living conditions of the highly diverse communities in the ZNIs, with approximately 840,000 indigenous people of different ethnic groups[[13]](#footnote-13) and 950,000 Afro-Colombians[[14]](#footnote-14). (ii) *MDG 7: Ensure environmental sustainability reducing fuel consumption by low-carbon technologies.* In the case of 1,118 communities in the ZNIs, 96% have low efficiency, expensive to operate diesel generators to cover their electricity needs. The energy use and GHG emissions are likely to contribute to a further deterioration of the environment unless low-carbon technologies are adopted. A challenge remains with respect to introducing new technologies to the grid. Generator service provider companies lack knowledge of the economic benefits of RE systems and perceive that RE investments are expensive (direct costs) and may not have the returns in the very short term of other alternative investments (opportunity costs).

Environmental co-benefits. In addition to GHG emissions reductions, by replacing the use of diesel, the project is expected to result in several other environmental benefits, such as (i) reduction in the risk of oil leakages and spills during transport of diesel to remote areas and operation of generators[[15]](#footnote-15); (ii) reduction in emissions of local pollutants such as particulates (NOx, SOx)[[16]](#footnote-16); (iii) in the case of waste to energy biomass projects, significant gains in terms of correct waste disposal, reducing soil, surface and ground water pollution (especially from animal manure)[[17]](#footnote-17) ,and (iv) in the case of solar projects, significant reduction in noise[[18]](#footnote-18).

The generation cost of electricity per unit from RE is estimated to be 53% lower than the generation cost from the existing diesel generators, which would mean lower electricity costs. This is particularly important for the Colombian government given the level of subsidies to diesel generation to provide affordable electricity prices to the end-users, who normally pay the same fee as a user at the same social level that is connected to the grid[[19]](#footnote-19).

**5. Implementation Potential**

Country and sector strategies. The proposed Program is aligned with a series of initiatives and policies from the Colombian Government. In particular, it will support commitments under the [National Development Plan 2014‑2018](https://colaboracion.dnp.gov.co/CDT/Prensa/PND%202014-2018%20Bases%20Final.pdf) (PND) to (i) consolidate national coverage, by providing 24-hour service in larger municipalities and localities of the ZNIs; (ii) boost schemes for power generation from non-conventional sources of energy and hybrid systems; and (iii) implement economically efficient electricity generation systems in the ZNIs and in areas of difficult access, according to the [ZNIs Electrification Plan](http://www.ipse.gov.co/informacion-institucional/planes/plan-desarrollo-admon/cat_view/82-planes/195-pezni). The PND creates an independent fund for the Pacific Region[[20]](#footnote-20), named “Fund for the Development of the Plan *Todos Somos Pazcífico*”. The Program is aligned with this Government’s initiative to increase access to energy, water and sanitation infrastructure in the Pacific Area of Colombia, and should complement efforts underway by the IDB’s Energy and Water Divisions. The proposed Program goals are also aligned with the Colombian government’s overall ambition to increase the share of RE in the ZNIs by 30%[[21]](#footnote-21).

As explained in detail in the loan proposal (section 1.20), the Colombian government has undertaken a number of initiatives to promote private investment in renewable energies for the ZNIs[[22]](#footnote-22)[[23]](#footnote-23) and has established the Institute for Planning and Promotion of Energy Solutions in ZNIs (IPSE) as responsible for identifying, promoting, developing and implementing energy solutions via organizational arrangements that would bring electricity to the ZNIs in an efficient and sustainable manner[[24]](#footnote-24).

Institutional and implementation arrangements. The Program will be executed and coordinated by Bancóldex, Colombia’s public bank in charge of supporting entrepreneurial development. Bancóldex has a long track record of implementing IDB operations, and the government has chosen it as one of the entities that will support its GHG emissions reduction efforts. Bancóldex is a solvent institution with exemplary risk management practices (see Annex 14. Institutional presentation of Bancóldex).

