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Artículo Original

Development of Large Photovoltaic Solar Energy Projects in South America

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ABSTRACT

Solar energy is one of the best sources of renewable energy because of its inexhaustible nature and easy implementation. In recent years European countries, such as Spain and Germany, have made great advances in the development of technologies for the production of both photovoltaic and thermal solar energy, becoming examples of environmental and economic benefits for South-American countries in the implementation of these kinds of technologies for distributed generation.

Keywords: Thermal, solar energy, photovoltaic solar energy, photovoltaic cells, distributed generation.

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Desarrollo de grandes proyectos de energía solar fotovoltaica en Suramérica

RESUMEN

La energía solar es una de las mejores fuentes de energía renovable debido a su carácter inagotable y fácil implementación. En los últimos años países europeos, como España y Alemania, han realizado grandes avances en el desarrollo de tecnologías de producción de energía solar térmica y fotovoltaica, que constituyen un ejemplo internacional sobre los beneficios económicos y socio-ambientales que pueden emular los países suramericanos con la implementación de estas tecnologías de generación distribuida.

Palabras clave: Energía solar térmica, energía solar fotovoltaica, fotoceldas, generación distribuida.

Desenvolvimento de grandes projetos de energia solar fotovoltaica na América do Sul

RESUMO

A energia solar é uma das melhores fontes de energia renovável por causa de sua inesgotável natureza e facilidade de implantação. Nos últimos anos países europeus, como a Espanha e a Alemanha, têm feito grandes avanços no desenvolvimento de tecnologias para a produção de energia fotovoltaica e energia solar térmica, que constituem um exemplo internacional dos benefícios económicos e socioambientais que podem emular os países sul-americanos com a aplicação dessas tecnologias de geração distribuída.

Palavras chaves: Energia solar térmica, energia solar fotovoltaica, fotocélulas, geração distribuída.

INTRODUCTION

Energy generation from fossil fuels increases pollution and contributes to the reduction of the planet's non-renewable natural resources. These facts constitute an incentive to develop alternative energy sources, at a global scale, as a priority, since it does not create pollution and contributes to the preservation of the environment.

In addition, providing electricity services to remote communities that currently have no access to them is a vital importance issue for South American countries. Unfortunately, in most of them, delivering electric power is not profitable in the traditional form. This is due to long distances and to relatively small demands that do not imply financial return to high investment costs. The solar energy as a source of renewable energy, which is characterized by its inexhaustible nature and easy deployment, is then one of the best options to solve this problem.

Nowadays, the great progress achieved in the world of distributed generation technologies, especially those related to photovoltaic and thermal solar energy and remarkably in European countries such as Spain and Germany, provides benefits on economic, environmental and social aspects that could be also achieved by South-American countries, as they give more importance to this kind of distributed generation.

The main objective of this technical contribution is related to the reviewing of the current level of development of solar energy in South America, including the developed technologies and the main barriers for their development.

METHODOLOGY

Systematic Literature Review (SLR)

A Systematic Literature Review (SLR) constitutes a mean to the identification, evaluation and interpretation of all available research works that are relevant to particular questions, a topic or a phenomenon of interest. Individual studies contributing to a systematic review are called primary studies: a systematic review is, therefore, a form a secondary study [1].

Questionnaire

The research question considered in SRL process was:

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How are South-American countries applying the expansion model in PV?

Answering this question required a deep search for publications (articles, books, book chapters, working papers, articles of conferences) in peer-reviewed data bases as Scopus, IEEE Xplore and Ebsco, including publications from 2008 to present day. Searching words were: solar, energy, photovoltaic, cells, power development, renewable, technologies, South America. A search command included:

(1) (TITLE-ABS-KEY (solar, power, development, renewable, technologies, photovoltaic, cells radiation) AND PUBYEAR > 2007) AND (country)

60 publications were collected in the search, and distributed as follows: 41 articles, 5 technical reports, 9 conference proceedings and 5 web publications.

