China-LAC Energy Cooperation

CIPA Professional Report

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Executive Summary

This paper conducts research on China's current policy support and Latin American and Caribbean countries' (LAC) energy mix background, as well as the environmental impact of traditional energy. China launched a plan entitled the China-Latin American and Caribbean Countries Cooperation Plan (2015-2019) several years ago, demonstrating its ambition to cooperate with LAC countries, especially in the energy and natural resources sector. Although LAC countries have experienced rapid development in the renewable energy sector in recent years, it still has a relatively large share of traditional non-renewable energy in its energy mix. In the last decades, China invested more and more in LAC in the energy sector. However, cooperation still needs to be enhanced in the renewable energy sector.

Renewable energy is a solution to substitute the traditional non-renewable energy like oil, gas and coal. LAC's renewable energy capacity and investment are both growing largely in recent years, especially in wind and solar power. China has already started its trade activities with LAC in the renewable energy sector.

Furthermore, this paper analyzes the challenges and opportunities for China and LAC, in order to better develop renewable energy cooperation between China and LAC. The main challenges include lack of policy and financial support, weak trading basis, and transportation and transmission problems. In the last section of the paper, the author provides specific suggestions that address these challenges. (Please note that this paper considers Latin American and Caribbean Countries as a whole, regardless of the differences among different LAC countries.)

1. Background

1.1 Current status of China-LAC energy cooperation

1.1.1 China's policy support

In the China-Latin American and Caribbean Countries Cooperation Plan (2015-2019), much attention was paid on the energy and natural resources sector. Guiding plans are described as follows[1].

- Foster closer cooperation in energy between China and Latin American and Caribbean countries and explore the possibility of inaugurating the China-LAC Energy and Mineral Resources Forum in due time.
- Enhance collaboration in the energy and mineral sectors, including technological research and development, and sustainable use of natural resources, based on equality, overall reciprocity and mutual benefit, with close observance of applicable laws, regulations and best international practices, while respecting the full sovereignty over their natural resources.
- Strengthen collaboration and investment in the electricity sector, including power generation, high and ultra-high voltage power transmission, water resources planning and development, bio-energy, solar, geothermal and wind power.
- Promote training programs for technicians and experts in management and development of renewable energy.

[1] The People's Republic of China, Ministry of Foreign Affairs. *Cooperation Plan (2015-2019)*. Retrieved from http://www.chinacelacforum.org/eng/zywj_3/t1230944.htm

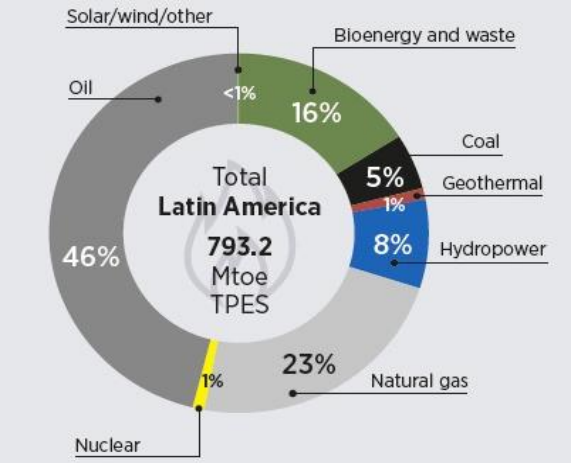
- Enhance collaboration to promote in CELAC countries the industrialization for value added goods.

1.1.2 LAC's energy background

LAC is known for its abundant energy and natural resources; the region is a key global oil and gas producer. In 2013, based on IRENA's research[2], 46% of the primary energy supply was oil in LAC and 23% was natural gas. In the last decade, due to the increasing commodity prices especially the rising oil prices, LAC countries benefit a lot. Mexico, Venezuela, Colombia and Ecuador are the main oil-exporting countries in the LAC region. Venezuela has the largest known oil reserve in the world, which is about 300,878 millions of barrels, according to U.S. Energy Information Administration[3], since the discovery of Venezuelan Orinoco Belt. Moreover, Brazil's deep water crude oil in Santos basin was also one of the biggest discovery in recent oil history. But if these four countries are excluded, LAC would become a net oil importer. The energy sector plays a very important role in LAC countries' domestic and regional dynamics and economic development. Latin America's natural gas reserves are smaller than those of oil (only 4% of global reserves as of 2013, compared to 20% for oil) and are located mostly in Venezuela and associated with oil. However, Argentina, Mexico and Brazil potentially hold significant unconventional natural gas resources. Except for oil and natural gas, bioenergy and waste (16%), hydropower (8%) and coal (5%) are also primary energy supply in LAC in 2013. Traditional non-renewable energy still constitutes most of the energy supply in LAC.

2 IRENA (2016), 'Renewable Energy Market Analysis: Latin America'. IRENA, Abu Dhabi.
3 U.S., Energy Information Administration. International Energy Statistics (Crude Oil Proved Reserves 2016). Retrieved from http://www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=5&pid=57&aid=6

Figure 1. LAC Primary Energy Supply in 2013



Source: IRENA

1.1.3 Cooperation between China and LAC

In the last decade (from 2005 to 2016), China invested, approximately US$100 billion[4] to LAC in the energy sector. Venezuela, Brazil and Ecuador were the top three countries that China invested the most for the energy development, followed by Argentina, Bolivia and Mexico. In Venezuela, China invested about US$55 billion in the last decade, which accounted for more than half of the total energy investment in LAC. However, it seems that China decreased its energy investment in Venezuela since 2010. In the past year, China only invested about US$2 billion in Venezuela, but US$15 billion amount of investment was sent to Brazil.