Bancóldex will implement the Program under its current organizational structure, and will be responsible, among others, for supervising the adequate use of Program financial resources and of the timely provision of human and technical resources necessary for its implementation. Also, it will apply its existing Environmental and Social Management System (ESMS) to identify, analyze, manage and monitor potential E&S risks. The ESMS will be enhanced to address particular E&S risks in the context of the sub-loans to private investors. In particular, it will require Bancóldex to (i) screen against the IDB’s List of Excluded Activities for Non-Sovereign Guaranteed Operations, (ii) comply with applicable Colombian environmental, social, health and safety, and labor regulatory requirements, (iii) develop, with IDB support, and apply a sector-specific checklist, and require a management plan in instances of high risk, (iv) implement a disposal protocol to avoid GHG emissions leakage, (v) exclude Category A sub-projects, and (vi) present an annual Environmental and Social Compliance Report (ESCR), among others. Please refer to the Environmental and Social Management Report (ESMR) (see Annex 8) for additional information and requirements.

Through the technical cooperation activities, Bancóldex will also support complementary activities to address non-financial barriers and perceived risks from private investors and IFIs, such as: (i) identification and promotion of business and contractual models that could ensure payments for the energy generated are sufficient to promote investment returns and address eventual investment risks; (ii) capacity building efforts with the local financial institutions and the Program beneficiaries around opportunities relating to eligible RE technologies; (iii) monitoring and evaluation of the project results and impacts; and (iv) ensuring that any E&R risks associated with financed activities are addressed.

Technology Development Status. The selected technologies to be promoted under the Program are commercially available in Colombia and have a high potential for replication across not only the ZNIs but also in the national interconnected zones.

**6. Additional Cost and Risk Premium**

In spite of the Government initiatives, most of the installed energy generation capacity in the ZNIs remains based on diesel. While some of the business models to promote private sector engagement in investing in the ZNIs, such as the “exclusive service areas” (ESA), are promising, private sector investments in the ZNIs, particularly in RE generation, are still very low (9.4% of total investments in energy generation in the ZNIs)[[25]](#footnote-25). The reason has to do with the differences in cash flow profiles between diesel and renewable technologies and the financing conditions available in the Colombian markets.

RE technologies provide a competitive generation cost compared with the conventional diesel solution, but the initial capital investment is higher, which makes it necessary to put in place special financing conditions for these kinds of projects, such as long term loans and concessional interest rates that allow the technology to be more competitive and attractive than diesel generation. While diesel has much lower CAPEX than a corresponding RE technology, the former presents much higher OPEX than the latter[[26]](#footnote-26).

If the financial market offered reasonable funding opportunities for long term projects, operators could be induced to switch from low upfront investment diesel into high upfront RE investments. However, the actual conditions do not provide medium and long term financing at reasonable rates[[27]](#footnote-27). This financial constraint, together with the still incipient regulatory environment for private sector investments in RE in the ZNIs, explains in large part the operators’ preference for diesel solutions. This problem is aggravated by the lack of familiarity and absence of contractual arrangements that could ensure financial return from RE solutions by the IFIs and the operators.

The proposed Program aims at addressing these barriers through a combination of technical support and financing measures, providing financing under adequate conditions to facilitate investments and the structuring of RE systems in the ZNIs in Colombia. This will contribute to strengthen the development of a business model that uses the framework and incentives established by the Colombian government.

The combination of (i) long term finance (to address payback and CAPEX barriers) with (ii) technical cooperation activities to address non-financial barriers; and (iii) government initiatives underway (in particular, those aimed at developing a methodology of tariff payment), should make it financially viable for operators and technology providers to invest in RE in the ZNIs[[28]](#footnote-28).

Without the government support through subsidies and concessional financing, it would be quite unlikely that RE projects in ZNIs would achieve competitive returns on the investment, and this will continue to keep away investors. CTF funding will be a complementary mechanism in helping the Colombian government with enabling conditions to increase private sector investment in RE in the ZNIs.

Some experiences in developing countries have shown the need for non-reimbursable funds varying form 40% to 60%[[29]](#footnote-29) of the initial investment to financially sustain the project and achieve a reasonable payback period. As shown in Table 1 at the end of this Annex, a number of existing case studies have also produced evidence to suggest that RE technologies in isolated localities that are not connected can provide cost-competitive forms of electrification (per unit, calculated over the system’s lifetime) and can offer a 24-hour enhanced service to power a wide range of appliances. Several studies support that RE systems can result in energy cost reductions compared with costs of conventional diesel generation, the energy source most used to provide electricity in rural communities not connected to the grid. Furthermore, the studies describe similar barriers and risks associated with investing in RE technology solutions, such as lack of appropriate regulation and policy, high upfront cost and long pay back periods, reliability of technologies, access to capital, financing cost and projects liquidity to undertake investments, among others[[30]](#footnote-30), [[31]](#footnote-31). In the case of Colombia there have been also some pilot RE projects demonstrating the viability of RE technologies compared with diesel generation plants.[[32]](#footnote-32) Some case studies highlight experiences in Latin American countries with similar conditions as Colombia, as is the case with Peru[[33]](#footnote-33), Bolivia[[34]](#footnote-34) and Ecuador[[35]](#footnote-35).

