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# Implications and Challenges for the Energy Sector in Brazil and Mexico to Meet the Carbon Emission Reductions Committed in Their INDC during the COP 21-CMP11

## *Implicações e desafios para o setor energético do Brasil e México para atender às reduções de emissão de dióxido de carbono comprometidas no INDC durante a COP 21-CMP11*

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**ABSTRACT:** Despite contributing only 1% to global emissions each, two of the largest economies in Latin America, Brazil and Mexico, are strongly committed to reducing their carbon dioxide ($CO_2$) emissions by 43% and 40% respectively by the year 2030. Achieving these goals, however, will not only necessitate the implementation of technical innovations, cleaner energy sources and active participation of all sectors, but will also require significant changes in the energy policies of both countries. This article will identify the goals stated by Brazil and Mexico in their Intended Nationally Determined Contributions (INDCs), and examine the actual and prospective primary energy mixes and consequent $CO_2$ emissions. In addition, strategies related to technical, economic and social efforts needed to achieve these purposes are explored. Finally, the opportunities for achieving COP21-CMP11 commitments through the implementation of renewable energy in different sectors will be discussed; while showing their potential for also providing energy sovereignty and potential economic benefits for both nations.

*Keywords:* Intended Nationally Determined Contributions (INDCs); COP21-CMP11; renewable energy; carbon dioxide emissions; Brazil; Mexico.

**RESUMO:** Apesar de contribuir com apenas 1% das emissões globais, duas das maiores economias da América Latina, Brasil e México, estão fortemente empenhadas em reduzir suas emissões de dióxido de carbono ($CO_2$) em 43% e 40%, respectivamente, até o ano de 2030. O alcance desses objetivos não só exige a implementação

de inovações técnicas, fontes de energia mais limpas e participação ativa de todos os setores, mas também demandará mudanças significativas nas políticas de energia dos dois países. Este artigo identificará as metas estabelecidas pelo Brasil e México em suas Contribuições Nacionalmente Determinadas Pretendidas (INDCs) e examinará as matrizes de energia primária atuais e perspectivas e as consequentes emissões de $CO_2$. Além disso, serão exploradas as estratégias relacionadas aos esforços técnicos, econômicos e sociais necessários para atingir esses fins. Finalmente, serão discutidas as oportunidades para alcançar os compromissos da COP21--CMP11 por meio da implementação de energia renovável em diferentes setores, assim como será mostrado o seu potencial para também fornecer soberania energética e benefícios econômicos potenciais para as duas nações.

*Palavras-chave:* Contribuições Nacionalmente Determinadas Pretendidas (INDCs); COP21-CMP11; energias renováveis; emissões de dióxido de carbono; Brasil; México.

## *1. Introduction*

The most recent Assessment Report of the Intergovernmental Panel on Climate Change (IPCC- AR4 Synthesis Report, 2014) indicates the unequivocal evidence of climate change. The report states that the anthropogenic-related contribution to greenhouse gases (GHG) concentration is very likely the cause of climate change. $CO_2$ has become the target GHG for most negotiations and goals related to global warming. The extraction, processing, transportation, distribution, and use of fossil fuels constitute the largest single source of anthropogenic $CO_2$ emissions. This is the reason why the nexus between climate and energy production and consumption patterns constitute the starting point to deal with climate change. A great challenge is the fact that GHG emissions by country are differentiated based on socio-economic development, consumption/production levels, and technology available. Meanwhile the impacts will be felt by everybody on the planet, although levels of vulnerability and adaptive capacity also vary. This inequitable situation increases the complexity of the interventions required to control GHG emissions, limit warming, and at the same time achieve economic development in developing countries. The international body responsible for leading these goals is the United Nations Framework Convention for Climate Change (UNFCCC).

The UNFCCC aims to stabilize the concentration of anthropogenic (human originated) GHG in the earth's atmosphere in order to avoid dangerous climate change (2015 Paris Climate Conference, 2016). The UNFCCC officially began on March 21, 1994, and since then it has been responsible for holding a series of annual meetings, referred to as "Conference of Parties' (COP), which started with the COP1 in Berlin in 1995. In 2005, the COP11 annual meeting was joined by the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol (CMP). The most recent meeting was the COP21-CMP11, which was held in Paris in December 2015. This conference was considered a milestone since the main purpose was to achieve a legally binding agreement to keep global warming below 2°C, while promoting equitable social development and adequate distribution of responsibilities and funding for adaptation and mitigation, especially by developing countries (2015 Paris Climate Conference, 2016). The COP21-CMP11 is regarded as the turning point for climate action because the world is reaching a point where the relative safe levels of warming can still be reached if there is a global international agreement with a

transparent legal framework that ensures immediate action (Nino, 2016).

