Effects of Incentives for Renewable Energy in Colombia[[1]](#footnote-1)

Efectos de los Incentivos para Energías Renovables en Colombia[[2]](#footnote-2)

**Abstract**

Renewable energy is becoming very important as a way to mitigate climate change and promote job creation. Colombia is not excluded from this reality, being a country with huge renewable resources and the challenge to give employment to thousands or rebels, signing the peace process. This paper studies the potential effects of the new regulation to promote the development of renewable energy technologies in Colombia. Two incentives are analyzed: tax deductions on the investment and accelerated depreciation on assets. The work also establishes a methodology to include the effects of tax incentives in the calculation of the Levelized Cost Of Electricity (LCOE). The results show up to 20% reduction in the LCOE; unfortunately, the regulation restricts small or new business to apply for all incentives. For this reason, two complementary mechanisms (granting five years as grace period for loan repayment and lower discount rate as subsidy from the government) are proposed in order to allow small business ventures such as forest biomass projects apply to incentives. As a result, 30% reduction in the LCOE is obtained for photovoltaics (PV) and 15% for forest biomass; being the last one a great opportunity in Colombia because of the huge amount of biomass resources and its potential to create new job opportunities.

**Resumen**

La energía renovable ha adquirido gran importancia como una forma de mitigar el cambio climático y promover la creación de empleo. Colombia no es ajena a esta realidad, siendo un país con abundantes recursos renovables y con el reto de dar empleo a miles de guerrilleros que están firmando el proceso de paz. En este artículo se estudian los efectos potenciales de la nueva regulación para promover el desarrollo de las tecnologías renovables en Colombia. Se analizan dos incentivos: deducción de impuestos en la inversión y depreciación acelerada de activos. También se establece una metodología para incluir los efectos de los incentivos de impuestos en el cálculo de los Costos Nivelados de Energía Eléctrica (LCOE, por sus siglas en inglés). Los resultados muestran hasta un 20% de reducción en los LCOE; desafortunadamente, la regulación no permite que pequeños o nuevos proyectos puedan aplicar a todos los incentivos. Por esta razón, se proponen dos mecanismos complementarios (cinco años como período de gracia para pago de préstamos y tasas de descuento más bajas como subsidio del gobierno) para permitir que pequeños proyectos como los basados en biomasa forestal, puedan aplicar a los incentivos. Como resultado se obtiene 30% de reducción en los LCOE para generación fotovoltaica y 15% para generación basada en biomasa forestal; siendo esta última una gran oportunidad en Colombia dado el gran potencial de este recurso y la posibilidad de crear nuevas oportunidades de empleo.

**Keywords:** renewable energy; tax incentives; levelized cost of electricity; forest biomass, job creation.

**Palabras clave:** energías renovables; incentivos fiscales; costos nivelados de electricidad; biomasa forestal; creación de empleos.

# Introduction

New renewable energy installations have experienced rapid growth in recent years. Only in 2011, the new installed capacity of renewable energy generation, accounted for half of the total energy added capacity (about 208 million kW) [1]. These new installations have not been equally distributed across the world, because of the higher cost of the electricity generated compared with conventional plants. Countries with a larger proportion of renewable energy capacity, have implemented programs with public subsidies and other incentives to promote new projects.

In recent years, renewable energy industries have received increasing support in many countries; with feed-in tariff (FIT) and renewable portfolio standard (RPS), as the most popular regulatory policies [1]. The authors of the last reference establish a two-stage game model to compare the effects of these two policies. It is found out that FIT is more efficient than RPS to increase the quantity of the renewable energy installed capacity, and that RPS is more efficient to reduce the carbon emissions and to improve the consumer surplus.

The efficiency of different incentives schemes for the development of renewable energy sources is studied in [2]; where it is concluded that a system of feed-in tariffs is more efficient than a bidding system, but highlights the theoretical interest of green certificate trading which must be confirmed though practice, given the influence of market structures and rules on the performance of this type of approach.

The effect of FIT to promote renewable energy projects in Latin America and the Caribbean region is analyzed in reference [3], where certain similarities are found when comparing five countries, namely Argentina, Dominican Republic, Ecuador, Honduras, and Nicaragua. First, most of them include a wide range of eligible technologies under their national support schemes. Second, most of the countries guarantee a tariff payment over a long period of time (10-30 years). Nevertheless, the analysis reveals that FIT policy design may not be the primary constraint to renewable energy market growth, because the policies have not resulted in a significant market response.

