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SOUTH-SOUTH TECHNOLOGY COOPERATION

The Case of Brazil and China's Wind Industry

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SOUTH-SOUTH TECHNOLOGY COOPERATION:
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Cooperation in the fields of technology is under the constant pressure of global competition. Countries are finding themselves in a race to increase their innovation capacity. This is particularly the case for emerging markets like Brazil and China. This race includes significant multi-dimensional commitments from government towards industry development and collaboration in an effort to develop mutually benefitting opportunities. Fully utilizing their growth in financial and technological capacity, Brazil and China have expanded their collaboration on renewable energy technology. Technology cooperation is a way to develop opportunities for reciprocal knowledge-sharing and investment.

Through the use of case study and literature review, this paper analyses the bilateral cooperation between Brazil and China on wind power technology. It focuses on the public and private sectors' research and development (R&D) of wind technology between the two countries. The extent and the outcomes of wind technology cooperation are closely examined to verify the significance of the cooperation relative to each state's unilateral technology development. Furthermore, an analysis of the drivers for this technology partnership, which derive from a myriad of policies and interests developed by each actor, are considered. By identifying the motives for their collaboration, we seek to delve deeper into the extent of cross-country technology cooperation. Based on our analysis, potential implications from the Sino-Brazil wind technology cooperation will be derived, which will provide an insight to understand the increasing South-South cooperation.

In addressing the research outlined above, various indicators are used to measure the extent of the bilateral technology cooperation. Collaborative R&D expenditure on wind technology and the size of mutual energy investments are the first indicators examined. By observing this data, we gauge the increase in public and private willingness to participate in technology cooperation projects. Nevertheless, evaluating the effectiveness of the cooperation requires more comprehensive evidence. An analysis of the empirical data related to patents filed or granted between Brazil and China relative to the increased efforts put in for the collaboration serves as an additional indicator of the extent of this bilateral relationship. It is important to note that evidence of immediate and tangible outcomes from the collaboration is not presented due to the fact that the technology cooperation is in its initial stages and does not currently produce these results.

South-South Cooperation

There is a wide array of definitions describing South-South cooperation. One adopted by the United Nations states: "South-South cooperation is a broad framework for collaboration among countries in the South in the political, economic, social, cultural, environmental and technical domains."[1] Ranging from bilateral, regional, sub-regional, and interregional networks of developing countries, South-South cooperation allegedly aims to share knowledge, skills, expertise and resources for collaborative development. Often, evidence of this new phenomenon in development is drawn from rapid increase in South-South flows of trade, investment and technology.[2]

Within the technological perspective, South-South cooperation examines the exchange of expertise and capacities necessary to meet the specific developmental needs of the participating states. South-South cooperation is at the crux of recent developmental dialogues due to its anticipated benefits to developing countries. By definition, South-South cooperation should be 'owned' by developing countries themselves whether at the governmental, public, private, non-governmental or individual level. From

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[1] "United Nations Office for South-South Cooperation - what is SSC?"http://ssc.undp.org/content/ssc/about/what_is_ssc.html (accessed 4/30/2014, 2014).

[2] *Ibid*

South-South cooperation, international stakeholders anticipate to observe "enhancement of the multiplier effect of technical cooperation; increased knowledge of and confidence in the capacities; development of indigenous technology for better adaption to local needs; and development of new capacities."[3]

While a comprehensive list of preconditions for South-South cooperation is yet to be compiled, a fruitful South-South technology cooperation is generally premised on a shared definition by participants of the possibilities and gains attainable through the partnership.[4] Thus, the critical stages of South-South cooperation are as follows: 1) identifying common areas of collaboration; 2) possessing the necessary technology or scale of experience; 3) understanding returns to technology cooperation; and 4) adhering to the promised process politically and financially. Technology cooperation among developing countries may occur when the technologies acquired by the participants are similar in its advancement or in need for improvement within an industry.[5]

Brazil and China, in particular, have actively endorsed South-South cooperation in the past decade. Both developing countries are leaders in their regions and are increasingly considered by developed nations as key players in international negotiations. For instance, Brazil co-initiated the India-Brazil-South Africa (IBSA) Dialogue Forum which focused on energy and medical technology cooperation. Additionally, the Brazil-Mozambique antiretroviral medicine collaboration has been particularly successful.[6]

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[3] "United Nations Office for South-South Cooperation - what is SSC?"http://ssc.undp.org/content/ssc/about/what_is_ssc.html (accessed 4/30/2014, 2014).

[4] Marco Antonio Vieira and Chris Alden, "India, Brazil, and South Africa (IBSA): South-South Cooperation and the Paradox of Regional Learship," *Global Governance*, no. 17 (2011), 507-528.

[5] Amitqva Krishna Dutt, *South-South Economic Cooperation: Motives, Problems and Possibilities* (Notre Dame: University of Notre Dame,[2013]).

[6] Options for facilitating the development, transfer and dissemination of clean and environmentally sound technologies, General Assembly, A/68/310, Sixty-eighth session, Sustainable development: implementation of Agenda 21, 12 August 2013.

Yet, no comprehensive academic research has been conducted to precisely define, measure or comprehend the implications of this sudden surge of South-South cooperation. Unlike the traditional North-South cooperation which has been incentivized to report its activities, no such monitoring framework has been set up to accurately depict the scope of its South-South counterpart.[7] Much of the research on South-South cooperation still remains as advocacy or anecdotal knowledge. Thus, by examining the case of Brazil-China wind energy technology cooperation, we hope to understand the extent, drivers and lessons learned from this South-South technology cooperation.

Brazil's Wind Energy Industry

In Brazil, wind energy is predominantly generated for installed capacity to be connected to the grid.[8] Most of the Brazilian wind power generation potential is in the Northeast region[9] and as the fastest growing source of power generation in Brazil today, wind energy has a potential estimated at 300GW and the industry expects to contract at least 2.5GW per year by 2020.[10]

In 1992, Brazil installed its first wind-energy turbine in Fernando de Noronha Archipelago. Since then, and with 4,600 miles of coastline, Brazil is taking advantage of its geographic location to develop their wind power industry.[11] In 2013, almost half of the new capacity installed came from new wind farm complexes: Asa Branca (160 MW), Calango (150 MW), and Renascenca (120 MW).[12] Additionally, the wind industry is crucial for Brazil's national energy security as it is expected to create more than 70 thousand jobs, produce

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[7] Options for facilitating the development, transfer and dissemination of clean and environmentally sound technologies, General Assembly, A/68/310, Sixty-eighth session, Sustainable development: implementation of Agenda 21, 12 August 2013.

[8] "World Energy Council 2004 Survey of Energy Resources." (2004).

[9] "Industry Profile | Brazil Energy S.A."http://brazilenergy.com.br/en/portfolio/brazil-wind/perfil-do-setor/ (accessed 4/30/2014, 2014).