Ahead of the COP21-CMP11, each participating country submitted their Intended Nationally Determined Contributions (INDCs), which are action plans that specify the way and the magnitude of their expected contributions (ibidem). The contributions each country provides are the key to reducing global emissions and reducing the concentration of GHG and therefore global warming. However, each country struggles with their INDCs, particularly developing countries dealing with reducing poverty and having less economic resources to shift to renewable energy sources. Probably one of the main challenges of ratifying the COP21-CMP11 agreement relies on finding a way in which developing countries can reach economic development with low carbon alternatives instead of business-as-usual fossil-fuel-intensive energy production. Up to January 2016, almost 200 countries had adhered to the agreement, which will be officially signed in April 22, 2016.[1]

Considering the above, the goal of this paper is to analyze the two most populated countries in Latin America, Brazil and Mexico, in terms of their status in the climate change arena, and their participation in the last COP21-CMP11 through their INDCs to GHG reductions; and explore the energy-related options available for them to reach these goals. The analysis of these aspects covers the projected changes and contributions up to 2030, which is the time-frame established in the countries' INDCs .

The next section of the article will cover the description of climate change issues with reference Brazil and Mexico's status, which will be followed by a description of these countries' commitments towards reductions in emissions by 2030, according to their INDCs. The third section addresses the description of the energy sectors in Brazil and Mexico. Since most of the $CO_2$ emissions are related to the use of carbon-intensive fuels, the energy sectors have the higher stakes in achieving reductions through shifting to alternative energies sources. The fourth section explores some mitigation alternatives such as consumption reduction, change to less GHG emission intensive fuels, and development of renewable sources. The fifth section presents the institutional arrangements developed by both countries towards the achievement of these goals. Finally, in the last section, we provide a discussion of the implications of these goals, and some conclusions informing energy-climate policies.

## *2. Climate change in Brazil and Mexico, and their Intended Nationally Determined Contributions (INDCs) towards COP21*

In the Americas, Brazil and Mexico are developing countries that are among the 15 top emitters of $CO_2$ in the world (PBL-NEAA & ECJRC, 2014). Both countries are struggling with taking people out of poverty while changing their development path to low carbon energy production. They have the 1st and 5th places in biodiversity in the world respectively (they are "mega diverse" countries) (Llorente-Bousquets & Ocegueda, 2008). Both have important challenges regarding social-ecological systems' adaptation to climate change because of the heterogeneity of their territories (they cover several altitudinal and eco-geographical gradients). Brazil is exposed to drought, floods, and freezes,

[1] Retrieved from: <http://newsroom.unfccc.int/paris/>. Access on January 2016.

while Mexico has extensive deserts and is exposed to drought and hydro meteorological events (IPCC, 1997).

Three of the ten most populated cities in the world (Mexico City, Sao Paulo, and Rio de Janeiro) are located in these countries. Like many nations, Brazil and Mexico have had an exponential growth in population in the last two centuries; but in the last four decades have shown a virtually linear increase. These countries had a 2% population size growth per year from 1970 to 2014, while the total primary energy consumption had a 3% and 2% rise per year respectively (World Bank, 2016). On the other hand, regardless of the population growth and rise in energy demand, there is a $CO_2$ emissions increase of 2% and 1% per capita each year for Brazil and Mexico respectively. However, the world emissions per capita has decreased on average by 1% a year (Olivier *et al*., 2015).

Considering the above, both Brazil and Mexico have a big challenge for reducing $CO_2$ emissions towards 2030. The INDCs' commitments of each country are described in the following subsections with special attention to mitigation, adaptation, and implementation measures.

### *2.1. Brazil's INDC*

Even though Brazil is a developing country, and as such, is less responsible for the current concentration of GHG compared to developed nations, it has taken clear action towards controlling its own GHG emissions. The Brazilian INDC states that it has reduced emissions by 41% in the year 2012 (in relation to the year 2005) what "represents one of the largest undertakings by any single country to date" (Brazilian Government, 2015).

The INDC of Brazil is unclear with regards to its dependence on the agreement reached during COP21-CMP11. It depends upon whether the different responsibilities and capabilities of every country are acknowledged, but at the same time states that it "is not contingent upon international support", which implies an unconditional intention to reduce GHG emissions (Brazilian Government, 2015).

The Brazilian INDC includes three parts: mitigation, adaptation, and implementation. With regards to mitigation, Brazil commits to reduce 37% GHG by 2025, taking as a baseline the year 2005 (Brazilian Government, 2015) (Table 1). Subsequent contributions include 43% by 2030. In terms of adaptation, Brazil has specific adaptation plants including: the National Adaptation Plan (NAP), the National Water Security Plan, and the National Strategic Plan for Protected Areas (Brazilian Government, 2015). Brazil's INDC implementation section includes an initiative called South-South that seeks collaboration with other developing countries (Brazilian Government, 2015).