Solar photovoltaic (PV), as another source of renewable energy, has experienced rapid growth over the past few years. One of the reasons that explain its growth is the dramatic drop in the price of panels, as an evidence of the increasing competitiveness of this energy source. Nonetheless, skeptics attribute the rapid growth of solar photovoltaic power, primarily to generous public policies in the form of tax subsidies. In particular, there seems to be no consensus as to whether photovoltaic power is approaching grid parity [4].

Reference [4] provides an assessment of the cost competitiveness of electricity generated by solar power, based on the concept of LCOE in order to identify the factors that are crucial to determine the economic viability of solar photovoltaic: geographic location of the facility, technological improvements, as well as, public subsidies in the form of tax breaks and regulatory mandates for renewable energy. It concludes that utility-scale PV installations are not yet cost competitive with fossil fuel power plants. In contrast, commercial-scale installations have already attained cost parity. This conclusion is shown to depend crucially on both the current federal tax subsidies for solar power and an ideal geographic location for the solar installation.

Factors influencing the grid parity on a country-by-country basis are analyzed in [5]. The paper accounts for both the quality of solar resource and the cost of capital in order to differentiate LCOE from PV. The results suggest that Northern countries may not be an unwise location to subsidize PV construction. Moreover, it suggests that the efforts to expand PV installation in developing countries may benefit greatly from policies designed to make low cost finance more widely available.

Reference [6] analyzes the impact of intermittently renewable energy on Italian wholesale electricity prices, concluding that this intermittency does not imply additional costs for the consumers. This work finds a threshold of Renewable Energy Sources (RES) development within which renewable power penetration would imply an increase in prices and beyond which a further increase in intermittent RES would determine a price collapse.

In [7], the analysis of the impact of the political influences on the adoption of financial incentives for renewable energy by the state governments in the United States finds that the adoption is also motivated by political factors. Economics is the most important aspect for tax incentives, but culture is the most important for grant and / or loan program adoption. The results also show that partisanship is greatly important in the adoption of policy.

Conducting an econometric analysis, reference [8] addresses what renewable energy instruments are effective ways to increase capacity of renewable energy sources. The findings show different effects of the policies. FITs, tender and tax have a positive and statistically significant effect on the capacity of renewable energy deployment in Europe and the United States. The study also finds that quotas do not provide significant results.

Even the costs of some renewable energy sources such as wave energy and offshore wind are still high, the life-cycle costs of offshore and onshore wind are decreasing, being the last technology one the most competitive at present. In [9], two factors behind the rapid growth of onshore wind capacity installation in China are found. The first is the radical reduction in turbine prices worldwide. The second is the Chinese feed-in-tariff effective since 2009 for wind power generation. The authors conclude that the learning-by-doing in China`s onshore wind industry had led to discussion and possible revision in subsidies, moving those resources to offshore wind and solar power.

The use of biomass energy may be an important option both for environmental and economic sustainability, considering that the cost per unit energy of firewood has been competitive in many countries. Reference [10] presents a model for the implementation of agro-energy chains based on the actual availability of forest biomass and the real demand for energy in the area of the Basilicata region, Italy. It tests the possibility to substitute methane gas for heating with thermal energy from biomass; the results shows how the feasibility of this replacement in both energy and economic term depends, respectively, on the biomass availability and investment costs. It highlights that the tax credit provided by the current national legislation and the new incentives on the production of thermal energy from renewable sources and on energy efficiency can give significant impetus to expand the market of thermal energy from renewable sources in Italy.

The potential for renewable energy deployment in Colombia is high but has not been fully estimated for all the resources. Water sources suitable for small run of river hydropower plants (less than 20 MW) are abundant with a potential of 5 GW [11]. Wind potential could be as high as 18 GW only in the region of La Guajira and 35 GW for all the country [12]. Solar energy is also abundant in Colombia with irradiation levels between 1200 and 2200 kWh/m2/year, and a few monthly variations compared with the annual average as the most important part [13]. Biomass makes sense because the country has a competitive advantage to produce biofuels and electricity with a large agricultural sector. Only the potential of agricultural biomass residues can generate approximately 35 TWh/year [13,14], almost 70% of the electricity demand. Besides, the high potential of the forest industry stands out as the country has more than 16 million not covered hectares of natural forests [15,16]. As reference [10] highlights, the enhancement of biomass could trigger processes of environmental improvement, socio-economic development and new job opportunities.

