



Renewable Energy Sources in Developing Countries: Challenges and Opportunities for a Sustainable Development Agenda

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Abstract: A renewable energy matrix plays a fundamental role in providing energy services in a sustainable platform and, particularly, to reduce climate change on a global basis. However, alternative energy sources usually poses extra challenges to adopters due to higher costs, mainly in the developing and emerging countries where: 1) basic needs still remain to be covered, and 2) top technologies, such as the required in those initiatives, are likely not to be promptly available. This article aims to verify the status of the current renewable energy sources contribution to the regular energy systems of some countries across the Latin American region as a measure to reduce the adverse impact over the average temperature and extreme climate events. Latin America, despite its vast territory and considerable availability of natural resources – which could well place the region in a leading position in terms of alternative energy – is still in the early stages of having the mindset and infrastructure required to respond to the current environmental challenges. This exploratory study compares the database of renewable energy and climate change drivers of some Latin American countries, seeking to verify similarities and differences, as well as the possible effect of strategies and government policies, barriers and issues in the generation of an energy system that support the region economic growth while following the key principles of sustainability. For our research, we use Multivariate Analysis based on a large set of available and updated open public indicators to establish critical areas and regional progress. The main finding is that, if not at length comparable to the leading EU countries and other advanced economies in the matter, some countries in the region have been presenting important advances to date, being able to combine economic growth to friendly-environmental practices – often a hard equation to solve – while others, on the contrary, stay behind in sustainable practices. Most importantly, at last, is the highlight of initiatives that stand out as positive examples having helped mitigate the environmental burden, clearly pointing towards solutions to the challenge of having sustainable development inclusive practices in the Latin American region.

Key words: Climate change; Renewable energy; Sustainable development; Latin america

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INTRODUCTION

Energy is considered, on a worldwide basis, as essential to the development of a nation. From the five modern energy sources: petroleum, coal, natural gas, nuclear energy and hydro-electricity, only the last one is renewable; however its use is still relatively concentrated in some countries. With the advance of technology, electricity became crucial to keep the urban life standards.

For many decades, and especially in the years of 1970 and 1980, the governments concern and focus towards energy were chiefly economical. In that time, in many countries there have been key investments in energy infrastructure works such as hydroelectric power plants, transmission networks, and water reservoirs.

According to the site Sustentabilidades, the global consciousness and concern about the environment has gradually evolved internationally and can be summarized by some landmarks. It started more strongly in the 1970's, with the Stockholm United Nations Conference about Human Environment (1972), and moved on with the United Nations World Committee about Environment and Development (1983), the Rio Summit Agreements (1992), the Kyoto Protocol (1997), and Rio+20 (2012). Despite such events comprising many countries, the ones that have a full adhesion and signed commitment with clear targets to reduce emissions are the European Union members, and a few other countries like Australia and New Zealand. A major country like the United States has not signed the Kyoto Protocol, for instance. The challenge posed to the Latin American countries, and possibly to other emerging nations, is how to promote country growth to raise the social and economic standards to the population while keeping a close eye at the environment – that means make use of the least invading and damaging practices as possible to conserve nature and the environment.

According to Coviello (2003), in the decade of 1990 the United States and the United Kingdom, following recommendations of international finance institutions, have privatized the state-owned energy companies, and as a result, there has been also some deregulation in the market in Latin America.

An event marked the 1990 decade: The writing of the Rio Statement on Environment and Development (Rio 92) and the Agenda 21 during the United Nations Conference on Environment and Development (UNCED), taken place in the Brazilian city of Rio de Janeiro, when it was discussed solutions for the sustainable development on a global basis.

Still in the same decade, it is worth mentioning some other events directed towards the promotion of renewable energy in Latin America such as the energy program of the National Commission for Energy Saving (CONAE) in Mexico, the National Program of Electric Energy Conservation (PROCEL) in Brazil, and the Andean Program for Energy Saving (PAE) in Peru. (COVIELLO, 2003).

Since then, the globalization and the economic and political competition take the agenda of the nations, and the changes in the world's energy system are consolidated in the first half of the 20th century (Barros, 2007) considering: Globalization as a reality, The growing competition of national and corporate economies, The strategic importance of energy source available for competitiveness, The energy crisis, mainly driven by the limited petroleum production level that reached all nations, exposing the degree of external dependence, which led to a re-evaluation of competitiveness and development agenda.