### *2.2. Mexico's INDC*

In June 2012, Mexico enacted the General Law on Climate Change (LGCC in Spanish), making Mexico the first developing country to have a law on climate change and the Mexican INDC is congruent with this law (Mexican Government, 2015). The INDC aims to reduce 50% of emissions by 2050, with a baseline to 2000, considering both mitigation and adaptation strategies (Mexican Government, 2015) (Table 1). With regards to mitigation, Mexico's INDC call for actions that are the least costly and at the same time provide wellbeing benefits for the people. Therefore, the short-lived climate pollutants (SLCP) – such as black carbon

– were included in the LGCC, along with several GHG (Mexican Government, 2015). There are two types of mitigation measures: unconditional and conditional. Unconditional measures refer to those in which Mexico will use its own resources for implementation, while the conditional measures depend on the results of the international agreements from COP21-CMP11 and on the resources that can be directed from developed nations for technology transfer. The adaptation component of the INDC focuses on protection of communities, which are vulnerable to impacts of climate change and the strategies include the increase of resilience through infrastructure as well as ecosystem services (Mexican Government, 2015).

### *2.3. Comparison of the INDC of Mexico and Brazil*

Overall, the intended contributions of Brazil and Mexico are very similar for the year 2030, Brazil and Mexico commit to a 43% and 40% GHG emissions reduction respectively. However, Mexico has a conditional statement for 15% of these 40% GHG reduction.

The INDCs of Brazil and Mexico are similar particularly in the adaptation sections. Both countries give strong emphasis to the prevention of disasters mainly by monitoring hydro-meteorological events. In addition, both countries focus on ecosystem services and conservation of biodiversity, and emphasize a human rights approach that considers vulnerable populations and gender issues.

Some differences between both countries' INDC include the baseline year, where Brazil chose 2005 while Mexico chose 2013, except for the reductions in the year 2050. In this case, Mexico considers 2000 as a baseline year. There is also a difference in the goal years for both countries, where they converge in 2030. In addition, Brazil's INDC provides exact emissions amounts for each goal year (in Gigatons of carbon dioxide emissions, or $GtCO_2e$), while Mexico's INDC does not. Finally, Brazil included an intention to collaborate with other developing countries, while Mexico did not mention collaboration.

A very important difference between the INDC of the two countries is that Brazil focuses on biofuels as a way to reduce carbon emissions, while Mexico emphasizes on the reduction of black carbon. Even though black carbon contributes to global warming, it is not considered a GHG, because it is a solid particle, or aerosol (US EPA, 2016). The inclusion of black carbon in the Mexican INDC decreases the actual contribution of reduced emissions of GHG (22% unconditional and 36% conditional). Finally, Brazil reserves its position towards international market based mechanisms, while Mexico considers these as essential.

Considering the INDC of Brazil, a 43% carbon emission reduction goal using 2005 levels as baseline reference, would imply going from 345.11 million tonnes per year, to 182.91 metric tonnes (Figure 1). In the case of Mexico, a 40% $CO_2$ emissions reduction using the year 2015 as baseline reference, would imply going from 450 million metric tones in that year to 283.55 metric tonnes by 2030. The current status of the energy sectors in each country and the alternatives for mitigation are explored in the following sections.

TABLE 1 – Comparison of the INDC of Brazil and Mexico.

| | Brazil | Mexico |
|---|---|---|
| **Coverage** | Nation-wide | Nation-wide |
| **Baseline year** | 2005 | 2015 |
| **Reduction of GHG by 2025** | 37% (1.3 $GtCO_2e$)[1] | Not included* |
| **Reduction of GHG by 2030** | 43% (1.2 $GtCO_2e$) | · 25% (unconditionally- 22% GHG and 51% black carbon)<br>· 40% (conditional upon intl. agreement – 36% GHG and 70% black carbon) |
| **Reductions by 2050** | Not included* | · 50% (with the year 2000 as baseline) |
| **GHG considered** | · Carbon dioxide ($CO_2$)<br>· Methane ($CH_4$)<br>· Nitrous oxide ($N_2O$)<br>· Hydrofluorocarbons (HFCs)<br>· Perfluorocarbons (PFCs)<br>· Sulphus hexafluoride ($SF_6$) | · Carbon dioxide ($CO_2$)<br>· Methane ($CH_4$)<br>· Nitrous oxide ($N_2O$)<br>· Hydrofluorocarbons (HFCs)<br>· Perfluorocarbons (PFCs)<br>· Sulphus hexafluoride ($SF_6$) |
| **Non GHG** | | · Black carbon |
| **Sectors involved in the reduction of GHG** | ·Energy- emphasis on biofuels<br>· Land-use change and forests<br>· Agriculture<br>· Industry<br>· Transportation | · Energy<br>· Industry<br>· Agriculture<br>· Waste<br>· Land-use, land-use change and forestry |
| **International market based mechanisms** | Position is reserved | Regarded as essential for a rapid and cost effective mitigation action |
| **Adaptation** | · Protection of vulnerable populations<br>· Increase resilience and reduce vulnerability through ecosystem services<br>· Promote research and technology development<br>· Monitoring extreme rain events with action plans to respond to disasters<br>· Conservation of biodiversity and sustainable use of natural resources | · Protection of vulnerable communities to adverse hydro meteorological events<br>· Increase resilience<br>· Conservation of biodiversity<br>· Reduction of deforestation<br>· Enhance adaptive capacity |
| **People** | Human rights approach considering vulnerable communities, indigenous populations, workers, and gender issues | Gender equality and humans rights approach |
| **Cooperation** | Cooperation with other developing countries (South-South) | |