Despite this high potential and the competitiveness of the Colombian electricity market since its structural reform in 1994, there is a lack of renewable electricity projects due to the absence of stimulus and mainly more than 70% of the demand is supplied by large hydropower plants. As a consequence, Colombia has only one 19.5 MW wind power plant up today. Fortunately, Colombian parliament recently passed the renewable energy law, which aims to encourage the construction of new clean electricity generation projects [17-19]. The new law provides a series of incentives covering, income tax deduction, accelerated depreciation, and exemption and elimination of tariffs on some imported equipment; in order to make these technologies competitive with conventional fossil and hydro plants.

Reference [20] provides a proposal of a home energy management model outlined in the Colombian renewable energy law, involving distributed generation for self-supplying, communication protocols, sensors, and intelligent metering systems. The results show the potential of the law to obtain more benefits, not only for the end user, but also for the whole chain value due to the lower use of energy supplied by the interconnected system, reducing the impact on the environment.

Being Colombia a country with large renewable energy resources including hydro, wind, solar and biomass; the regulation to promote these resources will give them the impetus to be part of the energy basket. Besides, the challenge of the peace talks to give occupation to more than ten thousand militants rebel group, will be supported by new renewable energy projects especially those related to biomass, given the country`s large biomass resources and their possibility to create new jobs through agro-energetic businesses.

The potential effects of the new regulation to promote the development of renewable energies in Colombia are studied in this paper. A proposed tax adjusted LCOE method which is calculated for the new incentives under the Colombian regulation, is used to determine the change in the cost of generating electricity from wind, solar PV, biomass and small hydro power projects. Two additional mechanisms are also proposed in order to make financially feasible small business ventures using forest biomass, which in opinion of the authors will play an important role in the peace process with new job opportunities to rebel groups.

# Methodology

This work is divided into four phases. The first phase reviews the Colombian electricity market. In the second phase, the incentives for renewable energy projects are explained. The third phase deducts a mathematical expression to calculate de tax adjusted LCOE under the Colombian regulation. The last phase compares the reference LCOE (without incentives) with the tax adjusted LCOE for the most promising renewable energy technologies in Colombia under different scenarios of investment tax credits, depreciation periods, grace periods, and discount rates.

# The Colombian Electricity Market

During 1992, Colombia experienced the most serious electrical rationing that the country has known. Direct costs were estimated at about three billion US dollars that the Colombian society paid in many ways. Rationing was mainly due to shortages of water resources brought about by an El Niño event. This event precipitated the formation of an electric market (July 1995) and therefore, from its origins, the regulation of the Colombian electrical market does not escape the fears that are derived from a new rationing [21].

Consequently, the regulation of the market has been determined by the interpretation that was made of the main cause of the rationing: shortage of hydro resources. Then, the efforts have been centered in preserving the resources and replacing them with more expensive resources that are complementary and more reliable. The initial two main markets: a spot market and a long term market based on bilateral not standardized contracts have been complemented by the AGC market (payment for system regulation) and the reliability market. Besides, an Independent System Operator (ISO) solves the ideal dispatch in the spot market [22].

As a consequence Colombia has a reliable and efficient electric system with 70% of demand supplied by large hydropower plants and almost 30% supplied by thermal power plants. Nevertheless, higher retail prices have been observed in the last ten years, in spite of the fact that most of the energy is contracted forward. It shows the questioned price paid for reliability and that the efficiency of the market has not benefitted consumers [22].

# Renewable Energy Incentives in Colombia

Two mechanisms have been approved in Colombia to promote the integration of non-conventional renewable energy sources to the grid [17-19]. The first included tax incentives related to: i) tax deductions on the investment income statement related to these purposes; ii) tariffs, through the exemption from the payment of import duties on machinery and equipment for this type of generation; and iii) accounting, where an accelerated depreciation on assets is permitted.

The second mechanism in the law provides for the establishment of a Non-conventional Energy and Efficient Energy Management Fund (FENOGE), which may finance all or part of the programs and projects for the residential sector, at levels 1,2, and 3, as long as they involve small scale, self-generation solutions and promote energy efficiency and good practice.

The regulation has an important drawback that specially affects most small business ventures. That is the restriction to apply to investment tax reductions, which in no case should exceed 50% of the net income and can only be exercised during the first five years of operation. In most of the situations, small businesses do not have profits during this period, being unable to apply to this important incentive.