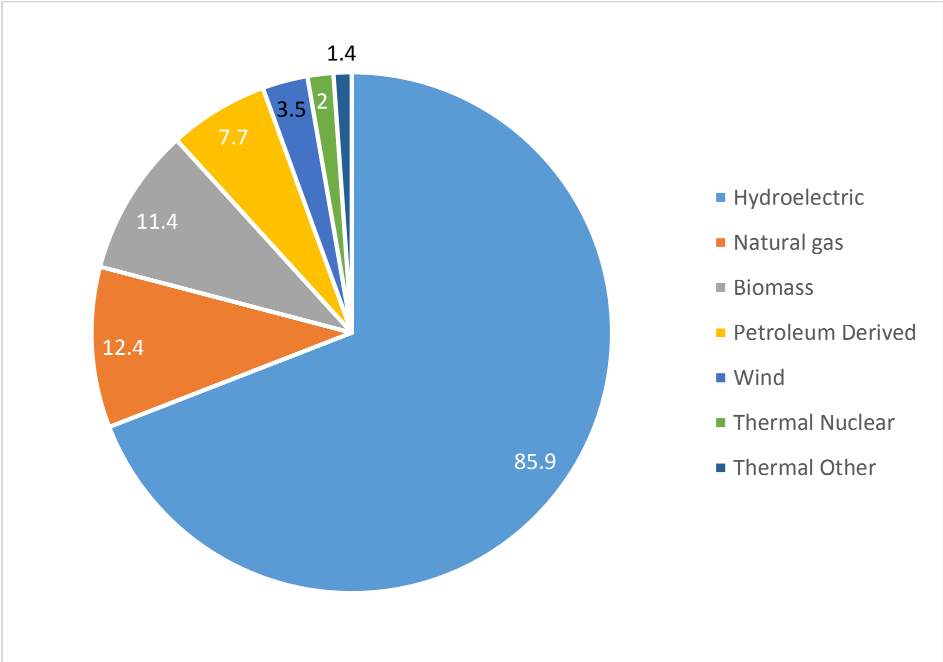
[10] "Brazil Windpower 2014."http://www.brazilwindpower.org/en/ (accessed 3/27/2014, 2014).

[11] "Brazil Windpower 2014."http://www.brazilwindpower.org/en/about.asp (accessed 4/10/2014, 2014).

[12] "GWEC | Global Wind Report – Annual Market Update 2013 - GWEC-Global-Wind-Report_9-April-2014.Pdf."http://www.gwec.net/wp-content/uploads/2014/04/GWEC-Global-Wind-Report_9-April-2014.pdf (accessed 4/30/2014, 2014).

$21.2 billion Brazilian Reals (approximately USD 9.48 billion[13]) in investments, supply energy to 8.5 million households, reduce CO2 by 4 million tons, and improve the rates of storage reservoirs.[14]

<Figure 1> Brazilian Energy Mix-Installed Capacity (in GW)



In 2002, ten years after the first wind-energy turbine was installed, the government created Proinfa, a program to incentivize the use of renewable sources which encouraged businesses to invest in renewables like biomass, small hydroelectric plants, and wind.[15] That same year, ABEEólica, the Brazilian Wind Energy Association was established. Today it represents over 80 member companies involved in manufacturing, intermediary services, consulting, development, and investments.[16]

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[13] 1 BRL = 0.447258 USD – 4/29/2014 www.xe.com

[14] "GWEC | Representing the Global Wind Energy Industry."http://www.gwec.net/abeeolica-celebrates-record-levels-wind-power-brazil/ (accessed 3/25/2014, 2014).

[15] "Programme of Incentives for Alternative Electricity Sources (PROINFA) | World Resources Projects."http://projects.wri.org/sd-pams-database/brazil/programme-incentives-alternative-electricity-sources-proinfa (accessed 4/10/2014, 2014).

[16] "GWEC | Representing the Global Wind Energy Industry.", http://www.gwec.net/abeeolica-celebrates-record-levels-wind-power-brazil/ ed., Vol. 2014, u).

During the early 2000's Brazil suffered a severe energy shortage prompted by a drought that affected the country's hydroelectric dams. This caused a negative impact on the country's economy and the government had to ration electricity. This situation heightened the urgency to diversify energy sources and seek new renewable technologies.[17] According to executives at the Global Wind Energy Council, "Brazil will most likely double its total installed capacity in 2014, and nearly do so again in 2015."[18] Last year Brazil led Latin America in this industry, adding 953 MW of new capacity. The government contracted over 10 GW through to 2018 and will probably add more to that number after the auction scheduled for June of this year takes place. While projects were fully commissioned some of them faced the issue of not being able to connect to the grid by the end of the year. Nevertheless, in an effort to alleviate some of the pressure, a new system to auction transmission lines will also take place.[19]

In 2013, Brazil held three auctions[20] which booked a total of 4.71 GW of new projects. This is a record for the wind industry in Brazil[21] at 142% more than the 2 GW goal,[22] and certainly an indication of the steady growth the industry is experiencing. Furthermore, it represents an effort to diversify their energy matrix,

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[17] "Brazilian Wind Power Gets a Boost - NYTimes.Com - NYTimes.Com."http://green.blogs.nytimes.com/2009/11/09/brazilian-wind-power-gets-a-boost/?_php=true&_type=blogs&_php=true&_type=blogs&_r=1 (accessed 4/29/2014, 2014).

[18] "GWEC | Global Wind Report – Annual Market Update 2013 - GWEC-Global-Wind-Report_9-April-2014.Pdf.", http://www.gwec.net/wp-content/uploads/2014/04/GWEC-Global-Wind-Report_9-April-2014.pdf ed., Vol. 2014, t).

[19] "GWEC | Global Wind Report – Annual Market Update 2013 - GWEC-Global-Wind-Report_9-April-2014.Pdf."http://www.gwec.net/wp-content/uploads/2014/04/GWEC-Global-Wind-Report_9-April-2014.pdf (accessed 4/30/2014, 2014).

[20] "GWEC | Representing the Global Wind Energy Industry.", http://www.gwec.net/abeeolica-celebrates-record-levels-wind-power-brazil/ ed., Vol. 2014, u).

[21] "GWEC | Representing the Global Wind Energy Industry."http://www.gwec.net/global-wind-grows-12-5-2013/ (accessed 2/19/2014, 2014).

[22] "Good Winds Boost Wind Power in Brazil."http://www.alstom.com/press-centre/2014/2/good-winds-boost-wind-power-in-brazil/ (accessed 4/30/2014, 2014).

which 74 percent of is based on hydropower, by supplementing it with wind-power plants. [23] The Brazilian Electricity Regulatory Agency (ANEEL) is the entity responsible for carrying out Brazil's energy auctions through a delegation from the Ministry of Mines and Energy. When holding reserve auctions, ANEEL, in an effort to reduce operational costs of the system, purchases additional energy supply for the National Integrated System (SIN).[24]

<Figure 2>

2013 New Wind Energy Regulations	
Resolution No. 391/2009	Establishes requirements for the permits needed for wind development in Brazil. This resolution also allows the company to request information about interested distributors and about the National System Operator – ONS.
Decree No. 274/2013	Presents amendment procedures for the Special Incentive Regime for Infrastructure Development (REIDI), including some tax benefits.
Decree No. 310/2013	Defines procedures for classification of power generation projects for the application of REIDI. This decree is exclusive to projects sold in the Free Market.

Source: GWEC | Global Wind Report – Annual Market Update 2013

China's Wind Energy Industry

While the wind energy industry experienced overall growth across the world in the recent decade, China emerged as the most prominent player above all. Besmirched with defame as the world's biggest carbon dioxide producer, China also holds, paradoxically, the world's greatest cumulative and newly installed wind capacity. As shown in Figure 3, in 2013 alone, China has installed more than 16 GW of wind capacity, adding up to 91,412 MW in total.[25] With more than 622 wind farms established and 45,000 wind turbines