Source: elaborated by authors with information from the INDC from Brazil and Mexico
[1] Assuming a Global warming potential (GWP) -100 (IPCC AR5)
* Not included in the analyzed documents

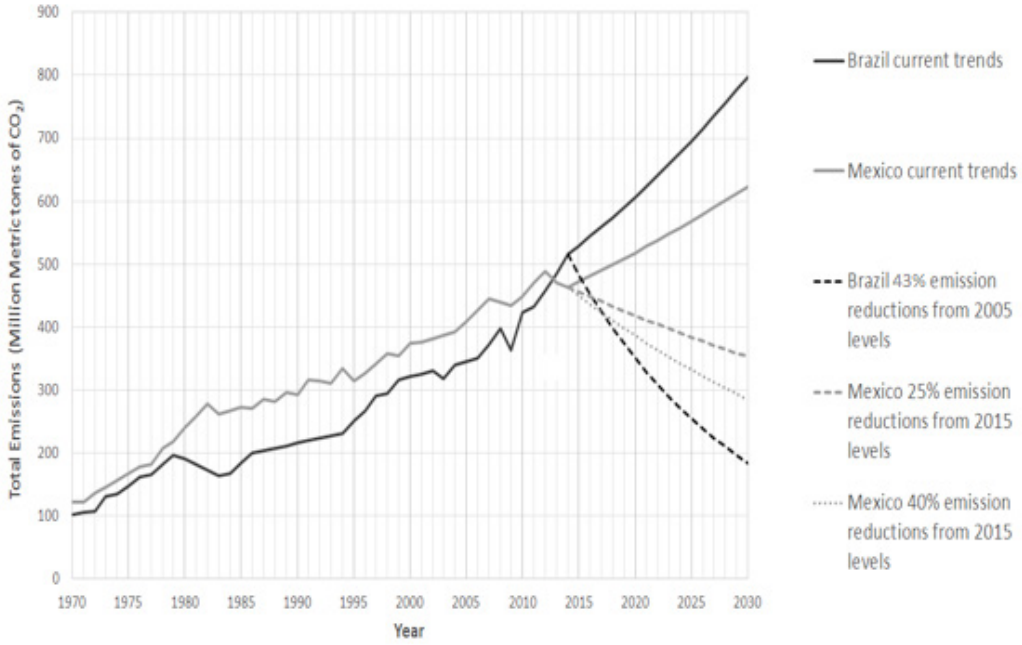


FIGURE 1 – Total $CO_2$ annual emissions and committed emissions for Brazil and Mexico.

## *3. Current and prospective energy consumption trends for Brazil and Mexico*

Brazil has one of the most environmentally friendly primary energy mixes in the world, with 39.4% arising from renewable sources, while the world average is 13.2% (and only 8.6% in developed countries). The main renewable energy sources include: sugar cane biomass (15.7%), hydropower (11.5%), firewood and charcoal (8.1%), lixivium (a chemical derived from wood ashes) and others (4.1%) (EPE, 2015) (Figure 2).

On the other hand, despite Mexican institutions having continuously expressed their interest in renewable energy sources, the country is still heavily dependent on fossil fuels; which account for more than 93% of its total primary energy consumption. The main renewable energy sources include nuclear power (1%), hydropower (4%), and other renewables (2%).

As can be observed in the graphs below, Brazil and Mexico have potential for fossil fuel replacement in the order of 60% and 93% respectively by renewable energy sources.

### *3.1. Consumption of primary energy sources by sector in Brazil and Mexico*

In Brazil, the sectors that consume the most energy overall are: industry (34%), followed by transportation (32%), energy sector and non-energy use (16%), residential (9%), commercial and public services (5%), and agriculture (4%) (EPE, 2014)