General data on countries included in the study

Table 1 presents the most representative information of every South American country analyzed in this technical contribution:

Table 1. General Data of South American Countries. **Source:** Author´s elaboration

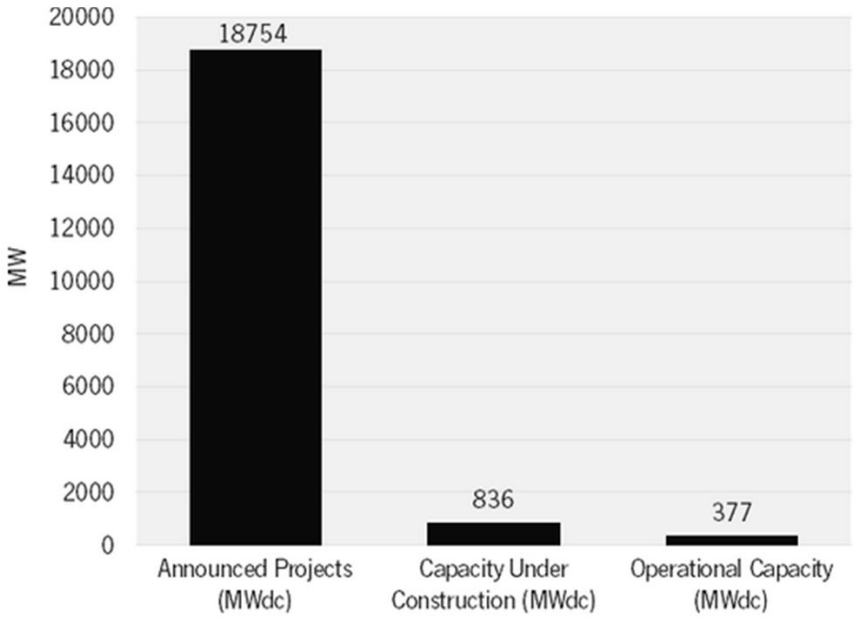
Country	Extension (km²)	Population	GDP (Official Exchange Rate USD)	Source
Brazil	8,515,770	202,656,788	$2.244 trillion	[2]
Venezuela	912,050	28,868,486	$209.2 billion	[3]
Argentina	2,780,400	43,024,374	$536.2 billion	[4]
Chile	756,102	17,363,894	$264.1 billion	[5]
Colombia	1,138,910	46,245,297	$400.1 billion	[6]
Paraguay	406,752	6,703,860	$31.3 billion	[7]
Peru	1,285,216	30,147,935	$208.2 billion	[8]
Ecuador	283,561	15,654,411	$100.5 billion	[9]
Uruguay	176,215	3,332,972	$55.6 billion	[10]
Bolivia	1,098,581	10,631,48	$34.08 billion	[11]
Surinam	163,820	573,311	$5.273 billion	[12]
Guyana	214,969	735,554	$3.142 billion	[13]

Solar Energy

The solar energy received at the earth's surface has been calculated as equivalent to 178 000 TW-year. In 1990, it was estimated that this amount was 15 000 times greater than the overall consumption. However, about 30% of this energy is reflected in the space, 50% is absorbed, converted into heat and forwarded to the earth's surface; from this 50 %, 49 000 TW-year are forwarded as heat energy in the form of electromagnetic radiation and 40 000 TW-year as caloric energy [14].