Figure 2. China's investment to LAC in energy sector (2007-2016)

[4] The Dialogue, China-Latin America Finance Database. (n.d.). Retrieved from https://www.thedialogue.org/map_list/

TYPE	NO. OF LOANS	AMOUNT
Energy	31	**$100B**

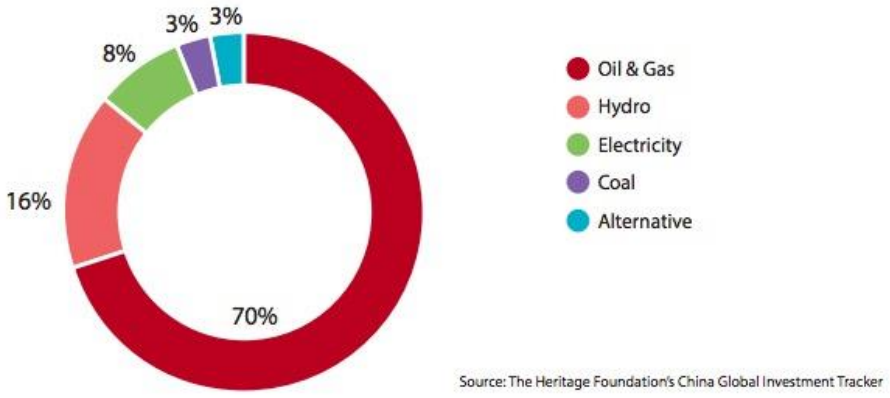
Country	Amount
Venezuela	$55B
Brazil	$34.3B
Ecuador	$6.1B
Argentina	$2.7B
Bolivia	$1.1B
Mexico	$1B

Source: Inter-American Dialogue

Among all the different energy categories (see figure 3), oil and gas attracted the most foreign direct investment (FDI) from China, followed by hydro, electricity and coal. China invested about US$39.3 billion, which accounted for about 70% of Chinese FDI to the LAC energy sector. All the Chinese national oil companies expanded their investment in LAC, including China National Petroleum Corporation (CNPC), China Petroleum & Chemical Corporation (Sinopec), China National Offshore Oil Corporation (CNOOC), and Sinochem Group (Sinochem). China also invested approximately US$ 9.2 billion in hydro power projects, mostly in Argentina and Ecuador. For example, a Chinese firm, Gezhouba Group, invested about US$4.7 billion to build the Nestor Kirchner-Jorge Cepernic hydroelectric plants. This project would let Argentina have the capacity of 1.74 GW. Another Chinese-invested project, Coca Codo Sinclair hydroelectric facility project, was reported to support about 44% of the Ecuador's domestic electricity demand[5].

[5] Espinasa, R., Marchan, E., & Sucre, C. G. (2015, July). *Financing the New Silk Road: Asian Investment in Latin America's Energy & Mineral Sectors* (Rep.). Retrieved http://www20.iadb.org/intal/catalogo/PE/2015/15622en.pdf

Figure 3. China's FDI Stock in LAC in Energy by Country (2005-2014)



Source: The Heritage Foundation's China Global Investment Tracker

1.2 Environmental impact

Traditional non-renewable energy such as oil, natural gas and coal have huge negative impact on the environment and the local people's health. LAC's environmental condition attracts more attention than other regions' conditions since Amazon is the "lung of the earth" with lots of indigenous people living in.

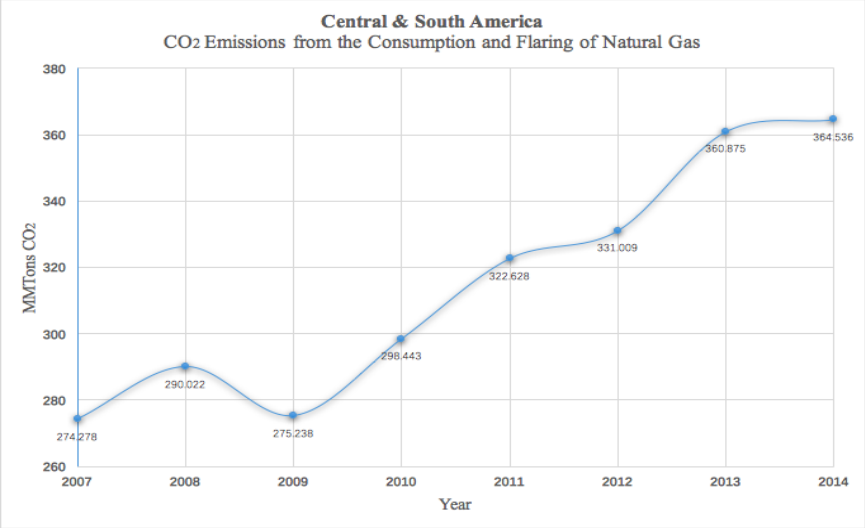
Firstly, oil and natural gas cause huge negative environmental impacts. The extraction of oil could lead to deforestation and degradation of lands especially in the Amazon. The contamination of local rivers, the endless land exploitation to the original forest areas, and major oil spills are all inevitable risks when extracting oil. Oil spills usually directly result in physical smothering and chemical toxicity to people. Spilt oil will also destroy the existing eco-system by replacing the

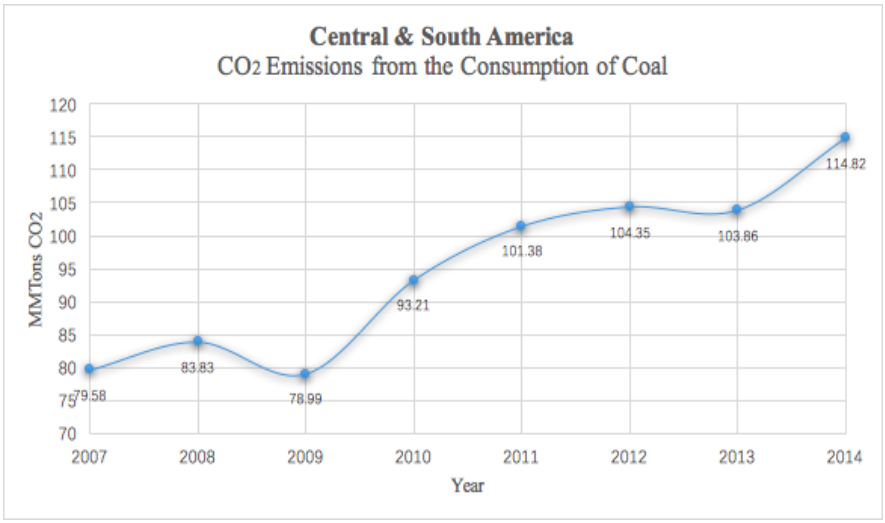
original species[6]. Although natural gas emits about 50% less carbon dioxide than coal[7], it still has many negative impacts. According to the database from Knoema[8], CO_2 emissions from the consumption and flaring of natural gas - million metric ton of carbon dioxide of Central & South America increased from 290.02 million metric tons in 2008 to 364.54 million metric tons in 2014, growing with an average annual rate of 4.01 %. Figure 4 shows the increasing trend of CO_2 emissions from natural gas and coal in Central and South America in recent years.