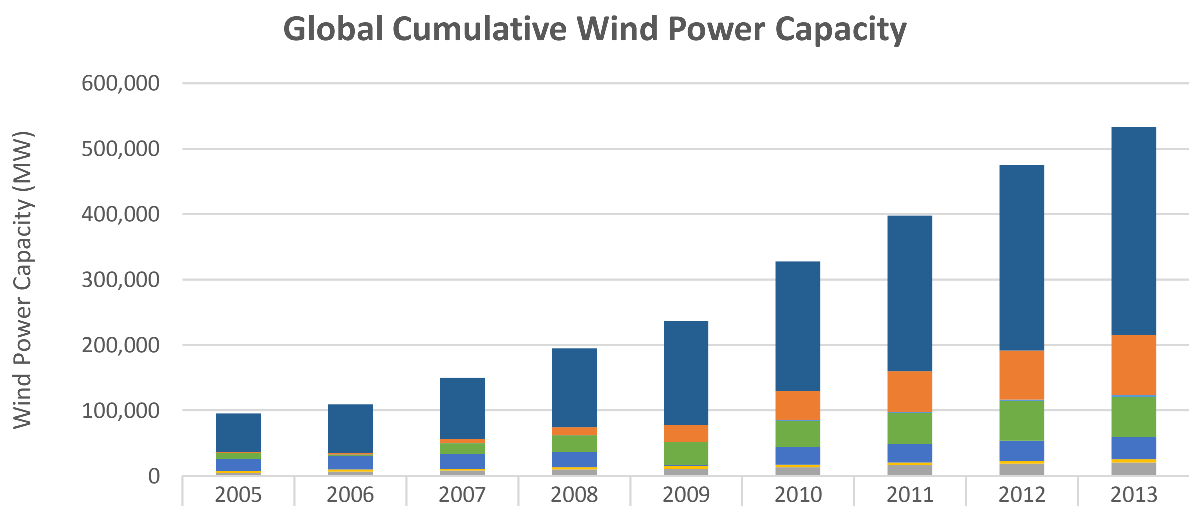
[23] "Developing Countries & Global Climate Change: Electric Power Options in Brazil | Center for Climate and Energy Solutions."http://www.c2es.org/publications/developing-countries-global-climate-change-electric-power-options-brazil (accessed 4/30/2014, 2014).

[24] "Brazil's Wind Power Auction Spurs More Clean Energy Development."http://www.renewableenergyworld.com/rea/news/article/2009/12/brazils-wind-power-auction-spurs-more-clean-energy-development (accessed 4/29/2014, 2014).

[25] The figure refers to the statistics in 2013 from Global Wind Energy Council. "GWEC – Global Wind Statistics 2013 - GWEC-PRstats-2013_EN.Pdf."http://www.gwec.net/wp-content/uploads/2014/02/GWEC-PRstats-2013_EN.pdf (accessed 4/10/2014, 2014).

erected, China's wind energy accounts for 28.7% of the global total.[26] Near two-fold continuous growth in newly installed wind power capacity clearly resonates China's role in the global wind market.

<Figure 3> Global Installed Wind Capacity (2005-2013)



	2005	2006	2007	2008	2009	2010	2011	2012	2013
World	59,091	74,051	93,835	120,297	158,908	197,637	238,050	283,194	318,105
China	1,260	2,599	5,910	12,020	25,805	44,733	62,364	75,324	91,412
Brazil	29	237	247	341	606	927	1,431	2,508	3,461
United States	9,149	2,454	16,824	25,068	35,086	40,298	46,929	60,007	61,091
Germany	18,415	20,622	22,247	23,903	1,493	27,191	29,071	31,270	34,250
Denmark	3,128	3,136	3,125	3,163	3,465	3,749	3,956	4,162	4,772
India	4,430	6,270	7,845	9,655	10,926	13,065	16,084	18,421	20,150

China's rapid expansion of wind power rests on its abundant wind resources, mainly located in the northern and western Inner Mongolia, far off from electricity demand-centers.[27] Distant wind resource exacerbates electricity loss from the current weak power transmission system. Meanwhile, rich offshore

[26] "Wind Energy Data for China - Country Wind Farms."http://www.thewindpower.net/country_windfarms_en_9_china.php (accessed 4/30/2014, 2014).

[27] "China Wind Energy Development Roadmap 2050 - China_wind.Pdf."https://www.iea.org/publications/freepublications/publication/china_wind.pdf (accessed 4/10/2014, 2014).

potentials – as much as 500 GW of exploitable wind energy – remain mostly untapped in the southeast coast by the Taiwan Strait. [28] Still in its experimental stage, near offshore and far offshore wind technology is expected to be heavily invested by the Chinese government until 2050.[29] In total, wind energy accounts for 2.6% of the national total energy consumption in 2013.[30]

Stemming from its initial attempt to support the development of the renewable energy industry, Beijing established its first *National Renewable Energy Law* in 2005. Envisioning 15% of national energy consumption to originate from renewable energies, the Chinese government adopted multiple incentivizing mechanisms to scale up wind power bases. With ambitious guidelines and targets to galvanize the domestic wind industry, the Chinese government guaranteed both financial and infrastructural support for potential energy developers. Flexible and low-cost capital is offered by the China Development Bank (CDB), tax breaks are granted, and roads are built to facilitate access to wind resources. Similarly, state policy intervention facilitated wind power industry pricing mechanism. Differentiated feed-in tariffs – guaranteed, long-term and fixed purchase prices of energy – were adopted in 2009.[31] From these 'push' and 'pull' initiatives, the Chinese wind industry experienced positive spill-over effects to related sectors, such as power transmission and wind turbine manufacturing. [32] Government's supporting measures do not come untied, however. Explicit obligations were imposed on

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[28] "China Wind Energy Development Roadmap 2050 - China_wind.Pdf."https://www.iea.org/publications/freepublications/publication/china_wind.pdf (accessed 4/10/2014, 2014).

[29] *Ibid*., 28.

[30] "GWEC | Global Wind Report – Annual Market Update 2013 - GWEC-Global-Wind-Report_9-April-2014.Pdf.", http://www.gwec.net/wp-content/uploads/2014/04/GWEC-Global-Wind-Report_9-April-2014.pdf ed., Vol. 2014, t).

[31] "GWEC | Global Wind Report – Annual Market Update 2013 - GWEC-Global-Wind-Report_9-April-2014.Pdf."http://www.gwec.net/wp-content/uploads/2014/04/GWEC-Global-Wind-Report_9-April-2014.pdf (accessed 4/30/2014, 2014).

[32] Joanna I. Lewis, " Building a National Wind Turbine Industry: Experiences from China, India and South Korea," *Int. J. Technology and Globalisation* 5 (2011), 281-305.

power producers regarding the specific size of the wind turbines and compliance with local content restrictions.[33]

Institutional support for the industry was particularly conducive to the success of Chinese wind manufacturers. Despite the difficulties in 2012, eight Chinese firms have secured their positions among the top 15 global wind turbine suppliers by annual market share in 2013.[34] In particular, Goldwind, also China's largest domestic wind equipment provider, has ranked second with 10.3 percent of global market share.[35] Explosive growth in the last decade for Chinese wind turbine manufacturers is highly dependent on its domestic demand. Securing domestic wind turbine market share had been the government's deliberate protectionist policy to develop the industry. High import tax on foreign equipment, local content requirements, and subsidies for domestically produced wind turbines were exemplary policies implemented by the Chinese government to spawn local manufacturing firms.[36] Currently, these policies have been loosened upon request from foreign manufacturers but domestic firms are often prioritized over foreign counterparts. [37]

Although tacit knowledge was transferred from motor industries which expanded into wind turbine industry, China's wind energy greatly benefitted from foreign technology transfer and cross-border technological learning. Various means of acquiring foreign technology were explored by China's wind

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[33] *Ibid*, 4.

[34] "North American Windpower: Top 15 Wind Turbine Suppliers of 2013 Revealed."http://www.nawindpower.com/e107_plugins/content/content.php?content.12710 (accessed 4/30/2014, 2014).

[35] *Ibid,* 8 wind turbine manufacturing firms included in the world's top 15 wind turbine supplier list and their market share in 2013 are: 2. Goldwind (10.3%); 8. United Power (3.9%); 9. Mingyang (3.7%); 11. XEMC (3.2%); 12. Envision (3.1%); 13. DEC (2.3%); 14. Sinovel (2.3%); 15. Sewind (2.2%)

[36] Pedro Campos Silva, Britta Klagge and Zhigao Liu, "Constructing China's Wind Energy Innovation System," *Energy Policy* 55 (2012), 370-382.