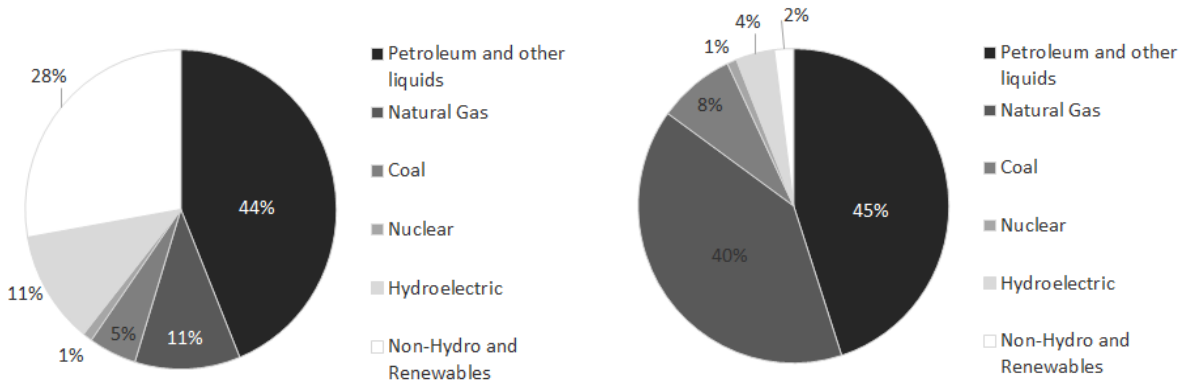


FIGURE 2 – Primary energy mix in Brazil (left) and Mexico (right).
SOURCE: Energy Information Administration Data and Analysis Tool (EIA, 2015)
*Non-hydro and renewables includes biomass, firewood and charcoal, lixivium and others.

(Figure 3). Industrial production, freight transport and mobility of people and families represent 66% of energy consumption in the country.

In Mexico, the extraction and production of oil is entirely controlled by the government-owned company "Mexican Petroleum" (PEMEX), while the sales of electricity operate under a similar scheme by the government-owned Federal Commission of Electricity (CFE). However, a new set of rules were included in the upcoming Mexican Energy Reform, which will allow the active participation of the private sector in energy production activities. Nevertheless, the participation of the end consumers has not yet been announced (Mexican Energy Reform, 2013). The energy sector consumes 42% for its own energy production, the transportation sector takes approximately 28% of the country's primary energy use, followed by industry (17%), residential (11%) and agriculture (2%). (EIA, 2015) (Figure 3).

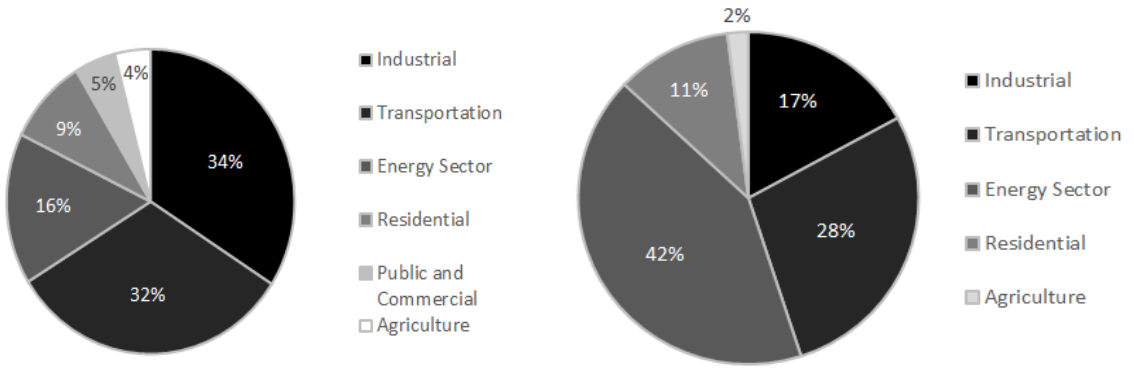


FIGURE 3 – Primary energy use in Brazil (left) and Mexico (right).
SOURCE: International Energy Agency, Key World Energy Statistics (2015)

There is a big difference between the industrial sector of both countries. As an oil producer country, Mexico losses a big percentage of its energy during the oil refining process and during transmission of electric power, therefore its replacement by renewable energy sources would eliminate this energy waste and its consequent $CO_2$ emissions. In addition, transportation is a large consumer sector in both countries and the use of less carbon emission intensive fuels could dramatically help in reducing GHG emissions.

### *3.2. Electricity generation in Brazil and Mexico*

According to the National Energy Report (EPE, 2015) in Brazil approximately 79.3% of the electric grid is powered by renewable energy sources (Figure 4). The renewable electricity production expanded by 1.7 percent in 2013, due to biomass produced from sugarcane and increased wind generation. Brazilian power model remains heavily dependent on hydropower, which represents large dependence on current and future sector in relation to water use available in the country.

The electricity generation in Brazil increased 3.3% in 2014 over 2013, reaching 590,000 Gigawatt-hour (GWh). The main generators are the public utilities, with 85.5% of total generation, which uses hydropower as the main source.

In Mexico, 79% of the total electric power produced comes from fossil fuels combustion, followed by 13% from hydropower and 3% from nuclear power. Renewable energy sources represent only 4% of the 168,370 GWh produced in 2015.