Within less than a month at the beginning of 2016, Peru's main oil pipeline was reported leaking three times, including at least 3,000 barrels of crude oil spill for the February incident[9]. Over the past year, more than 7000 barrels of oil were spilled into the rain forest, mostly in indigenous communities' lands. There were at least 20 oil spills in the Northern Peruvian pipelines since 2011 due to lack of maintenance. These oil pipelines were designed to last from 20 to 30 years, while most of the Northern Peruvian pipelines were in operation since 1977[10]. CNPC was reported having plans to invest at least $2 billion in Peru for the next 10 years[11].

Figure 4. CO2 Emissions from Natural Gas and Coal in Central & South America (2007-2014)

[6] ITOPF. (n.d.). Environmental Effects of Oil Spills. Retrieved from http://www.itopf.com/knowledge-resources/documents-guides/environmental-effects/
[7] UCSUSA. (n.d.). Environmental Impacts of Natural Gas. Retrieved from http://www.ucsusa.org/clean-energy/coal-and-other-fossil-fuels/environmental-impacts-of-natural-gas#.WYnaKknrvcs
[8] Knoema. (n.d.). International Energy Statistics, Monthly Update. Retrieved December 14, 2017, from http://cn.knoema.com/EIAIES2017/international-energy-statistics-monthly-update#
[9] BBC. (2016, February 23). Peru oil spill pollutes Amazon rivers used by indigenous group. Retrieved from http://www.bbc.com/news/world-latin-america-35636738
[10] Mega, E. R. (2016, March 04). Oil Spills Stain Peruvian Amazon. Retrieved from https://www.scientificamerican.com/article/oil-spills-stain-peruvian-amazon/
[11] The University of Texas in Austin. (n.d.). China CNPC sees to invest at least $2bn in Peru after Petrobras deal. Retrieved from https://www.jsg.utexas.edu/lacp/2014/06/china-cnpc-sees-to-invest-at-least-2bn-in-peru-after-petrobras-deal/





Source: Knoema

In addition, it cannot be denied that the use of coal also has negative environmental impact on the environment. It may result in greenhouse effect to the whole world, more frequent acid rain, and contaminate the surface or ground water near the local community. Among all the energy analyzed above, coal generated the most GHG emissions based on figure 4. CO_2 emissions from the consumption of coal - million metric ton of carbon dioxide of Central & South America increased[12]

[12] Knoema. (n.d.). International Energy Statistics, Monthly Update. Retrieved from https://knoema.com/EIAIES2017/international-energy-statistics-monthly-update#

from 79.58 million metric tons in 2007 to 114.82 million metric tons in 2014. In 2017, more than 21,000 people in Jamaica signed a petition to oppose a Chinese-invested coal power plant at Nain in St. Elizabeth. This project was invested by Jiuquan Iron & Steel Company Limited (JISCO) of China, which was designed to provide 1,000 MW and create 3,000 jobs[13].

As this report discusses above, China invested about 73% of its energy FDI in LAC on oil, gas and coal related projects during the last decade. By pointing out the huge negative environmental impact of these projects, it is expected that China could reduce its investment in these non-renewable energy projects， and change its investment to a greener direction for the energy sector.

2. Renewable Energy as a solution

2.1 Definition

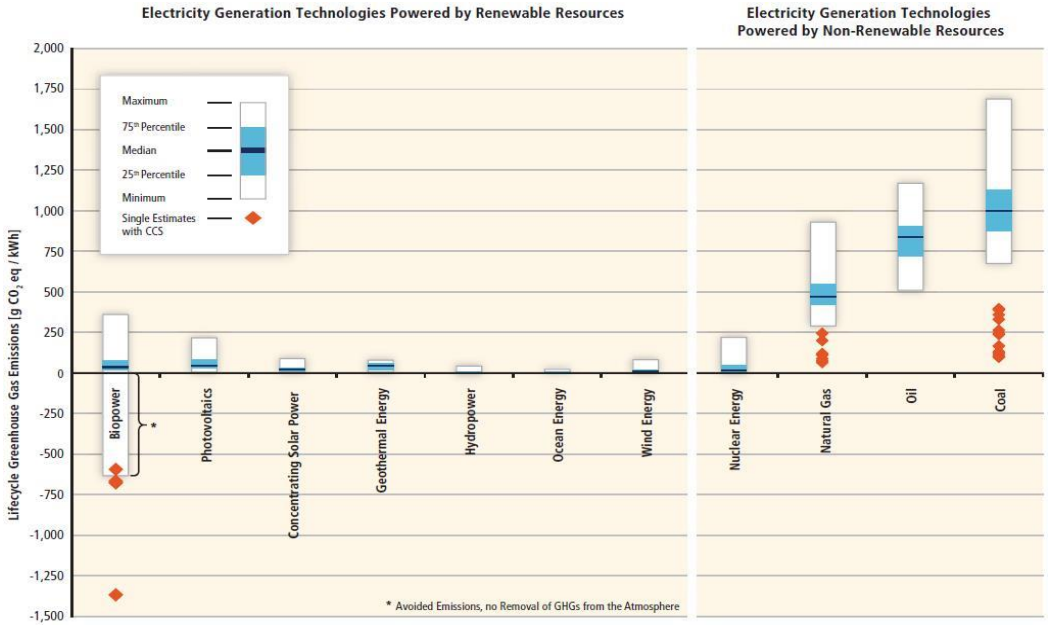
Renewable energy is energy generated from natural resources, which is believed to be a perfect replacement for traditional non-renewable energy sources. Sunlight, wind, rain, tides and geothermal heat are the most common natural resource which could be used to generate power, such as solar power, wind power, hydro power and biomass power[14]. From the following comparison in figure 5, we could clearly see that non-renewable energy on the right side generate

[13] Brown, D. L. (2017, February 26). Environmentalists Say No to Coal-Fired Power Plant in Jamaica. Retrieved from https://www.indepthnews.net/index.php/the-world/latin-america-the-caribbean/983-environmentalists-say-no-to-coal-fired-power-plant-in-jamaica

[14] Ciolkosz, D. (n.d.). What is Renewable Energy? Retrieved from http://extension.psu.edu/natural-resources/energy/what

much more GHG emissions than renewable energy, including solar, wind, hydra power on the left side.

