doi: 10.11144/Javeriana.iyu21-2.eire

Effects of Incentives for Renewable Energy in Colombia[1]

Efectos de los incentivos para energías renovables en Colombia[2]

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How to cite this article:
F. Villada Duque, J. M. López Lezama, and N. Muñoz Galeano, "Effects of Incentives for Renewable Energy in Colombia," *Ing. Unv.,* vol. 21, no. 2, pp. 257-272. doi: http://dx.doi.org/10.11144/Javeriana.iyu21-2.eire

[1] Submitted on: July 25th, 2016. Accepted on: May 2nd, 2017. Scientific and technological research article.

[2] Fecha de recepción: 25 de julio de 2016. Fecha de aceptación: 2 de mayo de 2017. Artículo de investigación científica y tecnológica

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Abstract

Introduction: This paper studies the potential effects of a new regulation to promote the development of renewable energy technologies in Colombia. *Methods*: This work establishes a methodology to include the effects of tax incentives in the calculation of the Levelized Cost of Electricity (LCOE). Two incentives are analyzed: tax deductions on the investment and accelerated depreciation on assets. *Results*: The first calculation shows up to 20% reduction in the LCOE; unfortunately, the regulation restricts small or new business from applying for all incentives. For this reason, two complementary mechanisms are proposed to allow small business ventures, such as forest biomass projects, to apply for incentives. As a result, a 30% reduction in the LCOE is obtained for photovoltaics (PV) and 15% for forest biomass. *Conclusions*: The deducted tax factor permits the direct computation of a tax-adjusted LCOE, avoiding extensive cash flow calculations. The high potential of biomass resources in Colombia and the proposed mechanisms can push LCOE prices lower than the grid parity cost in most isolated regions. This represents a great opportunity in Colombia because of the huge amount of biomass resources and the potential to create new job opportunities.

Keywords

renewable energy; tax incentives; levelized cost of electricity; forest biomass, job creation

Resumen

Introducción: En este artículo se estudian los efectos potenciales de la nueva regulación para promover el desarrollo de las tecnologías renovables en Colombia. *Métodos*: Se estableció una metodología para incluir los efectos de los incentivos de impuestos en el cálculo de los Costos Nivelados de Energía Eléctrica (LCOE, por su sigla en inglés). Se analizaron dos incentivos: deducción de impuestos en la inversión y depreciación acelerada de activos. *Resultados*: Los primeros cálculos 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 propusieron dos mecanismos complementarios para permitir que pequeños proyectos 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. *Conclusiones*: El factor fiscal deducido permite el cálculo directo de los LCOE ajustados y evita la elaboración de extensos flujos de caja. El alto potencial de biomasa en Colombia y los mecanismos propuestos permiten obtener LCOE menores que los precios de paridad de red en la mayoría de las zonas no interconectadas. Esto representa una gran oportunidad en Colombia, dado el gran potencial de este recurso y la posibilidad de crear nuevas oportunidades de empleo.

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. In 2011, newly installed capacity of renewable energy generation accounted for half of the total added energy capacity (approximately 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.

Renewable energy industries have received increasing support in many countries, with a feed-in tariff (FIT) and renewable portfolio standard (RPS) as the most popular regulatory policies [1]. The authors in [1] establish a two-stage game model to compare the effects of these two policies. It concludes that FIT is more efficient than RPS in increasing the quantity of renewable energy installed capacity and that RPS is more efficient in reducing carbon emissions and improving the consumer surplus.

Menanteau et al. [2] study the efficiency of different incentive schemes for the development of renewable energy sources. The authors conclude that a system of feed-in tariffs is more efficient than a bidding system but highlight the theoretical interest of green certificate trading, which must be confirmed by practice given the influence of market structures and rules on the performance of this type of approach.

The effect of the FIT to promote renewable energy projects in Latin America and the Caribbean region is analyzed in [3]; the authors find certain similarities when comparing five countries: Argentina, the 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 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].

Reichelstein and Yorston [4] provide 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, and 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 situation depends on both the current federal tax subsidies for solar power and an ideal geographic location for the solar installation.