[37] "North American Windpower: Top 15 Wind Turbine Suppliers of 2013 Revealed."http://www.nawindpower.com/e107_plugins/content/content.php?content.12710 (accessed 4/30/2014, 2014).

industry, for example: importing foreign equipment, clean technology support for development aid, licensing, foreign direct investment, joint design, joint ventures, and acquisition of foreign firms.[38] Influx of foreign wind energy technology to China is evident from patent data as well; China was the largest recipient of wind energy technology transfer, mostly originating from Europe and the US.[39] Once the know-how and technology is acquired from foreign sources, low production cost of wind turbines clearly set apart Chinese firms from the rest, boosting sales at an exorbitant rate.

Traditionally, domestic R&D for innovating wind technology had primarily remained within the public sector. Overseen by the central government, research on wind energy technology was conducted by public universities and research institutes, such as Tsinghua University and China National Renewable Energy Centre (CNREC).[40] Recognizing the disjunction between national-level R&D and wind industry companies, the government offers greater support for individual firm-level R&D (especially the state-owned enterprises) and encourages relationships between public research institutes and private enterprise.[41] Increasingly, private wind energy firms are also partaking in active R&D efforts by establishing domestic and overseas R&D centers.[42]

Despite its temporary setback in 2012, China's wind energy industry recuperated in 2013 and is expected to continue its growth in the future. Challenged with insatiable demand for energy and exacerbating air quality, the Chinese government will uphold its commitment to the expansion of the wind energy industry.

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[38] For more detail on means adopted by China's wind turbine manufacturers for acquiring technology, refer to Appendix.1 of Pedro Campos Silva, Britta Klagge and Zhigao Liu, "Constructing China's Wind Energy Innovation System," *Energy Policy* 55 (2012), 370-382.

[39] Ivan Hašcic et al., "Climate Policy and Technological Innovation and Transfer," (2010).

[40] "China National Renewable Energy Centre (CNREC) | Open Energy Information."http://en.openei.org/wiki/China_National_Renewable_Energy_Centre_(CNREC) (accessed 4/30/2014, 2014).

[41] Campos Silva, Klagge and Liu, *Constructing China's Wind Energy Innovation System*, Vol. 55, 2012), 370-382.

[42] *Ibid.*

Remaining hurdles for the Chinese wind industry lie in power transmission systems. In 2013, 11% of transmitted wind power was lost and some regions energy loss reached up to 35%.[43] Shortage and poor maintenance of existing power grids threaten stable supply of wind energy to its demand centers. Further research on wind energy transmission and expansion of grid system is needed for sustainable transmission of wind energy in China.

Extent of Sino-Brazil Wind Technology Cooperation

China's role in a South-South relationship is seen as a big, aggressive, and powerful state using its government-owned enterprises to procure the resources they lack to advance their economy.[44] However, while this has not necessarily been the case in all sectors of the renewable energy industry between China and Brazil, there are traces of this type of relationship in some aspects of the wind energy sector.

During the past five years, Brazil and China surged up to be new leaders in this sector globally. These two emerging countries also share similar grand wind energy expansion goals for the future.[45] To accommodate the burgeoning renewable energy market, both Brazil and China are dedicated to acquiring and further developing relevant technology. Recognizing the mutual benefits of collaborating in technology, Brazil and China have cooperated since 2011 on the development of wind technology at multiple levels.

43 "GWEC | Global Wind Report – Annual Market Update 2013 - GWEC-Global-Wind-Report_9-April-2014.Pdf.", http://www.gwec.net/wp-content/uploads/2014/04/GWEC-Global-Wind-Report_9-April-2014.pdf ed., Vol. 2014, t).

44 Vieira and Alden, *India, Brazil, and South Africa (IBSA): South-South Cooperation and the Paradox of Regional Learship*, 2011), 507-528.

45 "GWEC | Global Wind Report – Annual Market Update 2013 - GWEC-Global-Wind-Report_9-April-2014.Pdf.", http://www.gwec.net/wp-content/uploads/2014/04/GWEC-Global-Wind-Report_9-April-2014.pdf ed., Vol. 2014, t).

Institutional

China and Brazil officially established diplomatic ties in 1974 when they opened embassies at each capital.[46] Scientific collaboration between Brazil and China dates back to the 1980s when the two countries embarked upon a joint venture to develop and launch three Earth observation satellites to monitor oil exploration activities with the China-Brazil Earth Resources Satellite (CBERS). They collaborated and financed the launch of two satellites into space, the CBERS 1 and SACI 1.[47] This highly successful project encouraged Sino-Brazil bilateral relations and served as a basis for setting up the China-Brazil High Level Coordination Committee (CBHCC).

The CBHCC was established in 2004. Two years later a mining and energy sub-committee was created and in[48] 2008, a science and technology subcommittee held its first meeting. Since then, the two countries have established several formal centers for collaboration: the China-Brazil Joint Laboratory of Agricultural Sciences, China-Brazil Nanotechnology Research Centre, and of most relevance to this paper, the China-Brazil Center for Climate Change and Energy Technology Innovation. Furthermore, Memorandums of Understanding have been signed establishing a Biotechnology Center and Meteorological Satellite Joint Research Center.[49]

Following this endeavor, the government of the People's Republic of China and the government of the Federative Republic of Brazil (2010-2014) signed the Joint Action Plan, which enhances mutual investment

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[46] Lorenzo Riccardi, "Chinese Tax Law and International Treaties," in (Switzerland: Springer International Publishing, 2013), 111.
[47] "NASA National Space Science Data Center."http://nssdc.gsfc.nasa.gov/nmc/masterCatalog.do?sc=1999-057A (accessed 04/10, 2014).

[48] Denis Best and Joerg Husar, *Energy Investments and Technology Transfer Across Emerging Economies: The Case of Brazil and China* (Paris: International Energy Agency,[2013a]).

[49] "Vice Minister Cao Attends 3rd Session of China-Brazil High-Level Coordination and Cooperation Committee."http://www.brics-info.org/vice-minister-cao-attends-3rd-session-of-china-brazil-high-level-coordination-and-cooperation-committee-2/ (accessed 4/30/2014, 2014).

and cooperation in the renewable energy sector, and emphasizes further collaboration between the two countries. This is a result of successful foreign relations among the two countries. According to a 2011 report from the Ministry of Foreign Affairs of the People's Republic of China on the bilateral relationship,

> "Positive outcomes were made in China-Brazil practical cooperation. Brazil moved up the ranks as China's ninth largest trading partner while China remained Brazil's largest trading partner and export market as well as the second largest source of imports. Smooth progress was made in major cooperation projects on energy, infrastructure and finance. China's investment in Brazil saw fast growth. The Brazilian GASENE natural gas pipeline constructed by China was completed ahead of schedule and with high quality."[50]

Furthermore, this relationship is strengthened by their common memberships in international organizations and multilateral mechanism like the United Nations, the G20, the BRIC and the BASIC. Through their involvement in these, both countries have continued steady communication and cooperation on matters like the international financial system and climate change.

Public

China and Brazil's cooperation at the public level encompasses energy innovations as they relate to climate change and technologies.[51]A formal approach to develop this cooperation was instituted in 2009 when the two countries co-established the Brazil-China Center for Climate Change and Energy Technology Innovation (the Center). This initiative serves as their flagship public sector technology partnership and it gathers specialists and government representatives from the two countries to discuss opportunities of

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[50] "Ministry of Foreign Affairs of the People's Republic of China."http://www.fmprc.gov.cn/mfa_eng/ (accessed 4/30/2014, 2014).