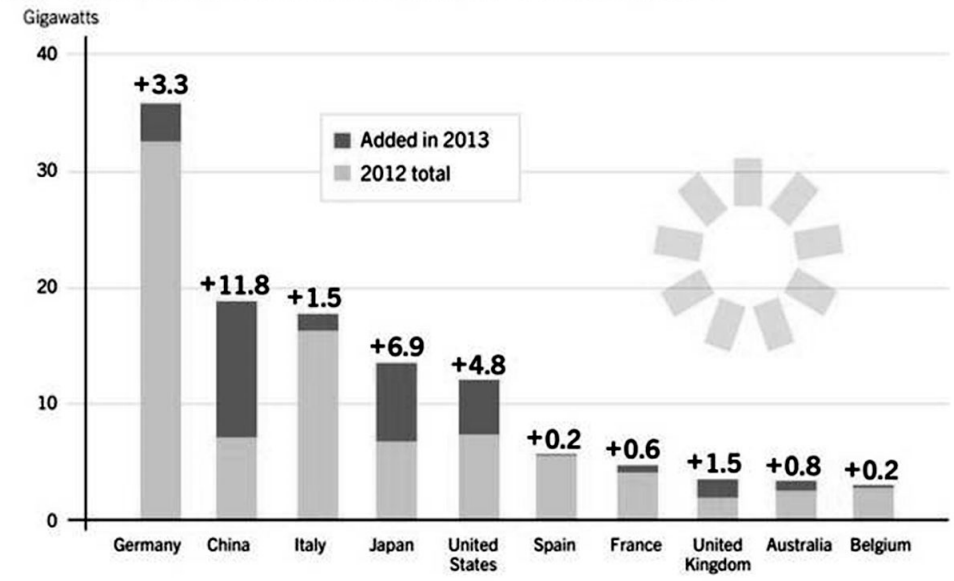
South American countries face interrelated energy challenges, since renewable energy is becoming a priority for this region due to challenges such as demand growth, high dependence on imported fossil fuels and

Figure 1. Latin America PV projects up to July 2014. **Source:** [16]



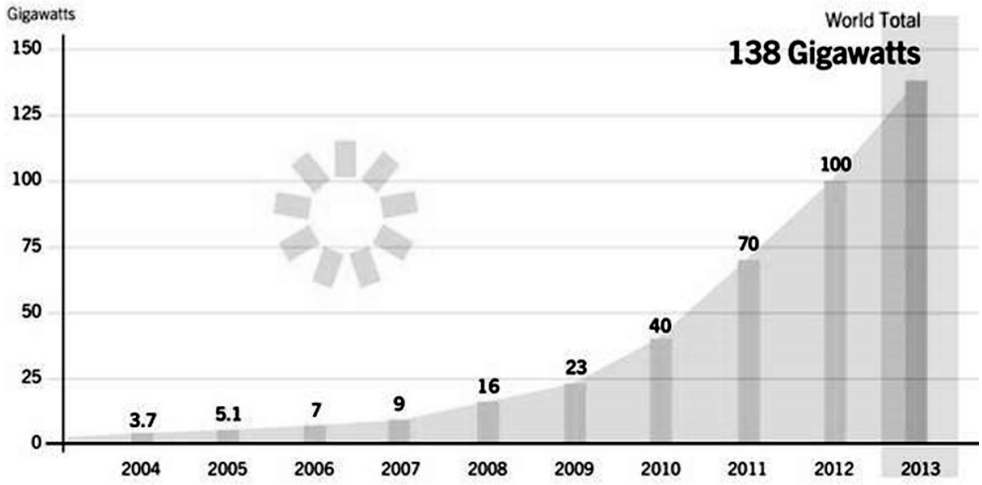
climate change [15]. First, the region will require a significant amount of new electricity generation in order to meet demand growth and replace aging infrastructure. Figure 1 presents the evolution of construction for electric generation, with the Latin American PV projects developed up to July, 2014 [15].

Figure 2. Solar PV Capacity and Additions. **Source:** [16]



The announced PV projects have a total capacity of 18.754 MW, whereas the capacity under construction is 836 MW and the operational capacity reaches up to 377 MW. Figure 2 presents the Solar PV Capacity and projected additions for the most representative countries in South America.

Figure 3. Solar PV total global capacity, 2004-2013. Source: [16]



As a reference for the reader, Germany, China and Italy are the leading countries, with the greatest Solar PV Capacity in the world. In 2013, the Solar PV total global capacity reached 138 GW. Figure 3 presents the Solar PV total global capacity, 2004-2013 [16]

DISCUSSION

This section presents some relevant results of the SRL for the previously mentioned countries.