Factors influencing grid parity on a country-by-country basis are analyzed in [5]. The paper accounts for both the quality of the solar resource and the cost of capital in order to differentiate LCOE from PV. The results suggest that Northern countries may not be a wise 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 financing more widely available.

Gulli and Lo Balbo [6] analyze 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], an analysis of the impact of political influences on the adoption of financial incentives for renewable energy by 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, Kilinc-Ata [8] addresses which renewable energy instruments are effective at increasing the capacity of renewable energy sources. The findings show different effects of the policies. FITs, tender and taxes 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.

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 to be engaged and one of 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 has led to a 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. Romano et al. [10] present 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 of substituting methane gas for heating with thermal energy from biomass; the results show how the feasibility of this replacement in both energy and economic terms depends on the biomass availability and investment costs. It highlights that the tax credit provided by the current national legislation and the new incentives for the production of thermal energy from renewable sources and for 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 resources. Water sources suitable for small runs 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 just in the region of La Guajira and 35 GW for the entire country [12]. Solar energy is also abundant in Colombia, with irradiation levels between 1200 and 2200 kWh/m^2/year and, most important, few monthly variations compared with the annual average [13]. Biomass makes sense because the country has a competitive advantage to produce biofuels and electricity due to its large agricultural sector. The potential of agricultural biomass residues can generate approximately 35 TWh/year [13],

[14], almost 70% of the electricity demand. In addition, the high potential of the forest industry stands out, as the country has more than 16 million uncovered hectares of natural forests [15], [16]. As [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 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 today. Fortunately, the Colombian parliament recently passed a renewable energy law that encourages the construction of new clean electricity generation projects [17]-[19]. The new law provides a series of incentives, including income tax deductions, accelerated depreciation, and exemptions from and the elimination of tariffs on some imported equipment, to make these technologies competitive with conventional fossil fuel and hydro plants.

Vega et al. [20] provide 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 distribution chain due to the lower use of energy supplied by the interconnected system, thus reducing the impact on the environment. Following the methodology of [4], Castillo-Ramírez et al. [21] present an assessment of the fiscal incentives stated in Law 1715/2014 [17] to calculate the LCOE. Numerical results show LCOE reductions between 16% and 33% when the incentives are applied.

Because Colombia is 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 overall energy basket. In addition, the challenge of the peace talks to provide work for more than ten thousand militant rebels 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 new regulations 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 regulations, is used to determine the change in the cost of generating electricity from wind, solar PV, biomass and small hydropower projects. This paper proposes two additional mechanisms to make small business ventures using forest biomass financially feasible, which in the opinion of the authors will play an important role in the peace process by providing new job opportunities for rebel groups.

1. 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 describes a mathematical expression to calculate the tax-adjusted LCOE under Colombian regulations. 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.

1.1. The Colombian electricity market

In 1992, Colombia experienced the most serious electrical rationing that the country has known. Direct costs were estimated at about three billion US dollars, which the Colombian society paid for 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 electricity market (July, 1995), and therefore, from its origins, the regulation of the Colombian electricity market cannot escape the fear of new rationing [22].

Consequently, the regulation of the market has been determined by the interpretation that the main cause of rationing is the shortage of hydro resources. Efforts have been centered on preserving 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. In addition, an Independent System Operator (ISO) solves the ideal dispatch in the spot market [23].

As a consequence, Colombia has a reliable and efficient electric system, with 70% of the demand supplied by large hydropower plants and almost 30% supplied by thermal power plants. Nevertheless, higher retail prices have been observed over the last ten years, despite the fact that most of the energy is contracted forward. This fact questions the price paid for reliability and shows that the efficiency of the market has not benefitted consumers [23].

1.2. Renewable energy incentives in Colombia

Two mechanisms have been approved in Colombia to promote the integration of non-conventional renewable energy sources into the grid [17]-[19]. The first includes 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 practices.

The regulation has an important drawback that especially affects most small business ventures. This is the restriction in applying for 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 situations, small businesses do not have profits during this period and cannot apply for 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 result from a deal with the lender bank, which will allow applying for 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 ease access to capital markets with lower debt payments.