**7. Financial sustainability**

In addition to the solid basis under which the Program is being developed, its sustainability is expected to come from the increasing awareness of relevant market players on the risks and returns of RE projects, as well as the strengthening of their capacities to structure and finance effective RE technology projects.

First, the Program will provide financial support through on-lending to IFIs. This is expected to result in IFIs becoming more familiar with these types of technologies, hence reducing their risk perception and, over time, increasing their supply of financing for RE.

Secondly, given the key role that Bancóldex can play in the market as a public institution with in-depth knowledge of private sector investors and local capital markets, and with the additional support of technical cooperation resources, the long-term financing line will be accompanied by a series of activities covering other (non-financial) risks, such as lack of knowledge of the risks and returns of RE technologies and the lack of appropriate contractual and concessional arrangements providing adequate return on investments[[36]](#footnote-36). In particular, this would be achieved through promoting good practices regarding contractual agreements to stimulate private investments; capacity building of key players to engage in these types of investments (IFIs, operators and technology providers) and monitoring and evaluation of results.

As explained in the Analysis of the Colombian Framework for Concessions in the ZNIs (see Annex 10) prepared for this Program, there are a number of potential contractual arrangements that could be promoted to create new windows of opportunities for private investors interested in the ZNIs. For instance, in addition to stimulating and replicating RE investments among the existing operators in the ZNIs, some models would allow for third party investors to engage through PPP contracts with existing operators and with technology service providers (EPCs - Engineering, Procurement and Construction). To the extent that these models could be piloted and be successful, they could result in powerful replication and transformational potential, which would make these business sustainable in the long term.

Finally, the program would be part of a broader, long-term initiative from the Colombian Government to incentivize investments in RE, through its [PND 2014‑2018](https://colaboracion.dnp.gov.co/CDT/Prensa/PND%202014-2018%20Bases%20Final.pdf) and its [Plan of Electrification of ZNIs](http://www.ipse.gov.co/informacion-institucional/planes/plan-desarrollo-admon/cat_view/82-planes/195-pezni), its initiative *Todos Somos Pazcífico*, as well as various regulations[[37]](#footnote-37). Promotion of the current Program is expected to be undertaken in close collaboration with Colombian Government authorities.

**8. Effective utilization of concessional finance**

The proposed Program is expected to test a business model and strengthen the Government’s efforts to scale up private investments and increase the share of RE in the ZNIs. It is designed to complement the policy framework and incentives that the government has put in place to mobilize private investments in RE generation in the ZNIs; and in order to maximize leverage from other sources. On top of the USD 10 million in IDB/Bancóldex lending that will be mobilized as co-financing of CTF resources (USD 9.265 million), it is estimated that the Program would result on a leverage of USD 8.7 million, which correspond to approximately 30% in financing from IFIs and equity from private investment.

Furthermore, as the Program is expected to pilot a model that can later be expanded to other ZNIs, the Program would be mobilizing additional private sector resources as IFIs and other relevant private sector actors become more knowledgeable about the risk and returns of RE investments in ZNIs.

It is estimated that most of the communities have average capacity plant of 750kW, equivalent to USD 2.39 million in investment[[38]](#footnote-38). Projects between 500kW and 10MW of capacity (USD 1.50 million to USD 32 million) will be eligible for credit evaluation, but for bigger projects the co-financing shall be much smaller than that to support to small scale investments in order to reach the target of at least 12 financed projects.

**9. Mitigation of market distortions**

There is currently no active RE market in ZNIs of Colombia, so no potential distortions are foreseen. The program is expected to crowd in private investment, as well as to develop tools to overcome current barriers for competitive institutional framework for RE to be strengthened.

**10. Risks**

There are minor to moderate Environmental and Social Risks, related to small-scale construction, land use change, occupational health and safety, and GHG emission leakage. Bancóldex will apply an existing ESMS to identify, analyze, manage and monitor potential risks. The ESMS will be enhanced to address particular E&S risks in the context of these sub-loans. Please refer to the ESMR (Annex 8) for additional information and requirements. Fiduciary risks in financial and procurement management are low.