As it can be observed above, the electric sector in Mexico has an enormous potential for the implementation of renewable energy sources. Changing the source of energy in the electric sector is easier than in the other sectors (for example in transportation), furthermore its extended networked nature allows the use of hybrid energy systems capable of integrating multiple renewable energy sources such as wind, solar, and geothermal, based on the potential of each of these at specific locations. In addition, the fact that the population's access to electricity in Brazil and Mexico represents 99.5% and 99.1% respectively, facilitates the prospection of changes in the energy sources (World Bank, 2016).

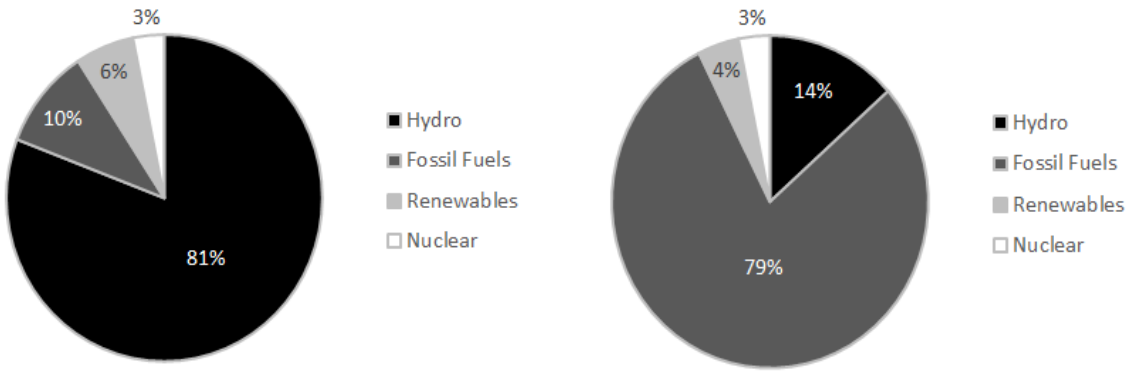


FIGURE 4 – Electricity sector in Brazil (left) and Mexico (right).
SOURCE: International Energy Agency, Key World Energy Statistics (2015).

The connection between energy and natural resources is evident in the case of Brazil that is well endowed in terms of water resources (in the central and southern parts of the country). This gives the country more room to develop hydropower-based sources in comparison to Mexico, which has two thirds of its territory classified as arid or semi-arid (Mexican National Water Commission, CONAGUA, 2015). The water-energy-climate nexus is an obligated consideration for designing sustainable energy policies (Scott, 2011).

## *4. $CO_2$ emissions mitigation alternatives*

In a world where fossil fuels provide more than 85% of the primary energy, the possibilities for reducing GHG emissions are immense thanks to the adoption of best energy use practices, energy efficient technologies, the use of less GHG intensive fuels, and the transition to renewable energy sources.

### *4.1. Energy consumption reduction*

A reduction of GHG emissions can be certainly achieved by decreasing energy consumption. However, the committed emission goals by Brazil and Mexico at the COP21-COP11 towards 2030 are so ambitious that achieving them by this strategy alone would seriously compromise the productivity and quality of life for both nations.

If the committed goals were to be achieved using the same primary energy mix while following their similar population growth rate within the last four decades, Brazil and Mexico would require significant emissions cut per capita equivalent to 72% and 53% respectively.

Although this reduction scheme may be hard to implement, the efficient use of energy can play an important role in the combined efforts to achieve the commitments made by Brazil and Mexico. Therefore, strong awareness campaigns, active participation from all sectors and a strong government leadership to legally handle incentives and sanctions are needed to successfully implement nation-wide energy conservation programs.

### *4.2. Change to less carbon intensive fuels*

The transition to less carbon intensive fuels to provide the same energy services can also help achieve committed goals without compromising the comfort, or the productivity of end users.

As an example of this transition, oil based generators in Mexico's power plants are being replaced by combined cycle turbines, which run on natural gas; a fuel that releases 27% less $CO_2$ to the atmosphere for the same energy content (SENER, 2015; EIA, 2016). However with approximately 56% of the electricity in Mexico already being produced with natural gas generators, the opportunities for $CO_2$ emission reductions in this sector that takes approximately 10.5% of the total primary energy are marginal. In the case of Brazil, with only 10% of the electricity produced from burning of fossil fuels, the opportunities for $CO_2$ emission reductions in this sector are significantly low as well.

Therefore, in order to meet COP21-CMP11 commitments, a change of fuel type in other sectors, such as the transportation and industrial sectors is needed in Brazil and Mexico, where the use of fossil fuels is more predominant, as shown in Figure 3. However, Mexico has limited resources of natural gas and does not have the technology for its exploitation thus relying on foreign capital

or the importation of natural gas itself is not ideal. On the other hand, although the use of natural gas may seem a cleaner fuel, its production has significant environmental implications, mainly where it is extracted (Reforma Energetica 2013; EIA 2013) and, although less, still emits $CO_2$.