[51] "Brazil-China Center | Coppe."http://www.centrochinabrasil.coppe.ufrj.br/en/conheca-centro/ (accessed 4/10/2014, 2014).

cooperation in renewable energy.[52] With the support of FINEP, the Brazilian Innovation Agency, the Federal University of Rio de Janeiro's (UFRJ) Coppe graduate school and the Tsinghua University in Beijing established a partnership to collaborate in research and innovation geared towards developing energy technologies that protect the environment.[53] FINEP, a Brazilian financing agency for projects of the Ministry of Science, Technology and Innovation, funds the Center's work.[54] The Center also facilitates information exchange through joint seminars, conferences, academic events and policy advisory meetings.[55] This partnership, provides a forum where stakeholders from premier engineering universities, private companies, government agencies, development banks and NGOs can regularly convene to discuss research, policy, technology transfer, innovation, and climate change mitigation issues within the renewable energy field.[56] Since its inception, the Center has hosted over 25 events in more than eight cities. Of most relevance are the World Bioenergy Symposium and the events organized during the United Nations Conference on Sustainable Development (Rio+20) in 2012.[57] Another noteworthy collaboration in academia is Brazil's 'Science without Borders" program which has assisted engineering student exchange between the two countries.[58]

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[52] "The China-Brazil Center: Wind Power and Biodiesel are to be the Main Areas of Cooperation | Coppe."http://www.centrochinabrasil.coppe.ufrj.br/en/projects-and-research/the-china-brazil-center-wind-power-and-biodiesel-are-to-be-the-main-areas-of-cooperation/ (accessed 4/10/2014, 2014).

[53] *Ibid*.

[54] Ilan E. Cuperstein, *Sino-Brazilian Technology Cooperation:The Case of the China Brazil Center of Climate Change and Energy Technology Innovation* (Rio de Janeiro: Brazil-China Center for Climate Change and Innovative Energy Technologies,[2014a]).

[55] Ilan E. Cuperstein, *Sino-Brazilian Technology Cooperation:The Case of the China Brazil Center of Climate Change and Energy Technology Innovation* (Rio de Janeiro: Brazil-China Center for Climate Change and Innovative Energy Technologies,[2014b]).

[56] "Brazil-China Center | Coppe."http://www.centrochinabrasil.coppe.ufrj.br/en/conheca-centro/ (accessed 4/10/2014, 2014).

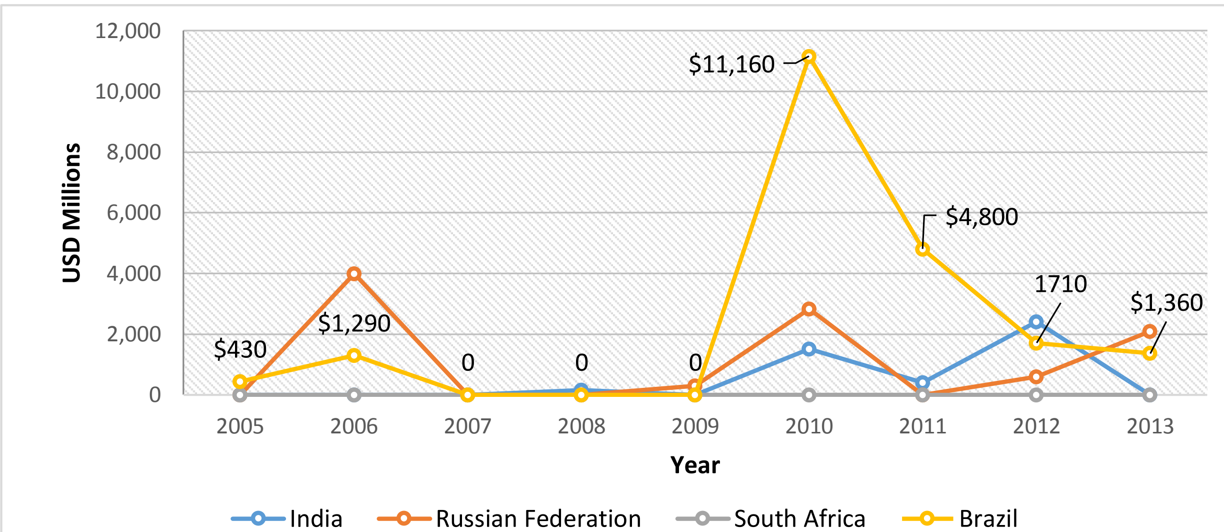
[57] Ilan E. Cuperstein, *Sino-Brazilian Technology Cooperation:The Case of the China Brazil Center of Climate Change and Energy Technology Innovation* (Rio de Janeiro: Brazil-China Center for Climate Change and Innovative Energy Technologies,[2014c]).

[58] *Ibid,* 9.Ilan E. Cuperstein, *Sino-Brazilian Technology Cooperation:The Case of the China Brazil Center of Climate Change and Energy Technology Innovation* (Rio de Janeiro: Brazil-China Center for Climate Change and Innovative Energy Technologies,[2014d]).

Private

Chinese private investment in Brazilian energy industry coincided with similar but smaller-scale investments in the rest of the BRICS energy sector. As illustrated in <Figure 4>, energy investment originating from China to Brazil increased dramatically between 2009 and 2010, after the Joint Action Plan agreement was finalized.[59]

<Figure 4> China's Energy Investment in BRICS



Source: the Heritage Foundation, China Investment Tracker Map

In 2013, energy investments from China to Brazil reached USD $22.2 billion, or 69% of total Chinese investment in Brazil.[60] Sudden surge of capital invested in the Brazilian energy industry did not last long, however. Since 2010, investments decreased gradually and were overridden by Russia in 2013. Energy sector capital flow between Brazil and China oscillated over the last decade, ranging as high as USD 11,160 million in 2010 and as low as zero. While increase in energy investment does not immediately translate

[59] Best and Husar, *Energy Investments and Technology Transfer Across Emerging Economies: The Case of Brazil and China* (Paris: International Energy Agency, 2013a), 20.

[60] "China Global Investment Tracker Map."http://www.heritage.org/research/projects/china-global-investment-tracker-interactive-map (accessed 4/10/2014, 2014).

to increase in technology cooperation, overall growth in bilateral energy investment provides the structural platform for individual corporations to collaborate on their expertise (see Figure 5). This is particularly significant for the wind energy sector where the key private wind energy corporations are often subsidiaries of larger power firms.

The majority of technological knowledge sharing in wind energy for Brazil and China occurs through the means of licensing, foreign direct investment and joint design activities.[61] Five noticeable wind energy technology collaborations in the private sector have taken place between Brazil and China since 2010, as shown in <Figure 5>. Means of entry adopted by the Chinese firms were strategic partnership, partial acquisition and contract for the wind turbine products.

<Figure 5> Brazil-China Private Sector Wind Energy Investment and Cooperation

Year	Chinese Partner	Brazilian Partner	Deal ($ million)	Status	Means of Entry
2010	XJ Wind Power	Santa Catarina State Government	4,500	Announced	Strategic Partnership (MoU)
2011	CTGC	Furnas (Electrobras)	N/A	Confirmed	Strategic Partnership (MoU)
2011	CTGC	Energias de Portugal (EDP)	3,500	Completed	Partial acquisition (21.35%)
2012	CTGC	Electrobras	N/A	Confirmed	Strategic Partnership (MoU)
2012	Sinovel	Desenvix	Undisclosed	Completed	Contract

Source: International Energy Agency | Energy Investments and Technology Transfer Across Emerging Economies: The Case of Brazil and China

For instance, New Energy and Furnas, subsidiaries of two major power producers, China Three Gorges Corporation (CTGC) and Electrobras, solidified their strategic partnership at the end of 2011.[62] This six-year partnership bolsters technology expertise exchange while jointly targeting commercial opportunities.[63] Whereas the scope of the technology cooperation between the two subsidiaries has not

[61] Lewis,
Building a National Wind Turbine Industry: Experiences from China, India and South Korea, http://files.eric.ed.gov/fulltext/EJ884383.pdf ed., Vol. 5, 2011), 281-305.