For this reason, two additional mechanisms are proposed in this work: grace periods for loan repayment and lower discount rates. The first one is not stated as an incentive in Colombia, but can it be a result of a deal with the lender bank which will allow apply to investment tax deductions to small business ventures as shown in the results. Lower discount rates are also studied in order to propose additional measures the government can implement to help easier access to capital markets with lower debt paying.

# The Tax Adjusted Levelized Cost of Electricity

The LCOE allocates the costs of an energy plant across its useful lifetime to give an effective price per unit of electricity generated. It represents the per kilowatt-hour cost of building and operating a generating plant, so it can be divided into the unit cost of capacity (c), the time averaged operating fix costs (f) and the time averaged operating variable costs (v) as represented by equation (1) [4].

|  |  |
| --- | --- |
|  | (1) |

The unit cost of capacity can be calculated using equation (2).

|  |  |
| --- | --- |
|  | (2) |

Where:

I: initial investment

r: discount rate

n: facility expected life (in years)

$E\_{j}$: total electricity generated in year j

This cost of capacity can be affected by the incentives, which in Colombia correspond to accelerated depreciation and tax deduction. The before taxes net present value of these incentives can be calculated as:

|  |  |
| --- | --- |
|  | (3) |

Where, i denotes the investment tax credits, t is the effective corporate tax income rate, T1 represents the maximum number of years to apply the investment tax credits and T2 the useful life of the power generating facility for accelerated depreciation purposes (in years).

Under Colombian renewable energy law new clean energy projects will receive up to 50% tax credits, but they can only be applied during the first five years. According to the earnings report, some restrictions would make no possible to deduct the 50% tax credits in the first year for all the companies. In general, investment tax credits can be calculated as shown in equation (4).

|  |  |
| --- | --- |
|  | (4) |

Therefore, on a pre-tax basis, the unit cost of capacity is adjusted to include the effects of incentives as shown in equation (5).

|  |  |
| --- | --- |
|  | (5) |

For the purposes of calculating the LCOE, the overall effect of income taxes is then summarized by the tax factor ∆ shown in equations (6) and (7).

|  |  |
| --- | --- |
|  | (6) |

Where:

|  |  |
| --- | --- |
|  | (7) |

This tax factor differs from the one shown in reference [4] as the latter assumes that tax deductions can be applied at the time of the investment, which is not possible in Colombia. Finally, LCOE calculation under the consideration of the tax factor effect can be summarized as:

|  |  |
| --- | --- |
|  | (8) |

# Tests and Results

The tax factor adjusted LCOE as deducted in equations (1) to (8) is used in this work as a metric measuring to compare the effects of the incentives proposed to be applied in Colombia. The reference discount rate used in this work is 8.10% which is calculated according to the WACC method for the regulated part of the electrical sector. The study is applied to the five most promising clean energy technologies in the country [19].

#  Investigated Cases

The base case corresponds to the LCOE without incentives of the renewable energy technologies: solar PV, wind, biomass cogeneration, forest biomass and small hydropower. The following scenarios were analyzed for the proposed technologies with the purpose of studying the LCOE under these considerations:

* Applying investment tax credits during the first five years of plant operation.
* Using accelerated depreciation methods.
* Granting several years as grace period for loan repayment.
* Providing access to capital markets with lower discount rate.

# Model Input Parameters

The input parameters are shown in Table 1 for the five most promising clean energy technologies with the values reported in references [16,19]. These technologies are: biomass cogeneration (Bio-cogen), small hydro (S-hydro), wind, solar photovoltaic (PV), and forest biomass (Bio-forest). The input parameters include: a) Investment cost, b) Discount rate, c) Capacity factor, d) Life span in years, e) Fixed cost in USD/kWh-year, and f) Variable cost in USD/MWh. The model output corresponds to the tax adjusted LCOE, calculated under the Colombian regulation.