Figure 5. Lifecycle GHG Emissions on Renewable and Non-Renewable Resources



Source: IPCC,2011[15]

For traditional non-renewable natural gas, it normally emits 0.6 to 2 pounds of CO_2 equivalent per kWh; and coal usually emits 1.4 to 3.6 pounds of CO_2 equivalent per kWh. For renewable energy, wind only emits 0.02 to 0.04 pounds and solar emits 0.07 to 0.2 pounds. Geothermal emits 0.1 to 0.2 pounds, and hydroelectric emits 0.1 to 0.5 pounds. It should be noted that biomass could be sustainable, but it may also generate significant GHG emissions as well it it's used unsustainably[16].

[15] Edenhofer, O., Pichs-Madruga, R., Sokona, Y., Seyboth, K., Matschoss, P., Kadner, S., ... & von Stechow, C. (2011). IPCC special report on renewable energy sources and climate change mitigation. Prepared By Working Group III of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, UK.
[16] UCSUSA. (n.d.). Benefits of Renewable Energy Use. Retrieved December 14, 2017, from http://www.ucsusa.org/clean-energy/renewable-energy/public-benefits-of-renewable-power#.WYnVeknrvcs

Overall, renewable energy can not only largely decrease GHG emission and local pollution, but also help countries out from fuel price volatility. Moreover, it may also improve countries' energy security and economic growth[17]. Therefore, investing more on renewable energy projects in LAC is a very good option for foreign investors including China.

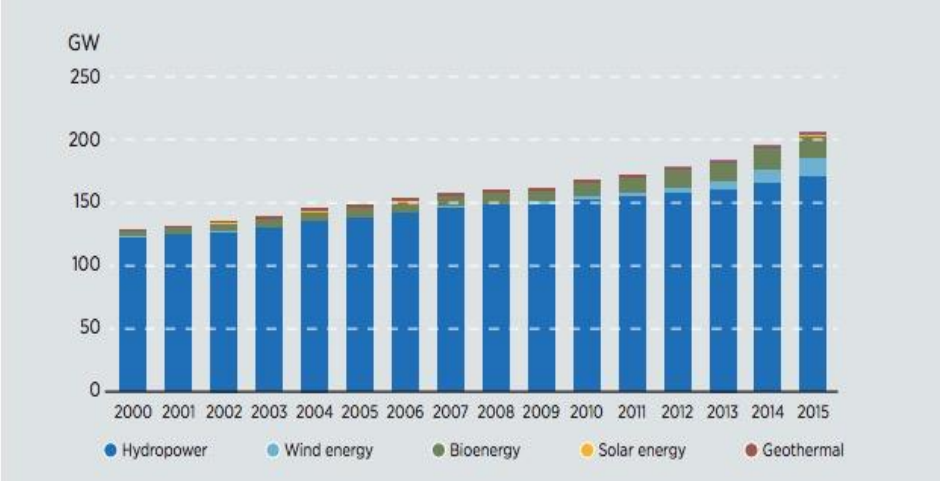
2.2 Current Status

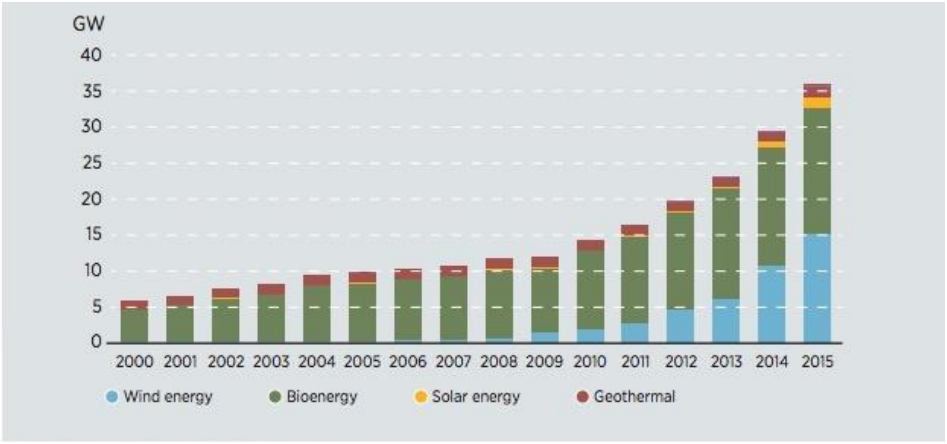
2.2.1 Capacity and Investment

Due to economic growth and urbanization, the energy and electricity demand in LAC keeps increasing in recent years. From figure 6, we could clearly see that the predominant renewable energy in this region is hydropower. The average share of hydropower in the LAC electricity mix was 50%. Uruguay was almost 100% rely on hydropower for its electricity generation. But the share of hydropower in total renewable capacity decreased from 95% in 2000 to 83% in 2015 due to the development of other renewable energy sources, especially bioenergy and wind. In the last decade, from 2006 to 2015, other renewable energy capacity has increased from 10 GW to 36 GW[18]. And more recently in the last five years, the most developed renewable energy was wind. Many LAC countries doubled or even tripled their wind power capacity in recent years.