COLOMBIA

In this country, reduced dependence on fossil fuels and the diversification of the market in order to minimize the risk of lack of supply, coupled with concerns on reducing the negative impacts of energy consumption, have made renewable energies attractive alternatives [6]. Additionally, the possibilities for energy production close to consumption centers and inadequate energy supply in remote and rural areas, make distributed generation an interesting and promising technological option [17]. Colombia has important potential for introducing solar photovoltaic sources into its electricity generation mix, given its high average annual insolation. However, there is a lack of incentives and support schemes for alternative renewable energy technologies [18].

The most popular applications of solar energy are heating water for domestic, industrial and recreational purposes and small-scale generation of electricity. Other less widely used applications are solar drying of agricultural products and the distillation of sea water, or other non-drinking waters. However, Colombia's achievements in the implementation of solar energy are modest and the current development does not correspond to the number of potential sources, which would enable the country to conduct energy technologies away from the traditional ones [19].

Tabla 2. (PV) Colombian projects.
Source: [20].

Project´s name	"Industrial V.C"
Location	Barranquilla
Capacity (MW)	770 KW
Creation date	2015
Developed by	Green Energy

BRAZIL

Brazil, with nearly 100 GW, almost reaches the double of the total installed capacity in comparison to Argentina, Chile and Colombia together (51GW) [21]. The successful development of renewable energy technologies like solar photovoltaic energy (SPV) critically relies on its understanding and acceptance by consumers and institutional customers [22]. The solar energy is one of the most mature technologies to produce electricity from renewable energy [23].

This country has, during recent decades, maintained its comparative advantage over the rest of the world in terms of the use of renewable sources of energy [2]. This country represented more than 90% of the investment made in South America in 2008, -US$ 10.8 billion- compared to the US$ 155 billion invested worldwide [24].

Tabla 3. (PV) Brazilian projects
Source: [25].

Developed by	"Sun Edison – Renova Energía"
Creation date	2017
Location	Florianópolis
Generation MW	1 MW

CHILE

Chile is a country that depends on fossil fuels to satisfy its energy consumption. As the country is not a fossil fuel producer, it must satisfy its consumption with imports. This situation makes the country vulnerable to supply disruptions and price volatility [26]. The government has ordered the adoption of renewable energy quotas for electricity production, which has sparked interest in wind, hydro, geothermal and biomass power plants [5]. However, solar energy is not being part of the discussion and lags behind other renewable energy sources, partly due to the lack of data [26]. The proper analysis and evaluation of solar energy systems make necessary the existence of a high quality database for each country [26].

Renewable energy promotion efforts in Chile aim to achieve a power production quota of 20% to be met by 2025. This plan has sparked interest in solar energy among other renewable sources, with PV, CSP, and industrial heat supply plants being announced [27].

Tabla 4. (PV) Chilean projects
Source: [28].

Project´s name	"Amanecer Solar CAP"
Location	Copiapó (Atacama)
Capacity (MW)	100 MW
Creation date	2014
Developed by	Sun Edison

ECUADOR

Ecuador is a country with very varied topographic features, great climatic diversity and unique conditions that mean a high potential for renewable and clean energy, which cannot be left out of the inventory of energy resources for electricity production [9]. The conditions for coverage and satisfaction of the demand demonstrate, at the present moment, a close link with the rural electrification and energizing [14].

Tabla 5. (PV) Ecuadorian projects I
Source: [29].

Project´s name	"Cóndor Solar"
Creation date	2014
Developed by	Cóndor Solar S.A
Generation MW	30 MW

Tabla 6. (PV) Ecuadorian projects II
Source: [30].

Project´s name	"Solar Connection"
Creation date	2014
Developed by	Radical Energy Inc.
Generation MW	20 MW

PARAGUAY

The conditions for the implementation of renewable energy technologies in Paraguay are very good, considering its abundant renewable natural resources [7]. This can be seen in the energy matrix, which is principally characterized by the generation of electricity through hydroelectric power plants [31].

Despite the fact that there is a great potential for energy generation from renewable energy sources in the country, like photovoltaic (PV) solar energy, nonconventional energy sources can only play a marginal role, given the wide coverage of electricity from hydroelectric sources of energy [31]. In this manner, the feasibility of installation of these energy sources is restricted only to certain specific areas or sectors of the country in rural areas, where there is no electricity coverage or other peculiar cases [31].