### *4.3. Use of Renewable Energy Sources*

Brazil, the largest tropical country in the world, has a target of renewable sources, in addition to hydroelectric generation, to reach 28% to 33% of the energy mix, making room for biofuels, solar, wind and biomass sources. Brazil receives intense solar radiation all year round, which is the basis for the production of biogas. In addition, the country has a very representative agribusiness, specially composed by grain production activities and animal protein, which greatly favors the country to develop clean and renewable energy technologies, taking advantage of the waste generated by those activities and diversifying its primary energy source.

Estimates suggest that biogas and biomethane potential in Brazil is about 15 billion $m^3$ per year, considering agricultural/industrial sectors, treatment of animal waste and effluents, and sugarcane production (ITAIPU, 2013).

Under current plans, Mexico intends to increase its renewable energy supply share to 10%. According to the International Renewable Energy Agency (IRENA, 2015), Mexico could potentially increase that share to 21%. Moreover, by 2030, Mexico could generate approximately 46% of its electricity from renewable energy sources, where solar and wind would represent 26% altogether, followed by hydropower (12%), geothermal (5%) and biomass (2.5%). Business-as-usual developments would imply a 18% share only.

Accelerating Mexico's implementation of renewable energy could not only bring significant $CO_2$ emission reduction and environmental benefits, but it could also result in potential savings compared to conventional power generation in the future.

In Mexico, the Energy Regulatory Commission (CRE) (an office in charge of issuing power plants construction permits) has been receiving an unprecedented increased number of applications for renewable energy plants each year despite of the complexity and lack of advertisement for this process. Although a significant number of permits have been issued already, an unclear new energy reform, the volatility of fuel prices and a constant promise of lower electricity tariffs by the Mexican government, have virtually halted the renewable energy projects construction relying on private investments. On the other hand, the process that involves participants (of the general public and electricity end users) as co-investors is null at the moment. Participation increase could be a significant source of seed capital for new renewable energy projects.

## *5. Institutional arrangements for emission reductions in Brazil and Mexico*

Brazil implemented the National Policy on Climate Change (NPCC) in 2009, through the Law nº 12.187, which aims to encourage the development and improvement of mitigation, contributing to the global effort to reduce emissions of GHG. This formalizes the voluntary commitment of Brazil to the UNFCCC to reduce emissions between 36.1% and 38.9% of projected emissions by 2020.

The Policy is structured into four areas: 1) mitigation opportunities, 2) impacts, vulnerability and adaptation, 3) research and development, and 4) education, training and communication. Some

goals are to reduce the annual rate of deforestation of the Amazon (80% reduction by 2020); increase the domestic consumption of ethanol over the next ten years to 11% annually; increase the supply of electric power co-generation, especially biomass, to 11.4% of the total electricity supply in the country in 2030.

The governance of NPCC is up to the Inter-Ministerial Committee on Climate Change and its executive group, established by Presidential Decree N° 6263/2007. The instruments for its implementation are, among others: the National Plan on Climate Change, the National Fund on Climate Change and Communication of Brazil to the United Nations Framework Convention on Climate Change (Brazil, 2016).

On the other hand, Mexican Government institutions have taken some actions to tackle the situations that arise from climate change. As mentioned above Mexico published a specialized law to address climate change issues. This law (LGCC) is the materialized effort of Mexican Government to guarantee its citizens the human rights held in the fourth article of the Mexican Constitution, which states the right to a healthy environment for citizens wellbeing and development. According to this law published on February 2012, anyone who provokes damage or degradation of the environment must repair it[2].

Mexican government hopes that LGCC will help to achieve its INDC commitments by establishing, regulating and instrumenting actions for mitigation and adaptation to climate change in different productive sectors. LGCC states that Public Policy instruments will regulate industry, transportation, agricultural, waste, trade and services and energy subjects (Article 7, fraction VI) to register and account information of the emissions. In November, 2014, regulation of the LGCC concerning the National Emissions Registry was enforced. This protocol serves different industries, including the energy sector, to identify the origins of compounds and GHG to trace, evaluate tendencies and establish national strategies to reduce emissions (SEMARNAT, 2015). Starting 2016, all companies that equal or exceed the 25,000 tons of $CO_2$ are obligated to report their annual emissions through a report uploaded in COA website (Cédula de Operación Anual), which is part of the Secretariat of the Environment and Natural Resources (SEMARNAT) platform. This instrument aims to reduce emissions by identifying inefficient processes. In addition, the National Emission Registry (RENE) was created to allow companies to register their voluntary mitigation projects. This programs represents a significant incentive for the energy sector companies since it could be used as a compensatory carbon tax mechanism.