While there is sufficient demand for financing by private firms to invest in RE under this program, if the government’s efforts to provide further incentives for private investments are delayed they could impact the replication potential of the program, as this could reduce the attractiveness for operators to invest in RE in the ZNIs. To address this risk, the program will be developed in coordination with relevant national authorities, in particular the Ministry for Mines and Energy (MME), the Energy and Gas Regulatory Commission (CREG), IPSE and the MME’s Mining and Energy Planning Unit (UPME). The replication of the Program’s pilot model could also be smaller than expected because of lack of knowledge of service providers in ZNIs or other potential private investors on the costs and returns of RE technologies. In order to ensure replicability and long term sustainability of the pilot model proposed by the program, it will be complemented by a technical cooperation to support knowledge gaps from firms and IFIs and promote contractual arrangements and other good practices to structure demand for credit with a pipeline of bankable projects (see Part B). A second technical cooperation activity will be focused on regulatory support (see Part C).

**Stakeholder engagement**

The effective implementation of the Program relies on the fact that the proposal and its implementation are being developed in close consultation and collaboration with a number of key actors in Colombia, including the MME, UPME, CREG, IPSE, local technology providers, operators, local investors and those IFIs that are more active in green finance.

Bancóldex has a strong mandate by the Government to support the implementation of its national low carbon development priorities. In fact as a second tier development bank, it is in a unique position to promote Programs such as the one being proposed, as it can easily establish contacts with all of the relevant public and private sector actors that need to be involved in the promotion and financing of climate change mitigation projects.

**Gender issues**

Improved electricity access offers opportunities for gender-inclusiveness and increased productivity of women in isolated communities, particularly low income communities with family-based businesses. The International Network on Gender and Sustainable Energy[[39]](#footnote-39) has shown there are a number of gender-related benefits from improving energy services quality and access in isolated communities.

First, small RE projects in developing countries revealed that households bought appliances to improve living conditions and save time and provide more work options, particularly for women. Second, modern energy services are important for the empowerment of women, because they improve women’s health and make their lives easier so they can participate more fully in development. For instance, more access to appliances such as television and radio was shown to provide language instruction and information on commodity prices, weather, and new farming methods and practices, increasing women’s knowledge through the media, which helped women negotiate their strategic needs both in the household and the community. Electricity and lighting quality can also facilitate home study and organization of evening classes for girls and women who are often housebound due to traditional family responsibilities. Third, affordable and reliable energy options can broaden the scope for women’s enterprises, thereby fostering employment and income generation among women.

The impacts of the Program on women will be assessed by quantifying at the end of Program execution the number of beneficiaries (in communities where the number of hours of supply has increased) disaggregated by sex.