Figure 6. Installed Renewable Energy Capacity in LAC, 2000-2015 (with and without hydropower)

[17] Inter-American Development Bank. (n.d.). Renewable Energy. Retrieved from http://www.iadb.org/en/topics/energy/se4allamericas/renewable-energy,17688.html
[18] IRENA. (2016, December 12). Latin America's Renewable Energy Market Analysis. Retrieved from https://irenanewsroom.org/2016/11/17/latin-americas-renewable-energy-market-analysis/





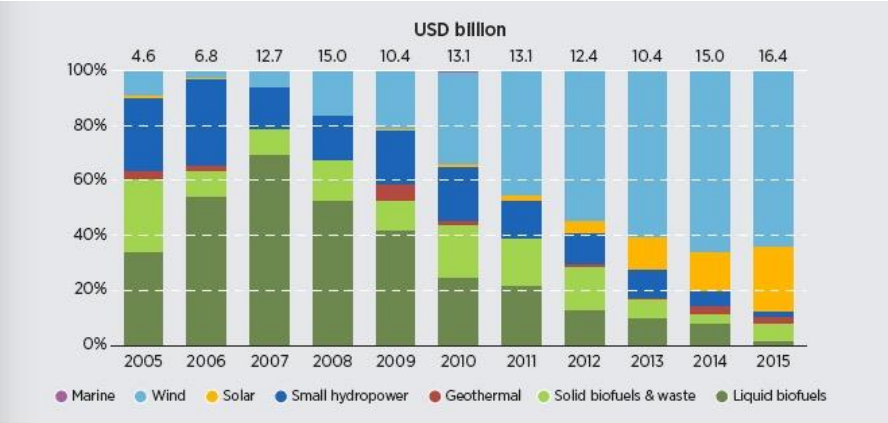
Source: IRENA

Investment in renewable energy has fluctuated in recent years. IRENA suggests that decreasing investment in renewable energy in LAC in 2013 was the result of decreasing investment in biofuels. But we should also note that in 2013, the world's and LAC's investment in renewable energy both declined. Bloomberg New Energy Finance[19] found that although the total investment worldwide in renewable energy reduced, the total number of projects keep increasing. So the decrease in the investment might also be the result of the increasing cost-competitiveness improvement of the

[19] McCrone, A., & Louw, A. (n.d.). Clean Energy Investment by the Numbers - End of Year 2016. Retrieved from https://www.bnef.com/dataview/clean-energy-investment/index.html

renewable energy equipment in recent years. It was estimated that from 2010 to 2015, LAC invested about $US 37 billion for hydropower. If we exclude the large hydropower projects, LAC invested more than $US 80 billion accumulatively from 2010 to 2015 for other renewable energy. In 2015, LAC invested about $US 16.4 billion for all the renewable energy, which represented about 6% of all the renewable energy globally[20]. More specifically, the investment in biofuels is obviously a decreasing trend in recent years, while investment in wind and solar energy has increased significantly. From 2014 to 2015, the investment in wind represents twice as much as the investment in other renewable energy in LAC.

Figure 7. Investment in renewable energy, 2010-2015 (by technology)



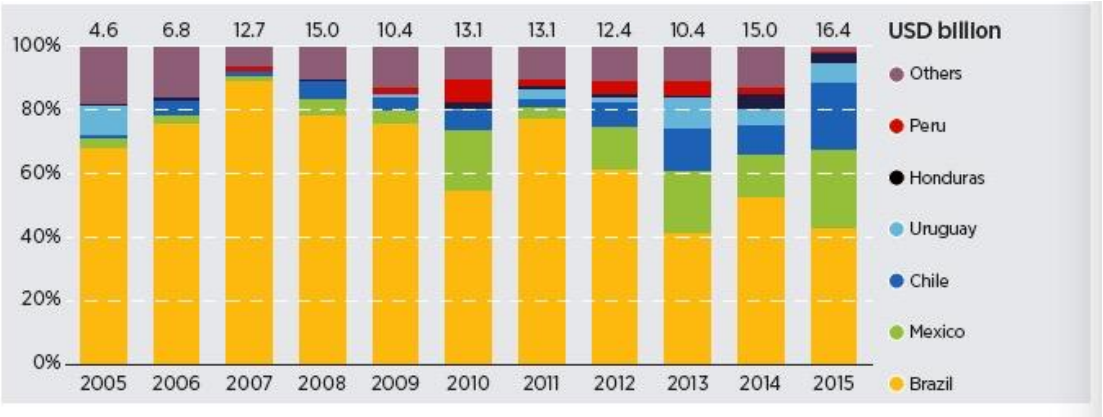
Source: Bloomberg New Energy Finance

Brazil used to be the predominant country in LAC which invested about 70% of the total renewable energy projects within the region before 2010. However, other countries have accelerated their rate of development for renewable energy since 2010, decreasing the Brazilian share of total renewable energy investment from 70% to 40%, with about $US 7.1 billion in 2015 in Brazil.

[20] Brower, M. (2014, April). *REGIONAL BRIEFING: RENEWABLE ENERGY IN LATIN AMERICA AND THE CARIBBEAN* (Rep.). Retrieved from ACORE website: https://www.acore.org/files/pdfs/Renewable-Energy-in-Latin-America-and-the-Caribbean.pdf

Mexico ($US 4 billion) and Chile ($US 3.4 billion) were another two countries achieved high goals in the development of renewable energy. Mexico and Chile invested about twice and 1.5 times separately in renewable energy in 2015 when compared to their own investment in 2014. Uruguay, Honduras, Peru comes afterwards with sizable investment as well. Apart from investment support, LAC also launched more than 300 renewable energy related policies as the policy support for the regional development. Almost 20 LAC countries announced their renewable energy targets, tax incentives, feed-in tariffs and other government-sponsored policies to boost their renewable energy market[21].

Figure 8. Investment in renewable energy, 2010-2015 (by country)



Source: Bloomberg New Energy Finance, 2016

2.2.2 China and LAC in Renewable Energy

In recent years, China has become the world's leading country in developing renewable energy. According to Bloomberg New Energy Finance, China invested more than $US 100 billion in its

[21] *Multilateral Investment Fund: Climatescope 2013* (Rep.). (2013). Retrieved from Bloomberg New Energy Finance website: http://idbdocs.iadb.org/wsdocs/getDocument.aspx?DOCNUM=38168432

domestic renewable energy, including wind, solar and hydro power. This is more than double amount of United States' investment in this sector. In recent years, China's overseas investment increased dramatically as well. It was reported that in 2016, China's overseas investment in renewable energy increased about 60% to $US 32 billion as a whole. Five of the six world largest solar module manufactures are owned by China[22].