1.3. 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; therefore, it can be divided into the unit cost of capacity (c), the time-averaged operating fixed costs (f) and the time-averaged operating variable costs (v), as represented by equation (1) [4].

$$LCOE = c + f + v \tag{1}$$

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

$$c = \frac{I}{\sum_{j=1}^{j=n} \frac{E_j}{(1+r)^j}} \tag{2}$$

Where:
I: initial investment
r: discount rate
n: facility expected life (in years)
Ej: total electricity generated in year *j*

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

$$NPV = \frac{tI}{1-t}\left(\sum_{j=1}^{j=T1} \frac{i_j}{(1+r)^j} + \sum_{j=1}^{j=T2} \frac{d_j}{(1+r)^j}\right) \tag{3}$$

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 is 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 it impossible to deduct the 50% tax credits in the first year for all companies. In general, investment tax credits can be calculated as shown in equation (4).

$$i = \sum_{j=1}^{5} i_j = 0.5 \tag{4}$$

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

$$c_{adj} = \frac{I}{(1-t)\sum_{j=1}^{j=n}\frac{E_j}{(1+r)^j}} - \frac{tI}{(1-t)\sum_{j=1}^{j=n}\frac{E_j}{(1+r)^j}}\left(\sum_{j=1}^{j=T1}\frac{i_j}{(1+r)^j} + \sum_{j=1}^{j=T2}\frac{d_j}{(1+r)^j}\right) \tag{5}$$

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

$$c_{adj} = c.\Delta \tag{6}$$

Where:

$$\Delta = \frac{1}{(1-t)}\left[1 - t\left(\sum_{j=1}^{j=T1}\frac{i_j}{(1+r)^j} + \sum_{j=1}^{j=T2}\frac{d_j}{(1+r)^j}\right)\right] \tag{7}$$

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:

$$LCOE = c.\Delta + f + v \tag{8}$$

2. Tests and results

The tax factor adjusted LCOE, as deducted in equations (1) to (8), is used in this work as a metric measuring the effects of the incentives proposed 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].

2.1. 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:

- Considering investment tax credits during the first five years of plant operation.

- Using accelerated depreciation methods.
- Granting several years as a grace period for loan repayment.
- Providing access to capital markets with a lower discount rate.

2.2. 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) Lifespan 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	40.00	18.77	77.00
Lifespan (years)	20.00	30.00	25.00	25.00	15.00
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	0.00	36.10

Source: references [16], [19].

3. Results and discussion

3.1. The reference case

The reference case assumptions (without incentives) were tested for the five most promising clean energy technologies described in section 2.2. Table 2 shows the results, where biomass cogeneration ranks as the most competitive case, with a LCOE of 47.90 US$/MWh, followed by small hydro at 47.90 US$/MWh; PV is the most expensive at 203.63 US$/MWh. It can be seen 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)

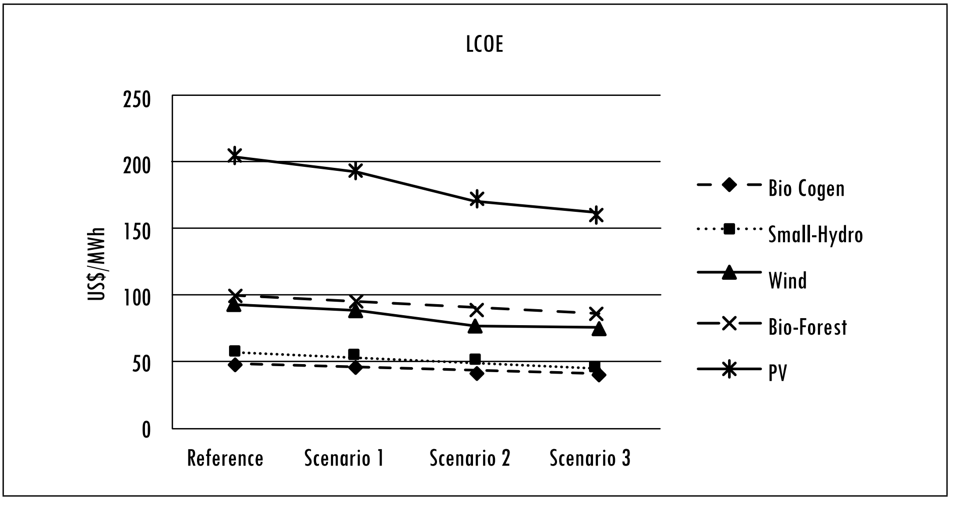
Type of technology	LCOE
Biomass cogeneration	47.90
Small hydropower	55.40
Wind	92.80
PV	203.63
Forest biomass	97.01

Source: Authors' own elaboration.