[62] Denis Best and Joerg Husar, *Energy Investments and Technology Transfer Across Emerging Economies: The Case of Brazil and China*, 19.
[63] *Ibid.*, 20.

gone public, based on the extensive R&D expenditures of their parent companies it can be deduced that this cooperation will fully utilize the technological capacity available.[64]

Drivers of cooperation

Common goal for wind energy

The world's urgency to shift to low carbon economies leads countries like China and Brazil to pursue cooperation in energy technologies to diversify and advance their industries. In the case of South-South cooperation between Brazil and China, their wind energy industry is ripe to develop a successful partnership. These two emerging countries also share similar grand wind energy expansion goals for the future.[65] In the last few years, both Brazil and China have become leaders in the global wind energy sector. Both countries ranked in 2013 among the top 10 newly installed wind capacity. China's 91 GW of installed wind capacity is the highest in the world and Brazil has also accumulated 3.4 GW, growing at an even faster rate than China.[66] Furthermore, China is the largest energy consumer in the world, with coal comprising almost 70 percent of its energy consumption.[67] According to 2012 numbers, Brazil is the 7th largest energy consumer in the world,[68] however, unlike China, its energy consumption is more diversified. In fact, over 80 percent of Brazil's energy consumption comes from oil, other liquid fuels and hydroelectricity.[69] Yet both countries have been identified as key drivers of growth for the global wind

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[64] "Investing in European Research."http://ec.europa.eu/invest-in-research/index_en.htm (accessed 4/30/2014, 2014).

[65] "China Wind Energy Development Roadmap 2050 - China_wind.Pdf.", https://www.iea.org/publications/freepublications/publication/china_wind.pdf ed., Vol. 2014, m).

[66] "GWEC – Global Wind Statistics 2013 - GWEC-PRstats-2013_EN.Pdf.", http://www.gwec.net/wp-content/uploads/2014/02/GWEC-PRstats-2013_EN.pdf ed., Vol. 2014, s).

[67] "China - Analysis - U.S. Energy Information Administration (EIA)."http://www.eia.gov/countries/cab.cfm?fips=CH (accessed 4/10/2014, 2014).

[68] "World Energy Statistics | World Energy Consumption & Stats."http://yearbook.enerdata.net/ (accessed 4/10/2014, 2014).

[69] "Brazil - Analysis - U.S. Energy Information Administration (EIA)."http://www.eia.gov/countries/cab.cfm?fips=br (accessed 4/10/2014, 2014).

industry, particularly as by 2018 China is expected to reach an installed capacity of 193 GW while Brazil is predicted to reach a capacity of 11 GW.[70] According to a report from the International Energy Association, "[t]he global financial crisis and a reduction in investment in wind energy in the United States and Europe attracted big wind manufacturers to Brazil."[71]

Brazil offers the ideal climate conditions for China to tropicalize its wind turbines. As China continues to improve its wind energy technologies[72] it will need to adapt it to the tropical weather predominant in Africa and Latin America. This will give China and Brazil the opportunity to better meet the demands of other developing countries in need of 'tropicalized technologies'[73] which coupled with the prospective growth of wind installations in both countries, will serve as important drivers for cooperation in research and development (Ilan E. Cuperstein, personal communication, April 7, 2014). Additionally, Brazil's 4,600 miles of coastline offers prime real estate for the research and development of off-shore wind technologies. This is relevant and makes this opportunity mutually beneficial to both countries because they each have most of their energy demand centers located near their coastlines.[74]

Government policies

In the 2000s, Brazil developed and implemented programs, incentives and policies to foster the growth of its renewable energy industry. The first significant one was Proinfa in 2002. It encourages businesses to

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[70] Best and Husar, *Energy Investments and Technology Transfer Across Emerging Economies: The Case of Brazil and China* (Paris: International Energy Agency, 2013b), 19.

[71] *Ibid., 19*

[72] "China Wind Energy Development Roadmap 2050 - China_wind.Pdf.", https://www.iea.org/publications/freepublications/publication/china_wind.pdf ed., Vol. 2014, m).

[73] "Emerging Powers - Brazil."http://www.emergingpowers.org/index.php/emerging-powers-submenu/112-emerging-powers/emerging-powers/51-brazil (accessed 4/28/2014, 2014).

[74] "China Wind Energy Development Roadmap 2050 - China_wind.Pdf.", https://www.iea.org/publications/freepublications/publication/china_wind.pdf ed., Vol. 2014, m).

invest in renewables like biomass, small hydro plants, and wind.[75] Its goal was to contract a total 3,300 MW of new capacity, split evenly between bioelectricity, small hydro, and wind sources. Proinfa established a fixed feed-in tariff for each technology for the electricity produced over the first 20 years of operation. Although it was a successful pioneering program for the industry, it was criticized for the even split among the three renewable energy sources because it did not consider the different technological aspects of each sector. Furthermore, a large percentage of the equipment had to be made in Brazil to be eligible for the best financing options.[76]

Towards the end of 2012, the Brazilian Development Bank (BNDES) issued a new system to eliminate the 60 percent national-content requirement and allow producers to qualify for preferential funding upon meeting three of four new criteria. These are based on the national-content of the different components of the industry.

<Figure 6>

Rules for Accreditation of Wind Turbines
manufacturing of towers in Brazil, with at least 70% of the steel plates manufactured in the country or domestically reinforced concrete
manufacturing of blades in Brazil in their own plant or that of a third party
assembly of the nacelle (main part of the wind turbine) in Brazil, in their own plant
assembly of the hub (the part that houses the nacelle) in Brazil, with a domestic dye-cast

Source: BNDES.gov.br – BNDES Improves Rules for Accreditation of Wind Turbines

According to the International Energy Agency, "local content requirements provide another challenge, yet also an opportunity for Chinese investment in Brazil… [while] China seeks to expand into overseas market

[75] "Programme of Incentives for Alternative Electricity Sources (PROINFA) | World Resources Projects.", http://projects.wri.org/sd-pams-database/brazil/programme-incentives-alternative-electricity-sources-proinfa ed., Vol. 2014, ac).

[76] Sergio Valdir Bajay, "Medium and Long-Term Energy Planning in Brazil: How the Implementation of Energy Efficiency and Renewable Energy Programs are being Carried Out in Brazil" (http://www.iei-la.org/index.php/projects/workshop-germany-brazil-comparing-the-brazilian-and-german-public-policies-experiences-on-renewable-energy-sources-and-energy-efficiency, 2013).

operations, Chinese firms may be more willing than other international competitors to develop manufacturing operations in Brazil."[77]

China has instituted market-based pricing schemes, energy efficiency measures, and competition among energy firms, while also making greater investments in upstream hydrocarbon plays and renewable energy projects. By 2017, the government aims to cap coal use to below 65% of total primary energy consumption; by 2020, they hope to raise non-fossil fuel energy consumption to 15% of the energy mix as a function of their 12th Five-Year Plan.[78] This aforementioned plan, gives sectors like energy, automobile, IT infrastructure and biotechnology a higher level of importance. This is clearly in line with the plan's three main priorities: sustainable growth, industrial upgrading and the promotion of domestic consumption. Furthermore, the Medium-and-Long-Term National Plan for Science and Technology reinforces research and development that strives to better manage energy resources and encourages academia and industries to pursue international cooperation.[79]

Evaluation of cooperation

Institutional

The bilateral agreements signed between the two governments, CBHCC and Joint Action Plan, laid the foundation for technological cooperation in the energy sector. Increased Chinese investment in the Brazilian wind industry and other major areas of cross-border collaboration is a reflection of this improved

[77] Best and Husar, *Energy Investments and Technology Transfer Across Emerging Economies: The Case of Brazil and China* (Paris: International Energy Agency, 2013a), 20.