For China's investment in LAC, hydropower and solar are the main renewable energy sources that China has invested in. According to the International Rivers, Chinese companies have already been involved in more than 20 hydropower project in LAC region. IEA claims that Brazil, Mexico, Chile and Uruguay are striving to develop clean energy recently, and China has the highest installed solar capacity in these countries[23]. China is also trying very hard to develop wind power cooperation with LAC. Brazil and Chile are the two main target countries for wind power projects. Goldwind company is the representative Chinese company which developed very broadly in LAC. By 2015, Goldwind[24] has already provide wind turbines and construction support to Cuba, Ecuador, Panama, Bolivia, and Chile. Their projects in Panama earned very good economic benefits, with the capacity of generating 270 MW electricity. In Uruguay, more than 80% of the solar water heaters were imported from China. The export of China's wind turbines was treated as a potential opportunity for exchange between China and LAC.

[22] Buckley, T., & Nicholas, S. (2017, January). *China's Global Renewable Energy Expansion* (Rep.). Retrieved from Institute for Energy Economics & Financial Analysis website: http://ieefa.org/wp-content/uploads/2017/01/Chinas-Global-Renewable-Energy-Expansion_January-2017.pdf

[23]中国在拉美可再生能源投资可观. (n.d.). Retrieved from http://solar.ofweek.com/2016-11/ART-260009-8420-30071022_2.html

[24] Yang, Y. (n.d.). 中国企业在拉美风电市场：机遇与挑战并存. Retrieved from http://world.chinadaily.com.cn/2015-05/22/content_20792076.htm

Brazil's Intended National Determined Contribution (INDC) [25] proposes that, it intends to achieve the goal of reaching 45% of the renewable energy in the energy mix by 2030. It includes increasing the use of non-hydro renewable energy in total energy mix to between 28% to 33% by 2030; increasing the share of non-hydro renewable energy in the power supply to at least 23% by 2030, including wind, biomass and solar; achieving 10% efficiency gains in the electricity sector by 2030. In Brazil, a Chinese company, Yingli Solar, won the sponsorship of the solar panel for 2014 World Cup. This company was the world's largest solar panel company, which generated about more than 1,500 MWh of electricity annually for Brazil. This could feed on about 6,000 Brazilians electricity consumption[26]. In 2011, a Chinese wind turbine company, Sinovel, signed a contract to provide 23 turbines for about 1.5 MW to Brazil.

Chile planned to achieve a goal of generating 20% of its electricity power by renewable energy by 2025, along with many specific incentives and policies. In 2015, attracted about $US 3.4 billion investment for renewable energy, which increased about 150% than 2014. Chile has very abundant solar and wind energy in the northern part. Chile started to cooperate with China in renewable energy since Mid-2000s, when Argentina closed its natural gas pipeline to Chile and China oversupplied its solar panels[27]. Chile imported about $US 40.9 million value of Chinese PV panels from China, which represented more than half of its total PV imports in 2013[28].

[25] FEDERATIVE REPUBLIC OF BRAZIL INTENDED NATIONALLY DETERMINED CONTRIBUTION (INDC). (n.d.). Retrieved from http://www4.unfccc.int/submissions/INDC/Published%20Documents/Brazil/1/BRAZIL%20iNDC%20english%20FINAL.pdf

[26] Soutar, R. (2015, April). China is a "major driver" of environmental degradation in Latin America. Retrieved from http://dialogochino.net/china-is-a-major-driver-of-environmental-degradation-in-latin-america/

[27] Borregaard, Nicola, Annie Dufey, Maria Teresa Ruiz-Tagle and Santiago Sinclair (2015, Forthcoming), "Chinese incidence on the Chilean solar power sector." Boston: BU Global Economic Governance Initiative Working Paper 2015-5.

[28]中国在拉美可再生能源投资可观. (n.d.). Retrieved from http://solar.ofweek.com/2016-11/ART-260009-8420-30071022_2.html

Mexico is progressing toward its own energy reform movement in recent years. This reform was designed to be completed by 2018. Its newly developed wholesale market, attracted worldwide wind and solar manufactures to invest[29]. A Chinese company, Suntech, supplied about 132,000 solar panels for Mexico[30]. In 2015, Chinese Envision Energy announced they purchased the controlling stake in a 600 MW wind power portfolio in Mexico.

In Argentina, Chinese capital and technology participated in at least half of the wind energy projects and three quarters of the solar energy projects, according to a survey conducted by Saint James, an Argentina-based consulting company, while the rest of the world still treat Argentina as a high-risk country for the investment activities. A Chinese company, Xinyuan Wind, participated in developing the wind farm, which would have 200 MW capacity in Patagonia. Xinyuan's investment achieved about $US 435 million[31].

3. Challenges and opportunities

3.1 Lack of policy and financial support

Latin American countries have abundant renewable energy resources and ambition to increase their renewable energy use and share in the total energy mix in the near future. China should seize

[29] Global Climatescope. (2017). Retrieved from http://global-climatescope.org/en/region/lac/
[30] Lahrichi, K. (2014, July 17). China taps into Latin America. Retrieved from https://www.chinadialogue.net/article/show/single/en/7147-China-taps-into-Latin-America-s-energy-market
[31] http://dialogochino.net/chinese-investment-generates-latin-americas-renewable-energy-expansion/

this excellent opportunity to invest more on the renewable energy projects. For now, China does not have any special loan programs or any specific renewable energy related policies to drive the investment and cooperation to this greener direction with LAC. China is one of the countries with the highest policy executive enforcement abilities, so that policy support would largely increase the investment and cooperation between China and LAC in the renewable energy sector.