Tabla 7. (PV) Paraguayan projects
Source: [32].

Project´s name	"Proyecto El Chaco"
Location	"El Chaco"
Creation date	2014
Developed by	Parque Tecnológico Itaipú (PTI)
Generation MW	40 KW

PERU

In Peru, thanks to the high solar radiation, photovoltaic solar energy is being used in telecommunications and agriculture (water pumping, mines and other industries) [8]. This country developed, as part of its rural electrification program, the "Atlas Solar", which checks the excellent conditions to take advantage of solar energy [33]

Tabla 8. (PV) Peruvian projects I
Source: [34].

Project´s name	"Tacna Solar"
Location	Tacna
Creation date	2013
Developed by	Gestamp Solar
Generation MW	20 MW

Tabla 9. (PV) Peruvian projects II
Source: [35].

Project´s name	"Panamericana Solar"
Location	Moquegua
Creation date	2013
Developed by	Gestamp Solar
Generation MW	20 MW

VENEZUELA

In Venezuela the recognition of the relevance of energy, especially of the renewable energies generated by the sun, is growing significantly, based on the possibility it has to improve the society´s quality of life, support the reduction of poverty and improve sustainable development [36]. Currently, there is limited official information available related to the status of solar photovoltaic projects. Although available data are not enough to conclude what really happens with the development of renewable energy projects in Venezuela, [3] the current set of completion and the non-compliance with the scheduled start-up show that there are important problems affecting this sector [36].

Tabla 10. (PV) Venezuelan projects
Source: [37].

Project´s name	"Planta de Gran Roque"
Creation date	2014
Location	"Gran Roque"
Generation MW	1,125 MW

BOLIVIA

Bolivia, for long one of the poorest South America countries, still misses a real industry and depends, on many sectors, on foreign imports [11] and [38] . The most important contribution to technological innovation seems to be the adaptation of existing technology to local necessities. In particular, photovoltaic and solar technologies were adapted to local spare parts and atmospheric conditions. However, the absorption capacity of local personnel has been much more important than technological adaptation. [38]. The Bolivian energy matrix has a great dependence on hydrocarbons, which are 93% of the total production of energy [39]. In 2011, the Government of Bolivia invested approximately USD $9 million to promote the development of alternative energy sources in the electricity sector [39].

In 2015 Bolivia inaugurated its first solar plant, thanks to a contribution from the Government of Denmark, with USD $6 million. The plant, in ITS first phase, will generate 1.7 MW; in the second, 3.3 MW and in the third, up to 5 MW, which will cover more than half of the electricity demand in the city of Cobija, the capital of Pando, with a population of 100.000 inhabitants [40].

Tabla 11. (PV) Bolivian projects
Source: [41].

Project´s name	"Planta Solar Fotovoltaica Cobija"
Location	Cobija
Creation date	2014
Developed by	ENDE
Generation MW	1,7 MW

ARGENTINA

Argentina is a federal republic located in Southeastern South America. Sharing the Southern Cone with its smaller neighbor, Chile, it is bordered by Bolivia and Paraguay to the north; Brazil to the northeast; Uruguay and the South Atlantic Ocean to the east; Chile to the west and the Drake Passage to the south [4]. This country has supported renewable electricity since 1998, through its National Wind and Solar Energy Rules. The law included a premium payment for renewable generators, set 40% above the whole sale market price [15].

Tabla 12. (PV) Argentinean projects
Source: [CAB, 2015].

Project´s name	"San Juan I"
Location	Provincia de San Juan
Creation date	2011
Developed by	EPSE
Generation MW	1,2 MW

URUGUAY

In Uruguay there have been some initiatives for the development of solar energy, specifically those engaged in the production of flat solar collectors for obtaining sanitary hot water, heating of fluids for industrial purposes and the thermal conditioning of space [10]. The most representative PV projects are:

Tabla 13. (PV) Uruguayan projects I
Source: [42].