THEORETICAL FRAMEWORK

1. Petroleum

Petroleum keeps on being the largest and most important energy source for modern society. Besides providing the fuel used in the thermoelectric power plants, being still a key energy source, other fuels are petroleum-derived such as gasoline, kerosene, and diesel, used both in automobiles and in the industries. The chemical industries are highly dependent on petroleum, since products such as plastics, asphalt and synthetic rubber are by-products extracted from petroleum.

Historically the petroleum prices have been raising – in the decades of 1970 and 1980 barrel prices have jumped from US\$ 5 para US\$ 33, when the famous petroleum crises took place. According to Campbell (2006), in the 1980 decade the world realized we were consuming more petroleum than we were finding – in 2005, for instance, for every five barrels consumed only one new has been found.

In view that petroleum is not found all over the world, it is worth pointing out the largest reserves, which according to the BP Statistical Review of World Energy (2012) are as follows. First is Venezuela, with the first position and 297 billion barrel reserves, over 17% or world's share, followed by Saudi Arabia, with 265 billion barrels and 16% of world's share. Then come Canada, Iran and Irak, which together have approximately 450 billion barrels in reserves, being nearly 30% of world's share.

Goldemberg (2007) highlights the challenges the world has to cope with regarding the use of petroleum:

- 1) The limits of available reserves;
- 2) The environmental impacts, particularly those connected with climate change;
- 3) Disputes to get access to petroleum in certain regions, and the use of nuclear technology, even for pacific reasons;
- 4) The pressure over the developing countries needing to import petroleum products, and consequently, the growth of their external debts. What is right is that petroleum is a key energy source available in limited quantity and as such and it is bound to be worn-out, which makes asks for long-term, sustainable alternatives.

2. Renewable energy

In Latin America, Brazil stands out as a large country that managed to find a sustainable alternative to fossil fuel, with sugar-cane derived ethanol. According to Janssen e Rutz (2011), besides the successful consolidated case of bioethanol in Brazil, other countries in Latin America have been progressing in creating and implementing policies that can create a renewable, alternative energy source to fossil fuel, such as Argentina with soy-based biodiesel, and Colombia, Costa Rica and Guatemala with sugarcane-based ethanol.

Coelho and others (2013) point out that, despite Brazilian widespread use of bioethanol in cars, there is an opportunity to extend that use into transportation vehicles, which currently contribute expressively to the increase of greenhouse emissions in Brazil.

As highlighted by The Economist magazine, the growth of bioethanol in Brazil to a high extent can be credited to the development of the flex motor cars, which can use both gasoline and ethanol as a fuel. The same article questions the expansion of ethanol as an alternative

energy source in terms of government policies and incentives after the large oil source discovered recently, but anyway it asserts that, in view of its sustainable aspect compared to fossil fuel, the sugar-based ethanol industry has a true potential to become global.

In another study, Goldemberg, Coelho and Guardabasi (2008) number what they consider the long-term consequences of the sugar-cane ethanol production: “Positive impacts are the elimination of lead compounds from gasoline and the reduction of noxious emissions. There is also the reduction of CO₂ emissions, since sugarcane ethanol requires only a small amount of fossil fuels for its production, being thus a renewable fuel (...) Negative impacts such as future large-scale ethanol production from sugarcane might lead to the destruction or damage of high-biodiversity areas, deforestation, degradation or damaging of soils through the use of chemicals and soil decarbonization, water resources contamination or depletion, competition between food and fuel production decreasing food security and a worsening of labor conditions on the fields”. (Goldemberg; Coelho; Guardabasi, 2008, p. 2086)

The paper *The Independent* recently reported Costa Rica stayed for about 75 days only using renewable energy. Furthermore, the article mentions their energy sources as 94% renewable, being 80% hydropower and 10% geothermal, and highlights the country’s investment in geothermal energy, taking advantage of the volcanic areas in their territory. Their objective is to be less dependent from hydropower, and, in the near future, use little or no fossil fuel energy – despite the recent discovery of rich oil sources in their coast area – to reach the carbon-neutral status by 2021. The article emphasizes the second position of Costa Rica, after Uruguay in Latin America, reached for its electricity and telecommunications infrastructure in the 2014 World Economic Forum Global Competitiveness Index.

However, Meisen and Krumpel (2009), bring a realistic, critical picture about renewable energy in Latin America. These authors assert that, different from the recurrent and somewhat optimistic widespread view, the situation in Latin America is no better than in other regions of the world. In fact, they comment that the initiatives to create renewable energy sources in the region are almost all limited to hydropower and biofuels. For hydroelectric energy, they call attention to the environmental damage required to build such huge constructions as well as the difficulties to have them to operate in a situation of dry weather and less water availability. About the biofuels, they mention that industrial biofuels, like ethanol, might not help reducing greenhouse emissions while traditional biofuels as firewood and grass could cause deforestation or not follow sustainable practices.