Meanwhile, some LAC countries also lack policy support for specific renewable energy plans. For example, WRI[32] believed that the INDC's commitment of achieving 45% of the renewable energy use "does not actually represent progress considering that renewables made up nearly 46 percent of primary energy production in 2013". More detailed and more comprehensive policies for the renewable energy especially the solar power is needed.

3.2 Weak trading basis

There are many differences between China and LAC in terms of their cultures, social norms, laws and regulations, labor standards, and tax policies. The risk of large investment could be high because of these differences. China's competitors, principally the United States and Europe, have been active in the LAC market for a longer time than China. So LAC would be more familiar with those countries, treating them as more reliable partners than China. This leads to the general weak trading basis for China and LAC. After exporting renewable energy products to LAC countries, there are two reasons causing the limited exporting problem - the poor quality and lacking of international-recognized certificates.

[32] World Resource Institute. Romeiro ,V. & Biderman, R. (2015, September 30). A Closer Look at Brazil's New Climate Plan (INDC). Retrieved from http://www.wri.org/blog/2015/09/closer-look-brazils-new-climate-plan-indc

Firstly, some Chinese companies still need time to build trust in the LAC market[33] due to quality concerns. Taking Chinese solar panel as an example. China started its solar panel industry within decades, but it manufactured[34] more solar panels than the rest of the world combined in 2013. It could be imagined that unqualified products exist with such a rapid expansion in this industry because of the competition and race among suppliers. Unqualified raw materials were being used to reduce the costs of the production. Wind turbine share the same question as solar panels. Secondly, most of the Chinese wind and solar companies do not have the international recognized certificates. It would be very difficult for Chinese companies to do business overseas without having such kinds of widely-recognized certificates. A case in South Africa should be a persuasive example here. The South Africa government once refused to admit Chinese domestic certificate in an important wind turbine bidding project several years ago[35]. At that time, South Africa had a clear view that only those wind turbines which had the DNV, TUV or the specified certificates could have the opportunities to join the competitive tender. China was forced to negotiate very difficultly with the South Africa's Department of Energy, and many international-recognized certification organizations to solve that problem. This barrier should be the same no matter in Africa or in LAC, therefore decrease the competitiveness of the Chinese renewable energy products.

[33] Lahrichi, K. (2014, April 17). China taps into Latin America. Retrieved from https://www.chinadialogue.net/article/show/single/en/7147-China-taps-into-Latin-America-s-energy-market

[34] Liu, C. C. (2014, August 12). Defective Photovoltaics and Other Flaws Plague China's Push to Build Solar Power. Retrieved from https://www.scientificamerican.com/article/defective-photovoltaics-and-other-flaws-plague-china-s-push-to-build-solar-power/

[35] Yao, J. (2017, May 17). 中国风机"出海"遭遇"认证"关. Retrieved December 14, 2017, from https://www.ddvip.com/weixin/20170517A088M400.html

3.3 Transportation and transmission difficulties

Even if Chinese products are competitive enough in the quality and gain international recognition, other problems still exist. The most common difficulty is the product transportation problem due to the fact that LAC's infrastructure is not developed, especially when the renewable energy factories are located in the remote and mountainous region. For example, it is very hard to transport heavy wind turbines to LAC's wind power industries. Secondly, even if the renewable energy industries have the ability to generate enough clean energy to meet people's growing demand, they don't have supporting facilities such as long distance national-wide grid lines or mini-grid to transmit (distributed renewable energy) the renewable energy. An example of the smart grid which is particularly beneficial for renewable energy will be mentioned in the next part of the paper.

4. Suggestions

4.1 Policy and financial incentives

Policy and financial support for renewable energy is the most important sector in promoting the renewable energy projects. The Chinese government could encourage this by developing a special renewable loan program with high priority. China could also facilitate customs clearance for the renewable energy related products. Both of these behaviors will provide incentives for Chinese companies to produce and export more renewable energy related products.

Chinese Side	a) The Chinese government should establish a priority investment profile and add prioritize renewable energy in this profile. b) CDB and Exim Bank should also promote the development of green finance by providing loans to renewable energy projects with priority. c) China could launch a special loan program for renewable energy. Due to the close relationship between infrastructure and renewable energy, China could put it as a sub-project under the existing special loan program for infrastructure. d) China should promote trade and investment facilitation on renewable energy projects. This could be done by prioritizing and reducing the duration of the examination and approval for renewable energy products or projects, or facilitating the customs clearance for the renewable energy related products. e) Promoting acceptance of PPM related standards for renewable energy products at voluntary based.
LAC Side	

	a) LAC governments could establish a special green infrastructure group to supervise and promote the environmental impact of infrastructure projects, independent from government and the contractors. b) LAC governments could lower the renewable energy related products' import tariff. LAC should also facilitate the customs of importation when importing renewable energy related products. c) LAC governments should pay more attention on the renewable energy contributions in their INDCs. More detailed and more comprehensive policies for the renewable energy are needed.
International Organizations	a) International organizations should enhance international Green certification system. b) International organizations should promote legal acceptance of PPM related standards for green products in WTO. c) International organizations should harmonize international standards and safeguards for international investments.

	d) International organizations should facilitate investment for renewable energy.

4.2 Ensuring the products' quality, introducing international certification

The Chinese government and customs should strictly supervise the quality of renewable energy products, especially for those which export to the LAC countries. China should also introduce international standards and widely recognized certification for their products in order to reduce the acceptance difficulties when trading with LAC.

There are two certification system that are reported to be widely accepted in LAC, TUV and DNV. TÜV SÜD is a world-leading certification for products[36], which is widely accepted in LAC. It tests the products with international standards and leading quality and safety marks. This certification system even has a special testing service for power and energy products. Conventional power, nuclear power, solar power and wind power are the main sectors that they are good at testing. DNV GL is world largest classification society[37]. It provides technical consultancy and supervisory to the worldwide renewable energy, including wind, solar, wave and tidal. It is reported that 65% of offshore pipelines around the whole world were designed and installed by sticking to the DNV GL's standards. This is another worldwide recognized certification which is applicable in LAC.