**Table 1: Case studies on mini-grid models**

|  |  |  |  |
| --- | --- | --- | --- |
| **Literature** | **Location** | **Description** | **Reference** |
| Raach Solar 2014 | Niger | The study analyses the current situation in Niger with PV systems and creates a financial model that includes the risks involved in project financing and execution. | Raach, J., 2014. Stratified Energy access in Niger [online]. Niger: Raach Solar. |
| ESMAP 2007a | Peru | Lessons learned from Padre Cocha hybrid project in Peru. | ESMAP, 2007a. Solar-diesel Hybrid Options for the Peruvian Amazon: Lessons Learned from Padre Cocha. Washington, DC: The International Bank for Reconstruction and Development/The World Bank. Report 111/07. |
| Lau et al. 2010 | Malaysia | The report analyses the performance of a hybrid stand-alone system under Malaysian conditions. The document highlights the importance of a hybrid technology as reliable and with low dependence on fuel cost changes. | Lau, K.Y., Yousof, M.F.M., Arshad, S.N.M., Anwari, M. and Yatim, A.H.M., 2010. Performance analysis of hybrid photovoltaic/diesel energy system under Malaysian conditions. Elsevier, Energy [online], 35, 3245-3255 |
| Bhattacharyya 2014 | Bangladesh | Techno-economic analysis which shows different scenarios of energy consumption | Bhattacharyya, S. C. and Palit, D., 2014. Mini-grids for rural electrification of developing countries. 1st edition. Switzerland: Springer International. |
| BID 2013 | Bolivia | Cost - benefit evaluation of different off-grid technologies to support the development of sustainable energy in Bolivia. | BID, 2013. Evaluación financiera y económica del proyecto electrificación rural con energía renovable. Cochabamba: Inter-American Development Bank. |
| Léna 2013 | Africa | Guidance to enable sound decision making when considering solar PV hybrid systems to address rural electrification needs. Presents the main issues to address – from the design, technical and implementation perspectives  | Léna, G., 2013. Rural Electrification with PV hybrid Systems: Overview and recommendations for further development [online]. IEA International Energy Agency |
| Thirumurthy et al. 2012 | India | The document, executed by the National Renewable Energy Agency, informs about the potential of solar mini-grid technologies in India. It has a business case and project economics and an assessment of macro-environmental elements including political, economic, environmental, social and technological. | Thirumurthy, N., Harrington, L., Martin, D., Thomas, L., Takpa, J. and Gergan, R., 2012. Opportunities and Challenges for Solar Minigrid Development in Rural India. Oak Ridge: National Renewable Energy Laboratory. Report NREL/TP-7A40-55562  |
| ESMAP 2007 | World | Technical and economic assessment of off-grid, mini-grid and grid electrification technologies, which includes LCOE for all sources of power generation technologies | ESMAP, 2007. Technical and Economic Assessment of Off-grid, Mini-grid and Grid Electrification Technologies. Washington, DC: The International Bank for Reconstruction and Development/The World Bank. Report 121/07. |
| IED 2013 | World | Identifies the gaps and builds the evidence base on mini-grids in a compilation of eight documents that review mini-grids around the world, executes a cost benefit analysis of different mini-grid technologies, offer some examples of good practices in implementation and operational management and highlight policies and regulatory frameworks for mini-grids | IED, 2013. Identifying the gaps and building the evidence base on low carbon mini-grids. London: Department for International Development. |
| JRC 2008 | Ecuador, Mauritania and Gambia | Cost analysis and financial assessment of hybrid and photovoltaic projects executed in Ecuador, Mauritania and Gambia. | JRC, 2008. A New Scheme for the Promotion of Renewable Energies in Developing Countries. Ispra: European Commission. |
| Szabo et al. 2011 | Africa | The study uses a spatial electricity cost model to determine whether diesel generators, photovoltaic systems or extension of the grid are the least-cost option in off-grid areas | Szabo, S., Bodis, K., Huld, T. and Moner-Girona, M., 2011. Energy solutions in rural Africa: mapping electriﬁcation costs of distributed solar and diesel generation versus grid extension [online]. Paris: IOP Publishing Ltd. |

**Figure 1. GHG emission reduction resulted from the proposed CTF Program**



Figure 1 illustrates the evolution of projected emissions for a scenario with and without the program, considering the potential impact of a transformation effect on RE investments by the CTF program. The emissions projections without the program indicate an exponential increase in emissions from 400,000 tCO2e in 2015 to 1.15 Million tCO2e by 2040, based not only on continued fuel consumption but also on an increase in energy coverage in the ZNIs. In contrast, in a scenario where the RE investments develop following the lead of the CTF Program model, emissions behave in a linear fashion, starting from the same point (shown by the blue line) in 2015 and rising to 840,000 tCO2e in 2040. The difference between the two scenarios presents a gap at the end of the Program of 300,000 tCO2e/year. This is a conservative estimation that does not consider the emissions created from transporting diesel to the ZNIs. It also assumes only a partial replacement of current diesel generation, implying further reductions in emissions if projects converted their technology mix towards RE.

Figure 2 illustrates the program’s potential to reduce operational cost of generation. We observe that a scenario with the CTF program and a replication effect on future investments could lead to a cumulative cost savings of USD 890 million by 2041 from an approximate 50% difference in unit generation cost in the ZNIs between a diesel plant and a (weighted) average RE plant. The application of the proposed innovative financing model for RE investments should have important transformational impacts on the technology that is being used in ZNIs, and on subsidies, and hence on additional emissions reductions over the long term.