Project´s name	"ASAHI"
Location	Salto Grande
Creation date	2013
Developed by	Tecnova Renovables
Generation MW	0,5 MW

Tabla 14. (PV) Uruguayan projects II
Source: [43].

Project´s name	"MENAFRA SOLAR"
Location	Río Negro
Creation date	2014
Developed by	Sky Solar Holdings Ltd.
Generation MW	20 MW

Tabla 15. (PV) Uruguayan projects III
Source: [43].

Project´s name	"ARAPEY SOLAR"
Location	Salto Department
Creation date	2014
Developed by	Sky Solar Holdings Ltd.
Generation MW	10 MW

SURINAM

Suriname is located along the northern coast of South America and is home to a population of 492,000 [12] and [44]. Is the third largest oil producer in the Caribbean after Trinidad and Tobago and Cuba [44]. Total generation capacity stood at 389 MW in 2009 and the country produced 1,618 GWh of electricity, from which 857.4 GWh (53 percent) were produced by the country's hydropower plant

[44]. Recently, the most representative PV project is the "ET Solar Energy", which has supplied 5MW of polycrystalline photovoltaic modules to a mining operation [45]. The solar project in the South American country will significantly help the mining facility meet electricity demands [45].

ET Solar claims that due to the short construction time and the low capital expenditure required for solar power plants, solar power plant installations are attractive energy options for mining facilities [45].

Tabla 16. (PV) Surinamese projects
Source: [45].

Project´s name	ET Solar Energy
Location	Paramaribo
Creation date	2014
Developed by	CEO
Generation MW	5 MW

GUYANA

Guyana's main supplier of electricity generation is highly dependent on petroleum [13]. Approximately 98% of GPL electricity generated is from petroleum, with 2% generated from biomass [46]. In Guyana, several standalone photovoltaic systems were installed between 1983 and 1991, in order to provide lighting and vaccine refrigeration at health clinics in rural areas, and Imported oil is sourced mainly from Venezuela and Trinidad and Tobago [47].

Recently, the most representative PV project is Guyana Energy Agency (GEA), a photovoltaic (PV) system 8.46 kWp PV system consisting of Schneider Electric Conext grid-tie solar inverters rated at 3800 web box and 1 x TV-style display board [48]. The PV system was installed on an office building in Georgetown, with the information displayed on the road, which makes the system very visible to visitors [48].

Tabla 17. (PV) Guyanese projects
Source: [48].

Project´s name	Guyana Energy Agency (GEA) photovoltaic (PV) System
Location	Georgetown
Creation date	2012
Developed by	Guyana Energy Agency (GEA)
Generation MW	0.0846 MW

Table 1 presents the installed capacity (PV) and the investment (US$/kW) for each South American country:

Tabla 18. (PV) Installed Capacity
Source: CIA (2015).

COUNTRY	INSTALLED CAPACITY (GW)	% RENEWABLE CAPACITY
Brazil	113,7	7,70%
Mexico	62	3,30%
Venezuela	27,5	0%
Argentina	32,87	0,20%
Chile	16,21	4,30%
Colombia	13,54	0,40%
Paraguay	8.816	0%
Peru	8.613	0%
Ecuador	5.243	2%
Uruguay	2.588	0,80%
Bolivia	1.365	1,50%
Surinam	1.618	0,12%
Guyana	1.643	0,20%

CONCLUSIONS

Solar power has been seeing dramatic growth in many countries across the world. In South America, however, the growth rates have been astounding. The development of solar energy in South America is relatively low compared with European countries such as Germany and Spain. Economic, political and social factors have prevented the implementation and development of solar technologies in most South American countries.

In remote places, where there is no electricity, solar energy can bring energy in the form of light and water. Therefore, the sun is the best and most economical source of energy for communities that live thousands of kilometers away from the urban centers.

The reduction of CO2 emissions, global warming and acid rain are the main advantages of deploying solar energy. Therefore governments and South American environmental authorities must promote the development and implementation of projects and technologies based on solar thermal and photovoltaic energies.