DATA ANALYSIS AND DISCUSSION

We used some key drivers and variables connected with renewable energy: Outdoor Air Pollution Attributable Deaths, Greenhouse Gas Emissions, Use of Alternative and Nuclear Energy Sources, Combustible Renewables and Waste, Fossil Fuel Energy Consumption, and Ocean Health Index. Then we carried out a multivariate analysis to verify similarities and differences among the Iberian American countries and of the countries of the advanced economies and the remaining countries, whose results are shown in the table 1 below:

Table 1 ANOVAs Compariing Means and F-Values for Variables – 132 countries sample

Reg/Var	FossFuel	OutAirPoll	CombRenew	AlternNuc	Greenhgas	OHI
AIBER	67.20	16.54	21.50	12.26	1.47	61.57
AVECO	70.60	21.01	9.24	22.76	0.90	73.15
OTHERS	67.68	23.52	23.67	5.91	4.87	63.20
F-Value	0.17	1.17	3.85	14.48	2.60	29.45

Source: the authors

When we compare the group of 132 countries, we observe there is no much discrimination that would allow for an adequate analysis. That is because each of the three groups comprise countries in different development stages, except for those included in AVECO. Being so, we go for a separate, detailed analysis only of the Iberian-American countries and discuss their status in terms of positives and negatives, whose main results are as follows:

1. Outdoor air pollution deaths

Iberian American countries have an average of 15 deaths per 100,000 people directly attributable to outdoor air pollution. Close to this figure (15 deaths) are countries like Mexico, Peru, Brazil, and Colombia. Six countries stand out with an index between 23 and 35: Cuba, Portugal, Argentina, Chile, Uruguay and Spain. In the positive extreme, we have Guatemala, Costa Rica, Panama, Paraguay, Nicaragua and Ecuador, presenting between 3 and 6 deaths per group of 100,000 people.

2. Greenhouse gas emissions

In terms of greenhouse gas emissions, we see a concentration of 12 countries ranking between 0 and 1, that is with emission that go from 1000 to 2000 CO2 equivalent per GDP, which is considered relatively high. Costa Rica, Peru, Spain, El Salvador, Portugal, Dominican Republic, Chile, and Colombia are the highest ranked in terms of emissions, while Bolivia, Paraguay, Nicaragua, Venezuela, and Uruguay are the lowest ranked ie with less emissions of CO2 per GDP. The outlier country here is Bolivia, with an index, 4 that is, below 100, and here we should mention is might be connected to GDP since Bolivia has one of the lowest GDPs of South America.

3. Use of alternative and nuclear energy sources

Overall, the Iberian American countries are far from being clean with regard to their key energy sources: averagely only 10% of the total energy employed comes from alternative and/or nuclear sources. However, two countries stand out as positive outliers with over 40% non CO2-generating energy sources: Costa Rica and El Salvador. After those, best ranked are Spain, Brazil, Colombia, and Uruguay with 15 to 20% of their energy coming from alternative sources. The other extreme show countries presenting less than 5% of alternative energy sources: Cuba, Dominican Republic, Bolivia, and Guatemala.

4. Combustible renewables and waste

Overall, Iberian American countries averagely have about 20% of use of combustible renewables and waste in relation to total energy consumed. The single outlier country is Guatemala, which presents a figure of over 66%. The majority of countries ranks between 5 and 15% and include Portugal, Cuba, Colombia, Panama, Dominican Republic, Spain and Equador. With 40 to 50% usage are Paraguay, Honduras and Nicaragua, while Uruguay and Brazil reach about 30%. The three countries positioned with less than 5% are Mexico, Argentina and Venezuela.

5. Fossil fuel energy consumption

Overall, we see nearly 75% of fuel consumption from fossil origin in the Iberian American countries. The largest group comprising Argentina, Dominican Republic, Mexico, Venezuela, Cuba, and Equador come as the top users, with 85 to 89% of fossil fuel energy usage. The second largest group, including Uruguay, Brazil, Honduras, Nicaragua, Costa Rica and El Salvador use between 45 and 55%. Only two countries use around 30% of fossil fuel: Guatemala and Paraguay.