**Figure 2. Operational cost reduction resulting from the proposed CTF Program.**



1. The DPSP document proposes an allocation of USD 10 million for Colombia, and an additional allocation of USD 0.5 million for technical assistance activities with a regional focus. However, the IDB is proposing using the full amount (USD 10.5 million) for Colombia. [↑](#footnote-ref-1)
2. See Annex 8: Environmental and Social Safeguards Arrangements for the Program. [↑](#footnote-ref-2)
3. The emission factor applied for diesel is 2.68 Kg CO2/l, based on the *Emission factors for Colombian fuels* (*Factores de Emisión para Combustibles Colombianos FECOC*)”. The reduction in black carbon emissions (a short-lived climate pollutant with impacts on glaciers, ecosystems and health) has not been accounted for. [↑](#footnote-ref-3)
4. Based on the difference between diesel generation cost of 0.22USD /kWh and average RE generation cost of 0.103 USD /kWh. See Annex 10. Analysis of the Colombian Framework for Concessions in the ZNIs. [↑](#footnote-ref-4)
5. See Annex 7, Analysis of Demand for Credit for Investments in Renewable Energy in ZNIs [↑](#footnote-ref-5)
6. Improving access to water and energy in poor communities in Latin America with mobile technology. <http://bit.ly/accLAmob>. [↑](#footnote-ref-6)
7. UNDESA, 2012. Synthesis of energy-related issues highlighted in national reports of Rio+20 [online]. Rio de Janeiro: UN-Energy. [↑](#footnote-ref-7)
8. BASE and POCH 2012. Diagnóstico, análisis de modelos de financiamiento y recomendaciones de coberturas y/o instrumentos de mitigación de riesgo para las energías renovables no convencionales (ERNC) en Chile. Chile: Ministerio de Energía. [↑](#footnote-ref-8)
9. [UPME,[“Acciones y retos para la energización de las ZNIs en Colombia”](http://www1.upme.gov.co/sites/default/files/ckeditor_files/UPME_Simposio_IPSE_Oct2012.pdf), 2014](http://www.upme.gov.co/zni). [↑](#footnote-ref-9)
10. The average electricity service in the ZNIs communities is around 13 hours per day (some communities have just 4 hours of electricity per day). [↑](#footnote-ref-10)
11. [DANE, Dirección Geoestadística, Grupo de Estratificación Socioeconómica](file:///C%3A%5CUsers%5Cmnetto%5CAppData%5CLocal%5CMicrosoft%5CWindows%5CTemporary%20Internet%20Files%5CContent.Outlook%5CAZ5PJTCK%5CLa%20estratificaci%C3%B3n%20socioecon%C3%B3mica%20en%20el%20r%C3%A9gimen%20de%20los%20servicios%20p%C3%BAblicos%20domiciliarios),. See also: <http://www.dane.gov.co/index.php/estratificacion-socioeconomica/generalidades>. [↑](#footnote-ref-11)
12. [E.E. Gaona n, C.L. Trujillo, J.A.Guacaneme. 2015. Rural microgrids and its potential application in Colombia](http://www.sciencedirect.com/science/journal/13640321/51) [↑](#footnote-ref-12)
13. Distributed in the regions of Vaupés, Guainía, Amazonas, Vichada, Putumayo, Guajira, Cauca and Chocó. [↑](#footnote-ref-13)
14. Distributed in the regions of Chocó, Archipelago of San Andrés, Providencia and Santa Catalina, Valle, Bolívar and Cauca. [↑](#footnote-ref-14)
15. World Bank. 2007. [Environmental, Health and Safety Guidelines. Industry Sector Guidelines: Thermal Power Plants - Hazardous Materials and Oil](http://www.ifc.org/wps/wcm/connect/dfb6a60048855a21852cd76a6515bb18/FINAL_Thermal%2BPower.pdf?MOD=AJPERES&id=1323162579734). [↑](#footnote-ref-15)
16. World Bank. 2007. [Environmental, Health and Safety Guidelines. General Guidelines: Environmental – Air Emissions and Air Quality](http://www.ifc.org/wps/wcm/connect/532ff4804886583ab4d6f66a6515bb18/1-1%2BAir%2BEmissions%2Band%2BAmbient%2BAir%2BQuality.pdf?MOD=AJPERES) and [Environmental, Health and Safety Guidelines. Industry Sector Guidelines: Thermal Power Plants – Air Emissions](http://www.ifc.org/wps/wcm/connect/dfb6a60048855a21852cd76a6515bb18/FINAL_Thermal%2BPower.pdf?MOD=AJPERES&id=1323162579734). [↑](#footnote-ref-16)
17. US Environmental Protection Agency. 2013. [Oil and Non-Hydroelectric Renewable Energy](http://www.epa.gov/cleanenergy/energy-and-you/affect/non-hydro.html). [↑](#footnote-ref-17)
18. World Bank. 2007. Environmental, Health and Safety Guidelines. Industry Sector Guidelines: Thermal Power Plants – Noise and World Bank. 1994. [Solar Energy: Lessons from the Pacific Island Experience](http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/1994/05/01/000009265_3970311122736/Rendered/PDF/multi_page.pdf). [↑](#footnote-ref-18)