REFERENCES

[1] B. Kitchenham, "Procedures for Performing Systematic Reviews," Software Engineering Group. Department of Computer Science, Staffordshire, 2004.

[2] CIA, "FactBook Brazil," 2015. [Online]. Available: https://www.cia.gov/library/publications/the-world-factbook/geos/br.html. [Accessed: 08-Jul-2015].

[3] CIA, "FactBook Venezuela," 2015. [Online]. Available: https://www.cia.gov/library/publications/the-world-factbook/geos/ve.html. [Accessed: 08-Jul-2015].

[4] CIA, "FactBook Argentina," 2015. [Online]. Available: https://www.cia.gov/library/publications/the-world-factbook/geos/ar.html. [Accessed: 08-Jul-2015].

[5] CIA, "FactBook Chile," 2015. [Online]. Available: https://www.cia.gov/library/publications/the-world-factbook/geos/ci.html. [Accessed: 08-Jul-2015].

[6] CIA, "FactBook Colombia," 2015. [Online]. Available: https://www.cia.gov/library/publications/the-world-factbook/geos/co.html. [Accessed: 08-Jul-2015].

[7] CIA, "FactBook Paraguay," 2015. [Online]. Available: https://www.cia.gov/library/publications/the-world-factbook/geos/pa.html. [Accessed: 08-Jul-2015].

[8] CIA, "FactBook Peru," 2015. [Online]. Available: https://www.cia.gov/library/publications/the-world-factbook/geos/pe.html. [Accessed: 08-Jul-2015].

[9] CIA, "FactBook Ecuador," 2015. [Online]. Available: https://www.cia.gov/library/publications/the-world-factbook/geos/ec.html. [Accessed: 08-Jul-2015].

[10] CIA, "FactBook Uruguay," 2015. [Online]. Available: https://www.cia.gov/library/publications/the-world-factbook/geos/uy.html. [Accessed: 08-Jul-2015].

[11] CIA, "FactBook Bolivia," 2015. [Online]. Available: https://www.cia.gov/library/

publications/the-world-factbook/geos/bl.html. [Accessed: 08-Jul-2015].

[12] CIA, "FactBook Surinam," 2015. [Online]. Available: https://www.cia.gov/library/publications/the-world-factbook/geos/ns.html. [Accessed: 08-Jul-2015].

[13] CIA, "FactBook Guyana," 2015. [Online]. Available: https://www.cia.gov/library/publications/the-world-factbook/geos/gy.html. [Accessed: 08-Jul-2015].

[14] F. Tacurí, "Atlas Solar del Ecuador." Corporación para la Investigación Energética, Quito, pp. 26–40, 2008.

[15] D. Jacobs, N. Marzolf, J. R. Paredes, W. Rickerson, H. Flynn, C. Becker-Birck, and M. Solano-Peralta, "Analysis of renewable energy incentives in the Latin America and Caribbean region: The feed-in tariff case," *Energy Policy*, vol. 60, pp. 601–610, Sep. 2013.

[16] M. G. Richard, "Latin America grew solar power by 370% in 2014, expected to triple again in 2015," 2015. [Online]. Available: http://www.treehugger.com/renewable-energy/latin-america-grew-solar-power-370-2014-expected-triple-again-2015.html. [Accessed: 07-Jul-2015].

[17] J. a. Hernandez, D. Velasco, and C. L. Trujillo, "Analysis of the effect of the implementation of photovoltaic systems like option of distributed generation in Colombia," *Renew. Sustain. Energy Rev.*, vol. 15, no. 5, pp. 2290–2298, Jun. 2011.

[18] A. a. Radomes and S. Arango, "Renewable energy technology diffusion: an analysis of photovoltaic-system support schemes in Medellín, Colombia," *J. Clean. Prod.*, vol. 2009, Jan. 2015.

[19] H. R. Murcia, "Desarrollo de la energía solar en Colombia y sus perspectivas Development of Solar Energy in Colombia and its Prospects," 2009.

[20] Greenenergy, "Energía Solar-Fotovoltaica La Energía de la Naturaleza," 2015. [Online]. Available: http://www.greenenergy-latinamerica.com/es/energia-solar-solar-fotovoltaica-197. [Accessed: 08-Jul-2015].