Mexico and Brazil are using their legislative mechanisms to to achieve their INDC. From the COP21-CMP11 perspective, these are legitimate efforts to reduce emissions, although some of the central issues concerning climate change remain unquestioned. Discussing control over production, involves high stakes, and it must be done carefully to avoid scaring away potential investors. Both countries seek to increase gross domestic product but at the same time have committed to reduce

[2] In Chapter III of ninth title of the LGCC, Mexican government establishes sanctions. Federal Attorney for Environmental Protection may apply pecuniary sanctions that range between 500 and 3000 minimum salaries wage (art. 114) to companies that fail to provide information, data or documents required by. Sanctions from 3000 to 10000 minimum salaries wage may apply to those companies who deliberately lie on their information, or fail to comply in the time.

emissions; both countries seek to tackle poverty, yet thinking of other ways of organizing production remains unspoken.

Consumption and production patterns in developed countries are responsible for most of the emissions causing climate change. Although developing countries strive to achieve comparable economic development it is impossible to attain this level of consumption and production for all humanity. Yet, for governments it is easier to develop a strategy to continue with the same economic model approach than to design an alternative way of achieving human prosperity. The piece of the pie held by corporate interests makes the private sector a key actor that can determine the way countries define and address the problem, design and implement the solutions to resolve this environmental crisis. Ecological damage and deep social inequality have been key factors for the emergence of grassroots representing different narratives of deep cultural change.

## *6. Conclusions and recommendations*

Mexico and Brazil's future development paths will play an important role in the global effort towards reducing GHG emissions. Our analysis of the INDC of both countries identified a clear willingness to shift from fossil-fuel intensive paths to a more environmentally friendly one, emphasizing conservation of biodiversity and ecosystem services, which are abundant in both countries. The international negotiations and organizations created to regulate and guide actions to address climate change have definitely helped in developing the action plans and legislation mechanisms in both countries introducing GHG emissions reduction into their development paths.

Both countries have shown their intentions. On the one hand, Brazil shows a clear inclination towards biofuels as a way to reduce emissions. Although this energy source is not entirely carbon-free, it is a significant reduction compared to fossil-fuel energy generation. Mexico, on the other hand, is more inclined to shift to natural gas, but this is a short-term solution because its reserves will not last two decades and is not a carbon free solution either. The achievement of the stated commitments by both countries will depend on the capacity of the governments and societies in Brazil and Mexico to actually enforce the new rules, and set the conditions to make these changes viable in economic, social and ecological terms.

Even though it is published in the federal documents that the Mexican ENCC will transform the great challenge of climate change in the great opportunity to conserve and have a more sustainable use of natural resources, develop clean energies, correct inefficiencies in the use of energy, promote sustainable territorial development, increase competitiveness, and improve public health and population's quality of life (ENCC, 2013) it is an oxymoron to publish these objectives on the one hand, and on the other hand, having the national strategy 2013, 2027 based on hydrocarbons and projects of fracking. Three big issues beyond the scope of this paper and still need to be discussed towards the achievement of real progress in emissions' reductions for both countries are: 1) the financing schemes for this transition in a way that promotes equity and sustainability; 2) the inclusive participation of stakeholders in decision-making and related transparency mechanisms; and 3) the policies that recognize the complexity of the energy-water-climate nexus and the broader consumption/demographic patterns.

The first issue is how to finance the transition towards less carbon-intensive sources. Financial contribution from developed countries would allow further GHG reductions, especially if they invest in alternative energy sources including solar, wind, tidal, etc. that are carbon-free but are significantly expensive. Because industrialized countries are responsible for most of the $CO_2$ global emissions, many developing nations are calling for their financial contribution to shift to renewable energy sources to achieve economic development. The adoption of more energy efficient and less polluting technology is more achievable by counties that can afford it. Raising the quality of life in developing countries following the energy consumption trends and the current-fossil fuel based economies would not only be unsustainable but also jeopardize the carbon emission reduction efforts so far. Therefore, it is crucial that developing countries learn from current challenges and adopt renewable energy sources not only for achieving energy security and independence, but also for a sustainable future.

The second issue relates to transparency, social inclusion and participation. The implementation of new strategies may increase the risk in vulnerable populations to cope with further climatic challenges if these strategies organizations responsible for this do not provide the means and capacity building for all sectors to integrate into these new energy alternatives. A clear, inclusive, and solid energy policy is very important and the private sector and the end users, in particular, can be a significant source of capital and innovation.

The third issue is closely connected to the second one, as it relates to the recognition of systemic connections between the way human beings produce, distribute, and use energy, and the complex nature of social-ecological systems. Policies need to include diversified options based on geographic potential (for example, hydropower can be an optimal alternative for Brazil, but not necessarily optimal for Mexico).

Although renewable energy can certainly be used to satisfy virtually all current human power needs, if climate change continues to pose new challenges beyond renewable-energy capacity, human societies will be in need of analyzing and developing alternative models of consumption-production when the low-hanging fruits are already harvested in the energy sector.

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