[36] TÜV SÜD. (n.d.). Testing. Retrieved from https://www.tuv-sud.com/activity/testing
[37] Wikipedia. (2017, November 23). DNV GL. Retrieved from https://en.wikipedia.org/wiki/DNV_GL

In addition, there are also particular renewable energy related certification systems that are being developed. The IECRE system[38] (IEC System for Certification to Standards Relating to Equipment for Use in Renewable Energy Applications) is a standard that some of the Chinese companies have already applied. This certification system intends to facilitate international trade in the renewable energy sector and maintain the safety of those equipment and services. The second one is a newly developed system. PEER (Performance Excellence in Electricity Renewal)[39] is a rating system, testing and improving sustainable power generation. This system is modeled after LEED, providing assessment on renewable energy projects from generation, transmission, and consumer participation.

On the LAC side, LAC should give incentives on promoting the use of renewable energy products among the local people. Moreover, LAC's acceptance on the Chinese renewable energy products is not ideal because the cooperative history between LAC and China is relatively shorter than United States or Europe with LAC, the cultural difference between those countries might be relatively small. As more cooperation going on in recent years between China and LAC, LAC should try to promote local people's acceptance of Chinese products.

Chinese Side	a) The Chinese government should accept international standards and safeguards and/or promoting mutual

[38] IECRE. (n.d.). What is IECRE. Retrieved from http://www.iecre.org/about/
[39] PEER. (n.d.). Advancing clean, efficient & reliable energy. Retrieved from http://peer.gbci.org/

	recognition of national ones for international investments b) Chinese government should accept international green certification and/or promoting mutual recognition of national green certification between trade partners. (TUV, DNV, IECRE, PEER, et al.) c) Chinese government should enhance the supervision on the quality of exporting products, checking strictly and improve the product exporting standards. d) Chinese companies should establish corporate responsibility department, releasing CSR report every year.
LAC Side	a) LAC should improve consumer awareness of renewable energy products, enlarging green consumptions, b) LAC should increase local people and local companies' acceptance level of Chinese products.

4.3 Hasten infrastructure and transmission construction

To solve the products transportation problem, China and LAC should pay more attention to related infrastructure development and cooperation. As for the energy transmission problem, it is

necessary for LAC countries to figure out what are the most suitable ways of developing their own renewable energy sources. To solve either the transportation problem or the energy transmission problem, the development of infrastructure is very important. LAC should pay attention on this, and China should seize the opportunities, helping LAC to develop their infrastructure as soon as possible.

For energy transmission, smart grid is the most popular concept in recent years. The most innovative aspect of this model is that smart grid provides a two-way communication for both power plants and users in real time. For power plants, they can charge a higher price to raise their revenue when the users' demand is high. And they can also generate less electricity to reduce waste when the users' demand is low. For electricity users, they know the prices paid for electricity a day ahead or an hour ahead, allowing them to adjust their usage in response to the real time prices more easily. For example, users may choose to lower their consumption during the high cost period. As a result, the power plants' total generation and users' total consumption of electricity can be reduced at the same time. And this may slow down the pace of climate change. In a word, smart grid can satisfy both the suppliers and consumers, and it is beneficial to the environment. What is more, smart grid can accelerate the development of renewable energy, which is also beneficial to the environment. For example, solar photovoltaic systems are usually installed at disperse customer locations and produce power intermittently. The smart grid can integrate those distributed renewable energy sources easily. And the power plants can charge in real-time prices according to real-time needs. LAC is expected to expand its smart grid investment[40] to about

[40] Hill, J. S. (2015, August 11). South American Investment In Smart Grid Infrastructure To Reach $38.1 Billion By 2025. Retrieved from https://cleantechnica.com/2015/08/11/south-american-investment-smart-grid-infrastructure-reach-38-1-billion-2025/

US$ 38 billion by 2025. Brazil has already announced over US$ 3 million investments on smart grid at the end of 2015. About US$ 25.6 billion investments are planned to put on the smart grid in Brazil in the next ten years.

Based on Greenpeace East Asia's research[41] in 2015, Dynamic Line Rating (DLR) technology - a technology which cools power lines and increases efficiency - with renewable energy (RE) is the best choice for China. Greenpeace stated that China could save about 50% if they choose DLR technology to expand the network. Jiangsu Province could be the leader in China during the energy revolution period. According to Greenpeace, Jiangsu could easily integrate 30GW of wind and 30GW solar energy. It could then meet a 2020 renewables target of 14%. This model might be suitable for some LAC countries.

For energy's long-distance distribution problem, mini-grid could also be a solution. Some LAC countries may also be interested in incorporating distributed renewable energy for off-grid applications. A recent report[42] from WWF shows that mini-grid is very effective in Africa. For example, Kenya could use only the half of its original budget on grid expansion to meet the growing demand within five years, if they choose to apply mini-grid.

LAC countries should conduct R&D first in order to figure out what are the most cost-effective way of developing their own grid with renewable energy. For those countries which share the similar situation with China, they could cooperate with China on the grid extension.

[41] Greenpeace. (2015, July 15). Greenpeace: Jiangsu a potential leader of China's 'energy revolution'. Retrieved from http://www.greenpeace.org/eastasia/press/releases/climate-energy/2015/Greenpeace-Jiangsu-a-potential-leader-of-Chinas-energy-revolution/

[42] WWF, Mini-grids and Electrification: A Case for China-Africa Cooperation

Chinese Side	a) China should expand infrastructure cooperation with LAC b) China should pay attention on LAC's power grid extension demand, helping LAC countries with financial and skills support on developing renewable energy transmission
LAC Side	a) LAC should promote infrastructure construction with the cooperation with China b) Different LAC countries should conduct R&D to figure out what are the most cost-effective ways for them to develop their power grid to transmit the renewable energy.
International Organizations	International organizations should help LAC countries on the R&D process, in order to find the best way to develop their power grid.

5. Conclusion

China and LAC should pay a lot more attention to promoting renewable energy cooperation in the future. Policies and financial supports from China and LAC, the renewable energy related products' quality, the widely-recognized international certification, and the improving transportation and energy transmission construction are all important factors for the cooperation. China, LAC, and international organizations need to work together in solving the existing problems. It is beneficial if they could push the trade and investment activities between China and LAC in a more sustainable direction.