**Table 1. Model input parameters.**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|   | **Bio-cogen** | **S-hydro** | **Wind** | **PV** | **Bio-forest** |
| Investment (US/kW) | 2000 | 2130 | 2300 | 2500 | 2200 |
| Discount rate (%) | 8.10 | 8.10 | 8.10 | 8.10 | 8.10 |
| Capacity factor (%) | 82.75 | 62.56 | 40.0 | 18.77 | 77.0 |
| Life span (years) | 20 | 30 | 25 | 25 | 15 |
| Fixed costs (US$/kW-yr) | 43.27 | 49.70 | 82.66 | 180.14 | 90.75 |
| Var. costs (US$/MWh) | 4.20 | 5.00 | 5.80 | 0 | 36.1 |

Source: references [16,19]

# Results and Discussion

* + 1. **The reference case**

The reference case assumptions (without incentives) were tested for the five most promising clean energy technologies described in section 3.2. Table 2 shows the results where biomass cogeneration ranks as the most competitive one with LCOE of 47.90 US$/MWh, followed by small hydro with 47.90 US$/MWh, and PV as the most expensive with 203.63 US$/MWh. It can be observed that forest biomass, wind and PV are not competitive with prices above the grid parity in Colombia.

**Table 2. LCOE for the reference scenario (US$/MWh).**

|  |  |
| --- | --- |
| Type of technology | LCOE (US$/MWh) |
| Biomass cogeneration | 47.90 |
| Small hydro power | 55.40 |
| Wind | 92.80 |
| PV | 203.63 |
| Forest biomass | 97.01 |

Source: Authors’ own creation

* + 1. **LCOE with incentives**

The tax adjusted LCOE is calculated incorporating the new renewable energy incentives approved in Colombia. Three scenarios for incentives are compared with the reference case: a) Scenario one for accelerated depreciation, b) Scenario two for tax credits, and c) Scenario three for combined accelerated depreciation and tax credits. Results are shown in Figure 1 where, up to 20% reduction in the LCOE is obtained for solar PV but only 12% reduction accounts for forest biomass.

**Figure 1. LCOE for three scenarios of incentives**

Source: Authors’ own creation

It must be taken into account that the described restrictions in the renewable energy regulation in Colombia allows small business ventures to apply only for accelerated depreciation shown as scenario 1, then the reduction in the LCOE is only 4.5% for PV and 2.5% for forest biomass.

* + 1. **Complementary mechanisms**

The previous results showed that up to 20% reduction in the LCOE can be obtained with the application of investment tax credits and accelerated depreciation methods. Nevertheless, small business ventures or new companies can only get a reduction between 2.5% and 4.5% of the LCOE, corresponding to scenario 1. For this case, two new mechanisms are proposed in order to get the investment tax credit incentives for these businesses. These mechanisms are: a) Granting five years as grace period for loan repayment, and b) Access to lower discount rate as subsidy from the government.

The proposed grace period due to the regulation allows deducting the initial investment only in the first five years of operation. Results for the LCOE under this condition are shown as scenario 4 in Table 4 and Figure 2, where the reduction can be 8% for forest biomass and 14% for PV.

These results are not attractive for new businesses, especially thinking in forest biomass projects with new job opportunities for rebel group soldiers that are signing the peace with the government. For this case, we are proposing a lower discount rate, incentive that has been proposed in India [23] and also Colombia has used it previously as a mechanism to promote the housing sector with very good results in employment creation. Following the example of the housing sector where the government subsidies between two and three percent of the cost of the debt, the LCOE values under the new discount rate are shown as scenario 5 in Figure 2.

**Figure 2. LCOE for additional scenarios of incentives**

Source: Authors’ own creation

The new values shown in Figure 2, result in a LCOE that is 30% lower for PV and 15% lower for forest biomass. PV is not yet competitive but forest biomass price gets the grid parity in the isolated regions of Colombia. These country regions are the most appropriate to create new renewable energy business ventures with job opportunities to the rebel group soldiers that are signing the peace in Colombia.

# Conclusions

 Colombia has huge potential of renewable energy resources that had no incentives to be developed in the past, having only a 19.5 MW wind power plant in operation. Fortunately, a new regulation approved a set of incentives to promote new renewable energy projects.

The deducted tax factor allows calculate directly the tax adjusted LCOE avoiding long cash flows calculations. Results show between 12% and 20% reduction in the LCOE for the incentives approved under the renewable energy Colombian regulation.

The approved incentives are not sufficient for all the renewable energy technologies and do not apply for small business ventures, then two additional mechanisms: grace period for loan repayment and lower discount rate are proposed. These mechanisms can give more reductions, especially for those businesses that have restrictions to get access to the incentives existing today.

The high potential of biomass resources in Colombia and the proposed mechanisms can get LCOE prices that are lower than the grid parity in most isolated regions. As a result, they can give impetus to the peace process allowing the creation of jobs for the new labor force coming from the rebel groups.

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