19. The proposed model requires the government to continue paying the subsidy to the generator temporarily, so that they can recover the RE investment within a reasonable period. This is aligned with the remuneration resolution proposed by the government. For example, operating a 500KW diesel plant 12 hours per day costs an estimated USD 144,540 per year. On the other hand, an RE plant generating the same energy should cost USD 68,081, implying a reduction of USD 76,458 per year per plant. This also represents the savings on subsidies for the government once the RE plant has achieved its return on investment. [↑](#footnote-ref-19)
20. [El Artículo 178 del Plan Nacional de Desarrollo 2014-2018 Crea un Patrimonio Autónomo para la Región del Pacífico](http://www.somospazcifico.gov.co/gestion/Paginas/g_El-Articulo-178-Del-Plan-Nacional-De-Desarrollo-2014-2018-Crea-Un-Patrimonio-Autonomo-Para-La-Region-Del-Pacifico.aspx). [↑](#footnote-ref-20)
21. Ministry of Mines and Energy, [Program for Rational and Efficient Energy Use and Non-Conventional Energy Sources in Colombia](http://www.minminas.gov.co/documents/10180/558752/Informe_Final_Consultoria_Plan_de_accion_Proure.pdf/e8cdf796-d7b1-4bb1-90b9-e756c7f48347) (PROURE), 2010. [↑](#footnote-ref-21)
22. [UPME, [“Acciones y retos para la energización de las ZNIs en Colombia”](http://www1.upme.gov.co/sites/default/files/ckeditor_files/UPME_Simposio_IPSE_Oct2012.pdf), 2014](http://www.upme.gov.co/zni). [↑](#footnote-ref-22)
23. Which include: incentives to improve the share of RE and energy quality for the ZNIs , enabling a framework for private investment in public services through concessions and “exclusive service areas (ESA)” (exclusive private concessions); and most recently, a resolution that regulates tariffs and remuneration to encourage the use of renewable energies for the ZNIs , which is expected to be approved in the coming months. These initiatives are aligned with a recently approved law (1715 in 2014) that aims at promoting investments in energy efficiency and RE in Colombia and increasing their share in the energy matrix. The law seeks to prioritize investment projects in RE from non-conventional sources in the ZNIs and its further regulation (expected to take place during 2016) should result in a number of additional incentives for private investments, such as tax exemptions. [↑](#footnote-ref-23)
24. The Government has also. Towards this end, IPSE carries out directives from the MME by working closely with public service providers in the ZNIs. IPSE also facilitates the use of two dedicated funds, the Financial Support Fund for ZNIs (FAZNIs) and a Rural Electrification Fund (FAER), aimed at providing technical cooperation and financing for the expansion of new generation infrastructure, particularly for the population of the ZNIs with no access to energy. These funds have supported most of the generating capacity in ZNIs and connections to the SIN, allocating USD 100 million a year to these activities. [↑](#footnote-ref-24)
25. This percentage is the relation between private and public investments in the infrastructure of the ZNIs during the period 2010-2013 (calculated based on data from FAZNIs, 2015). [↑](#footnote-ref-25)
26. As mentioned in the Program project document, the new tariff methodology to be applied by CREG to the ZNIs should make the RE projects more attractive as they would benefit from similar conditions as diesel projects. The main difference with regards to costs would however still be CAPEX. See Annex 7: Analysis of Demand for Credit for Investments in Renewable Energy in ZNIs and UPME, 2014. [Acciones y retos para la energización de las ZNIs en Colombia](http://www1.upme.gov.co/sites/default/files/ckeditor_files/UPME_Simposio_IPSE_Oct2012.pdf). [↑](#footnote-ref-26)
27. Currently, the local Colombian financial system does not offer investment finance at maturities greater than 5 years. Specifically (i) for bank liabilities, average maturity is less than one year; and (ii) for bank assets, the average maturity of local currency loans is around 5 years. In addition, Intermediary Financial Institutions (IFIs) lack capacity to market, analyze and structure RE deals, are uncertain about their returns and losses, and often require guarantees of debt repayment. See: Annex 11. Colombia’s Financial Sector Assessment, and Annex 7. Analysis of Demand for Credit for Investments in Renewable Energy in ZNIs. [↑](#footnote-ref-27)