6. Ocean health index

The Iberian American countries show a relative high Ocean Health Index – average 61. It should be in view of the vast coast and the resources that are available such as fish, salt and petroleum and its importance to the national economies and the populations. Top ranked are Mexico, Costa Rica, Colombia and Guatemala, with an index between 68-75. Lowest positioned are Paraguay, Nicaragua, Uruguay, Dominican Republic and Honduras, going from 45 to 55. Paraguay seems fully justifiable, since the country has no coast, being dependent from Brazil and Argentina to have a sea access.

CONCLUSION

Overall, we notice that the Iberian American countries rank in an intermediate position, driven usually from Spain, Portugal, Chile, Costa Rica and Uruguay – excluded such countries, most probably, the region would be in a much lower position, sometimes close to average figures shown by the African countries. We also see that the best-positioned countries in terms of the policies connected with relatively sustainable practices are also those that have the highest economic performance. That is the case of countries like Costa Rica, Chile and Uruguay, which usually present some economic and social figures relatively similar to those of the advanced economies. The same occurs to Spain and Portugal, which benefit from being full members of the European Union and have to be aligned in terms of the policies of the richest and full-developed nations, which are also more advanced in these questions. In fact, it seems that Iberian America as a group presents similarities with the group of 132 countries, replicating, in a microcosm, the conditions of that macrocosm in terms of diversity. In other words, if in Iberian America we have countries very well ranked as we mentioned, on the other hand, we may have countries presenting figures comparable to those of the Sub-Saharan region, for instance. Even in the case of the few successes, we can see that, behind some positive figures there may be serious problems hidden, such as that of income inequality. Furthermore, there have been some advances with specific types of renewable energy such as hydroelectric and biofuel, and in smaller scale, geothermal, but other equally productive and perhaps less invasive alternatives are still to be explored in

more depth, like solar and wind energy generation, for instance. So far, this relatively limited reach in terms of a sustainable energy matrix, particularly in Latin America, makes more evident that numbers are cold, and, being so, in order to have a more critical view it claims a deeper comparison and contrast, checking an isolated figure with a magnifying glass and then grouping them together to allow a good inference of the results, having in mind the interdependence of the facts and their weight to the analysis and the overall performance of a country or another. Clearly, there is a long way to go in the region, and the good examples, particularly of some small countries, can be brought to open discussion as the ones to be followed along with the successful experiences and initiatives of other regions.

BIBLIOGRAPHIC REFERENCES

- [1] Barros, E. The global energy and the competitiveness of nations: a new basis geopolitics. Engevista. Rio de Janeiro, 2007
- [2] BP and Sustainability <http://www.bp.com/en/global/corporate/sustainability.html>. Retrieved 28 July 2015
- [3] Campebell, C. Brazil and the end of the Oil Era Veja, São Paulo, 20.12.2006
- [4] Coelho, S.T. et al. Bioethanol from Sugar: The Brazilian Experience. Encyclopedia of Sustainability Science and Technology. Springer New York, p 1-28, 2015
- [5] Coviello, M. F. International environment and opportunities for the development of renewable sources of energy in Latin-American and Caribbean countries. CEPAL – Serie Recursos naturales e infraestructura. Santiago, Chile, 2003
- [6] Energy in Brazil: Ethanol's Mid-life Crisis. The Economist, Sep 2010 <http://www.economist.com/node/16952914>. Retrieved July 25, 2015
- [7] Garcia, Felipe B. The Emergence of Sustainability. Mundo da Sustentabilidade. October 2009 http://sustentabilidades.com.br/index.php?option=com_content&view=article&id=5:surgimento-dasustentabilidade&Itemid=37
- [8] Goldemberg, J., Coelho, S.T., Guardabassi, P. The sustainability of ethanol production from sugarcane. Energy Policy, Vol. 36, Issue 6, p. 2086–97, 2008
- [9] Goldemberg, J., Lucon, O. Renewable energy: a sustainable future. Revista USP. São Paulo, 2007
- [10] Janssen, R., Rutz, D.D. Sustainability of biofuels in Latin America: Risks and opportunities. Energy Policy, Volume 39, Issue 10, p. 5717–25, 2011
- [11] Meisen, P., Krumpel, S. Renewable Energy Potential of Latin America. Global Energy Network Institute, 2009 <http://www.geni.org/>
- [12] Rio+20. Sustainable Development 20 Years on from the Earth Summit. June 2012 <http://rio20.net/en/documentos/sustainable-development-20-years-on-from-the-earth-summit/>
- [13] Tufft, B. Costa Rica goes 75 days powering itself using only renewable energy. The Independent. March 2015. <http://www.independent.co.uk/news/world/americas/costa-rica-goes-75-days-powering-itself-using-only-renewable-energy-10126127.html>