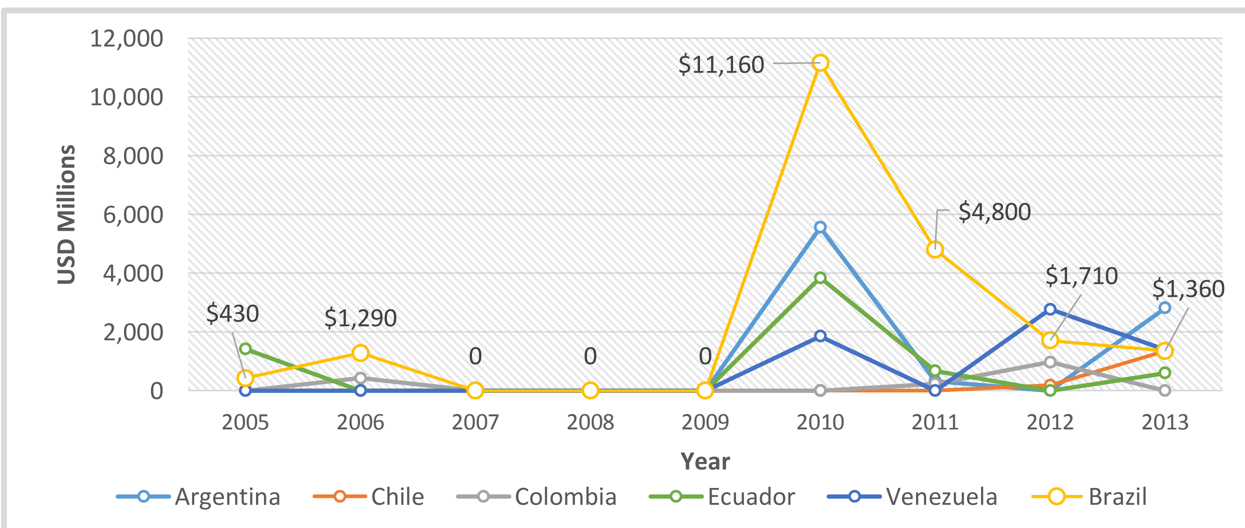
[78] "China - Analysis - U.S. Energy Information Administration (EIA).", http://www.eia.gov/countries/cab.cfm?fips=CH ed., Vol. 2014, i).

[79] "Erawatch Medium- and Long-Term National Plan for Science and Technology Development 2006-2020."http://erawatch.jrc.ec.europa.eu/erawatch/opencms/information/country_pages/cn/policydocument/policydoc_mig_0004 (accessed 4/10/2014, 2014).

intergovernmental dialogue.[80] While each country's governmental policies strive to strengthen international collaboration this is only seen at the inter-governmental level and it is not reflected throughout other domestic policies. For example, BNDES's national-content funding regulation poses a threat to Chinese firms seeking to expand into the Brazilian wind market. Brazil's international collaboration and domestic industrial policies are not aligned and are contradictory to each other's objectives, hindering further collaboration with China. <Figure 7>, depicts an increase in investments between 2009 and 2010 from China into Latin America, with Brazil in the lead.

This occurred after the Joint Action Plan was finalized. Current numbers on the graph show a significant decrease of investments in Brazil after 2010 with an increase towards neighboring South American countries, such as Argentina, Chile and Venezuela. These countries have similar natural resources but lax regulations which may be more attractive for Chinese investors.[81]

<Figure 7> China's Energy Investment in Latin America



[80] Denis Best and Joerg Husar, *Energy Investments and Technology Transfer Across Emerging Economies: The Case of Brazil and China* (Paris: International Energy Agency,[2013c]).

[81] "China Global Investment Tracker Map."http://www.heritage.org/research/projects/china-global-investment-tracker-interactive-map (accessed 4/10/2014, 2014).

In the meantime, in 2009, when China joined the World Trade Organization, they were pressured into removing their national content requirement which had been 70 percent since 2004.[82] Although this was designed to increase foreign direct investments, Chinese state-owned enterprises still control more than 85 percent of the domestic wind energy market share.[83]

Public

A long-standing bilateral relationship between the two countries contributed to the creation of the Center and established a platform for the development of technology cooperation. In particular, the government's initial brokering of collaboration between recognized educational institutions marked an important step toward fostering the renewable energy industry in both countries. The Center's budget receives funding per project from the government and a very limited amount through private partnerships. On average, it reaches a total of USD 4 million per year. This segregated funding structure makes it hard to sustain the Center's programs and staff (Ilan E. Cuperstein, personal communication, April 7, 2014).

In 2011, the Center signed a memorandum of understanding (MOU) to establish a wind energy specified research facility. Under the terms of this memorandum, China would provide the necessary equipment, while Brazil would supply the land and human capital to conduct research on improving Chinese products. Unfortunately, the joint venture did not materialize as China was unwilling to meet the national-content requirements unless Brazil guaranteed sales for the equipment produced. Although Brazil has since modified its national-content requirements to promote greater flexibility, China does not feel confident in the capabilities of this endeavor and will not commit to investing in a plant. Furthermore, although

[82] Campos Silva, Klagge and Liu, *Constructing China's Wind Energy Innovation System*, Vol. 55, 2012), 370-382.

[83] Pedro Campos Silva, Britta Klagge and Zhigao Liu, "Constructing China's Wind Energy Innovation System," *Energy Policy* 55 (2012), 370-382.

Brazil has improved its incentives infrastructure to attract and promote collaboration in renewable energies, its domestic bureaucracy continues to stymie efficiency. For instance, operations at the Center have suffered because grant award disbursement can take years to be issued (Ilan E. Cuperstein, personal communication, April 7, 2014). This poses a serious threat to an industry in which fast-paced technological innovation is critical. Moreover, the absence of cross-patent application of wind technology between China and Brazil suggests that further policy reforms must take place to encourage greater cooperation.[84] Lastly, the Center lacks private sector involvement, which may severely constrain execution of R&D projects.

Private

Initially, wind technology was transferred to China without active local R&D support. Although a handful of the wind turbine corporations stemmed off from a related field, such as the motor engines industry, China was devoid of necessary technical and tacit knowledge to develop wind turbines. Thus, licensing, foreign direct investment (FDI) and joint ventures were the primary means of acquiring advanced technology from early innovators, namely Denmark, the Netherlands, Germany and the United States.[85] With the rapid development of China's wind industry in the last decade, however, outward FDI targeted acquisition of foreign companies with desired technological capacity. For example, CTGC's partial acquisition of a Portuguese renewable energy subsidiary firm equipped China with the wind technology expertise that CTGC lacked.[86]

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[84] Cross-patent application data collected from WIPO patent database; Duan Liping, "Analysis of the Relationship between International Cooperation and Scientific Publications in Energy R&D in China," *Applied Energy* 88 (2011), 4229-4238.

[85] Campos Silva, Klagge and Liu, *Constructing China's Wind Energy Innovation System*, Vol. 55, 2012), 370-382.

[86] Denis Best and Joerg Husar, *Energy Investments and Technology Transfer Across Emerging Economies: The Case of Brazil and China* (Paris: International Energy Agency,[2013d]).

However, evidence of similar technology acquisition or joint R&D efforts between China and Brazil's wind energy corporations is lacking in multiple dimensions. First, the number of potential collaborative efforts only account up to five incidents between 2010 and 2013. Furthermore, the scheduled strategic partnership between XJ Wind Power and Santa Catarina State Government is yet to materialize. Second, encounters of Sino-Brazil wind industry produced no joint ventures or similar active technology development. Strategic partnership, acquisition nor contracting guarantees knowledge flow between the participating firms (see Figure 5). Third, private sector's cooperation were often not disclosed or limited to the public. Difficulty in measuring the accurate cooperation size is critical to fully capturing the scope of private sector engagement between Brazil and China's wind industries.[87]

Hindered Sino-Brazil wind technology cooperation in also evident in cross-border patenting behavior between the two partners. <Figure 8> illustrates China's international patenting activity with major actors in the wind industry. No wind technology patents are filed to the World International Patenting Organization that would indicate technology collaboration between Brazil and China among three categories: 1) Brazil owned Chinese invention, 2) Chinese owned Brazilian invention, and 3) Brazil-China co-invention.[88] Similarly, no collaboration was observed between China and other BRICS countries other than India. Lack of patenting activities indicate that collaborations were limited in depth and scope to produce a significant outcome.