28. The new regulatory framework is expected to establish a clear and transparent remuneration structure for RE investments in the ZNIs. The framework will provide a remuneration structure to attract private investors. Although this framework aims to stimulate private investment, it would be necessary to complement it with the Program, which will facilitate access to appropriate financial characteristics. [↑](#footnote-ref-28)
29. (1) Raach, J., 2014. Stratified Energy access in Niger [online]; Niger: Raach Solar; (2) BID, 2013. Evaluación financiera y económica del proyecto electrificación rural con energía renovable. Cochabamba: Inter-American Development Bank; (3) Bhattacharyya, S. C. and Palit, D., 2014. Mini-grids for rural electrification of developing countries. 1st edition. Switzerland: Springer International. (4) JRC, 2008. A New Scheme for the Promotion of Renewable Energies in Developing Countries. Ispra: European Commission. [↑](#footnote-ref-29)
30. [Léna, G., 2013. Rural Electrification with PV hybrid Systems: Overview and recommendations for further development. IEA International Energy Agency](https://www.iea.org/media/openbulletin/Rural_Electrification_with_PV_Hybrid_systems.pdf). [↑](#footnote-ref-30)
31. OFID, 2014. The mini-grid option: Lessons learned and factors of success. Vienna: Sustainable Energy For All. [↑](#footnote-ref-31)
32. Examples of RE generation where considered in detail under the [Determinacion de inversiones y gastos de administración, operación, y mantenimiento para la actividad de generación en ZNIs usando recursos renovables CREG 2012.](http://www.corpoema.com/web/IMG/pdf/informe_zni_renovables.pdf) [↑](#footnote-ref-32)
33. [Solar-diesel Hybrid Options for the Peruvian Amazon Lessons Learned from Padre Cocha . ESMAP 2007](http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2007/07/11/000090341_20070711100914/Rendered/PDF/402410Peru0Solar1Diesel1Amazon1111107.pdf). This study shows how providing an RE mini-grid system in a small community in has positive impacts on the quality and reliability of power supply to isolated villages and communities in developing countries. [↑](#footnote-ref-33)
34. [Evaluación Financiera y Económica del Proyecto Electrificación Rural con Energía Renovable., IDB 2013](http://idbdocs.iadb.org/wsdocs/getdocument.aspx?docnum=37894538). This evaluation shows how an array of alternative RE technologies is more cost effective than diesel in areas not connected to the grid. [↑](#footnote-ref-34)
35. [A New Scheme for the Promotion of Renewable Energies in Developing Countries. Case study Ecuador. EU Commission PV Technology Platform, 2008.](https://www.energy.eu/publications/LDNA23284ENC_002.pdf) This scheme analyses incentive mechanisms to leverage private sector investments, including conditions relating to a regulated purchase tariff (subsidized price) financial scheme, similar to the conditions currently being developed by the CREG in Colombia. [↑](#footnote-ref-35)
36. See barriers identified by operators, technology providers and IFIs in the Analysis of Demand for Credit for Investments in Renewable Energy in ZNIs (Annex 7). [↑](#footnote-ref-36)
37. Including law 1715 of 2014 that regulates the integration of non-conventional renewable energies into the national system and decree 1623 of 2015 and GREC resolution 004 from 2014 to revise the methodology of tariffs for RE in the ZNIs. [↑](#footnote-ref-37)
38. See Annex 10. “Analysis of the Colombian Framework for Concessions in the ZNIs” report, which includes interviews with municipalities and operators, September 2015. [↑](#footnote-ref-38)
39. Cecelski E. 2000. Enabling equitable access to rural electrification: current thinking and major activities in energy, poverty and gender. Proc. Brainstorming on Poverty Alleviation Women, Jan. 26–27, Washington, DC, World Bank. <http://www.energia.org> and Richter M, Meunier B. 1997. Accelerating Rural Electrification in Inner Mongolia with the Use of Wind and Solar Energy. Eschborn, Ger.: GTZ [↑](#footnote-ref-39)