3.2. LCOE with incentives

The tax-adjusted LCOE is calculated by incorporating the new renewable energy incentives approved in Colombia. Three scenarios for incentives are compared with the reference case: (a) Scenario 1. for accelerated depreciation; (b) Scenario 2. for tax credits, and (c) Scenario 3. for combined accelerated depreciation and tax credits. The results are shown in Figure 1, where up to a 20% reduction in the LCOE is obtained for solar PV but only 12% for forest biomass.

Figure 1. LCOE for three scenarios of incentives



Source: Authors' own elaboration.

It must be considered that the restrictions in the renewable energy regulation in Colombia allow 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.

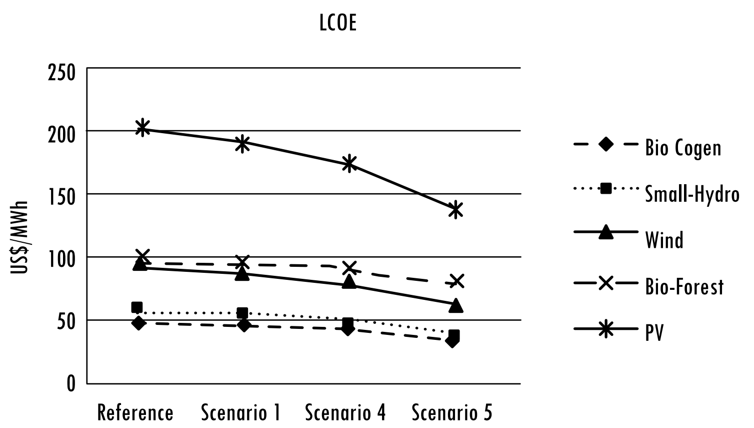
3.3. Complementary mechanisms

The previous results showed that up to a 20% reduction in the LCOE can be obtained with the application of investment tax credits and accelerated depreciation. Small business ventures or new companies can only get a reduction between 2.5% and 4.5% of the LCOE, corresponding to Scenario 1. Because of this, two new mechanisms are proposed to get the investment tax credit incentives for these businesses. These mechanisms are (a) granting five years as a grace period for loan repayment and (b) access to a lower discount rate as a 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. The 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 for forest biomass projects with new job opportunities for rebel group soldiers that are signing a peace agreement with the government. For this case, we are proposing a lower discount rate, an incentive that has been proposed in India [24], and Colombia has used this method 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 subsidizes 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 elaboration.

The new values shown in Figure 2 result in an LCOE that is 30% lower for PV and 15% lower for forest biomass. PV is not yet competitive, but the forest biomass price matches 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 for the rebel group soldiers that are signing the peace agreement in Colombia.

Conclusions

Colombia has a huge potential of renewable energy resources that had no previous incentives for development, with only a 19.5 MW wind power plant in operation. Fortunately, a new regulation provides a set of incentives to promote new renewable energy projects.

Although there are some previous studies regarding the calculation of the LCOE, most of them consider tax deductions at the moment of the investment; however, these must be applied year by year during the terms established by the regulation, as proposed in this paper. This leads to a more accurate calculation of the LCOE.

The deducted tax factor allows calculating directly the tax-adjusted LCOE, thus avoiding long cash flow calculations. The results show between 12% and 20% reduction in the LCOE for the incentives approved under the Colombian renewable energy regulations.

The approved incentives are not sufficient for all the renewable energy technologies and do not apply to small business ventures. Two additional mechanisms are proposed: a grace period for loan repayment and a lower discount rate. These mechanisms can provide 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 achieve 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.

The main limitations of any LCOE calculation depend on the stability of regulations. In this case, fixed fiscal conditions are assumed for a long period of time. This might not be the case in most Latin American countries, where there are continuous fiscal reforms.

Acknowledgments

The authors gratefully acknowledge the support of the sustainability program 2016-2017 of Universidad de Antioquia.

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