In sum, institutionalized technology cooperation at the international level failed to trickle down to the private level to galvanize further exchange of wind energy technology. Regardless, substantial potential exists for private collaboration in R&D. Wind turbine manufacturers heavily invest in R&D and smaller

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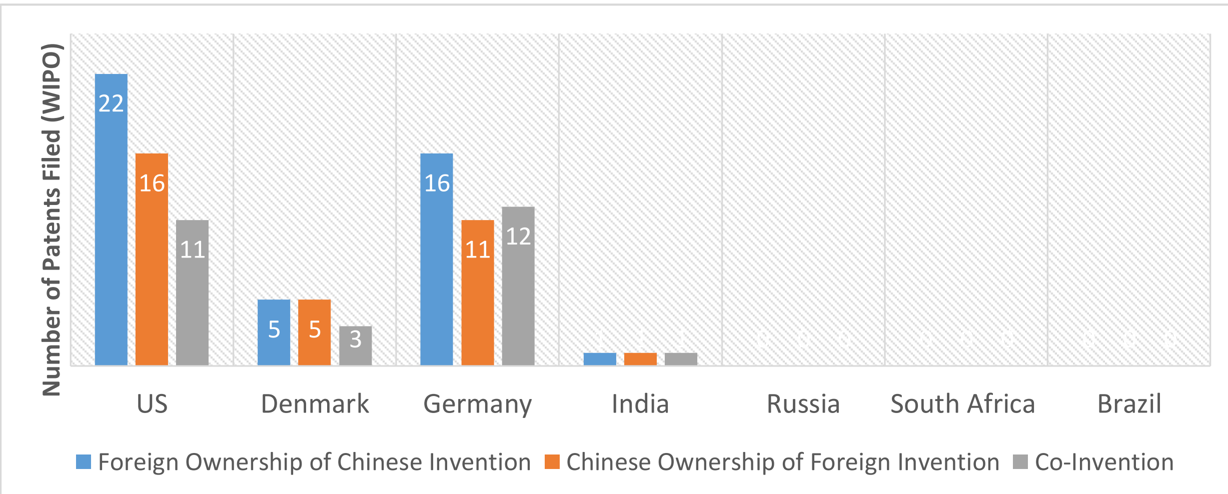
[87] . *Climate Policy and Technological Innovation and Transfer: An Overview of Trends and Recent Empirical Results* (Paris: Organisation for Economic Co-operation and Development,[2010]).

[88] WIPO patenting data accessed through Patentscope on April 10, 2014. Refer to <Appendix A> for details.

energy subsidiary firms also have large parent companies with substantive R&D capabilities. Goldwind, for instance, invested 133,706 RMB for its R&D (ranked 1765th in the world) and Eletrobras, the parent company of Furnas, is the second largest corporate investor in R&D in Brazil with over 90 labs and private technology research centers.[89]

<Figure 8> China Wind Energy Technology International Patenting Activity



Source: WIPO (International Patent Applications filed under the PCT) - Accessed through Patentscope, April 10, 2014

Lessons Learned

South-South Cooperation

There is a general positive outlook for the successful development of increased South-South cooperation between China and Brazil. Nevertheless, a lack of a monitoring framework to accurately measure the extent of this relationship still needs to be developed; and until a reporting mechanism is established, understanding of this type of relationship is limited to advocacy efforts and anecdotal knowledge.

[89] "IRI - the 2013 EU Industrial R&D Investment Scoreboard."http://iri.jrc.ec.europa.eu/scoreboard13.html (accessed 4/30/2014, 2014).

In the case of China and Brazil, both countries are seen as regional leaders with the capabilities to leverage relationships in the political, economic, social, cultural, environmental and technical areas. While technology cooperation between China and Brazil has been fruitful in other renewable energy sectors, due to the limited amount of data available, the wind industry has not seen the same results.

Improvement of Government Policies

While there is a clearly mutually beneficial relationship to be had between Brazil and China, our research shows that government regulations and entities attempting to increase FDI, may cause a counterproductive effect on China's interest in Brazil's wind industry. Consequently, there has been a decline in investment from China into Brazil and an increase into other neighboring Latin American countries with more lax policies. While both countries define clear expectations at a macro level for the furtherance of research and development of renewable energies, other local content requirements and cultural bureaucracies are discouraging the expansion of this relationship in the wind energy sector.

Moreover, China's paradoxical North-South mentality breeds reluctance to co-develop technology with Brazil. Patent evidence proves little advancement in this area and the example of the failed wind energy research facility through the Brazil-China Center for Climate Change and Energy Technology Innovation demonstrates interest but a lack of willingness to compromise. For a relationship between these two countries to be fruitful, they need to see these types of ventures as mutually beneficial. Government policies at all levels need to be improved so as to encourage more collaboration.

Involvement of Private Sector

Private sector technology cooperation lies at the crux of future South-South technology cooperation. While public research and development collaborations on wind energy may stimulate the initial process of Sino-Brazilian scientific networks, the absence of the private sector will ultimately thwart the cooperation. As illustrated in detail above, the Brazil-China private wind industry collaboration on R&D

efforts are stymied by protectionist policies whether it be explicit in the regulations or *de facto*. Thus, there is a need for governmental support to actively link public cooperation institutions and private sector partners to engage in fruitful discussion on maximizing returns to cooperation. For instance, strengthening private wind industry associations' linkages, Abeeolica and China Wind Energy Association, may also stimulate further cooperation in private sector.

Fully supporting the private wind industry's role in developing the potentials and renovating loopholes of wind energy technology is fundamental to supporting the Brazil-China cooperation. Near and far offshore wind industry are common potentials of both Brazil and China which promises high returns on capacity. While China arose as initial non-European leader for this particular advanced technology, it is crucial that Chinese wind energy corporations are incentivized to fully collaborate with the Brazilian counterpart to explore this newly emerging market. Grid transmission systems pose great threat to the viability of wind energy in both Brazil and China. A comprehensive network of wind turbine manufacturers, wind energy operators and power transmission managers from Brazil and China is desirable to promote cooperation overall.

<Appendix A>

Cross-border Patenting Activity

Source:

- WIPO (International Patent Applications filed under the PCT) accessed through Patentscope
- Last Updated on April 10th, 2014

Wind Energy Technology:

- Wind energy technology refers to a combination of following International Patent Classifications:
  - B63B 35/00: Vessels or like floating structures adapted for special purposes
  - B63H 11/00: Effecting propulsion by wind motors driving water-engaging propulsive elements
  - E04H 12/00: Towers; Masts, poles; Chimney-stacks; Water-towers; Methods of erecting such structures
  - H02K 7/18: Structural association of electric generator with mechanical driving motor, e.g. turbine

Types of International Patenting Activities:

- Foreign Ownership of Chinese Invention
  - Patent filed by Residents in Respective Country Invented by Resident(s) from China
- Chinese Ownership of Foreign Invention
  - Patent filed by Residents in China Invented by Resident(s) from Respective Country
- Co-Invention
  - Patent Invented by Resident(s) of China and Resident(s) of Respective Country

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"Ministry of Foreign Affairs of the People's Republic of China.", accessed 4/30/2014, 2014, http://www.fmprc.gov.cn/mfa_eng/.

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