[21] J. M. Kissel, R. Hanitsch, and S. C. W. Krauter, "Cornerstones of a renewable energy law for emerging markets in South America," *Energy Policy*, vol. 37, no. 9, pp. 3621–3626, Sep. 2009.

[22] F. Echegaray, "Understanding stakeholders' views and support for solar energy in Brazil," *J. Clean. Prod.*, vol. 63, no. December 2011, pp. 125–133, Jan. 2014.

[23] L. Guzman, a. Henao, and R. Vasquez, "Simulation and Optimization of a Parabolic Trough Solar Power Plant in the City of Barranquilla by Using System Advisor Model (SAM)," *Energy Procedia*, vol. 57, pp. 497–506, 2014.

[24] M. G. Pereira, C. F. Camacho, M. A. V. Freitas, and N. F. Da Silva, "The renewable energy market in Brazil: Current status and potential," *Renew. Sustain. Energy Rev.*, vol. 16, no. 6, pp. 3786–3802, Aug. 2012.

[25] E. Meza, "SunEdison, Renova Energia to develop 1 GW of utility-scale solar in Brazil," 2014. [Online]. Available: http://www.pv-magazine.com/news/details/beitrag/

sunedison--renova-energia-to-develop-1-gw-of-utility-scale-solar-in-brazil_100017272/#axzz3fKSmgFYx. [Accessed: 08-Jul-2015].

[26] A. Ortega, R. Escobar, S. Colle, and S. L. de Abreu, "The state of solar energy resource assessment in Chile," *Renew. Energy,* vol. 35, no. 11, pp. 2514–2524, Nov. 2010.

[27] A. Pino, E. Bueno, R. A. Escobar, and F. Ramos, "Solar energy resource assessment in Chile : Satellite estimation and ground station measurements n Cort e," vol. 71, no. 2014, pp. 324–332, 2015.

[28] CAP, "'Amanecer Solar CAP', la planta fotovoltaica más grande de Latinoamérica ya es una realidad," 2014. [Online]. Available: http://www.cap.cl/amanecer-solar-cap-la-planta-fotovoltaica-mas-grande-de-latinoamerica-ya-es-una-realidad/. [Accessed: 08-Jul-2015].

[29] BNamericas, "Proyecto Cóndor Solar," 2015. [Online]. Available: http://www.bnamericas.com/project-profile/es/condor-solar-project-condor-solar. [Accessed: 08-Jul-2015].

[30] BNamericas, "Proyecto Solarconnection," 2015. [Online]. Available: http://www.bnamericas.com/project-profile/es/solarconnection-solar-plant-solarconnection. [Accessed: 08-Jul-2015].

[31] E. Bohn, "Observatory of Renewable Energy in Latin America and the Caribbean," Asunción, 2011.

[32] MEF, "Promoción de la Inversión Privada del Proyecto El Chaco La Puntilla," 2015. [Online]. Available: http://rondandoinambari.blogspot.com/2012/07/mef-ratifica-plan-de-promocion-del.html. [Accessed: 08-Jul-2015].

[33] D. Volt, "Energía Solar Fotovoltáica," 2015. .

[34] BNamericas, "Planta Solar Fotovoltaica Tacna Solar 20 T," 2015. [Online]. Available: http://www.bnamericas.com/project-profile/es/tacna-solar-20-t-solar-plant-tacna-solar-20-t. [Accessed: 08-Jul-2015].

[35] BNamericas, "Planta Solar Fotovoltaica Panamericana Solar 20 TS," 2015. [Online]. Available: http://www.bnamericas.com/project-profile/es/panamericana-solar-20-ts-solar-plant-panamericana-solar-20-ts. [Accessed: 08-Jul-2015].

[36] L. Pietrosemoli and C. Rodríguez Monroy, "The impact of sustainable construction and knowledge management on sustainability goals. A review of the Venezuelan renewable energy sector," *Renew. Sustain. Energy Rev.*, vol. 27, pp. 683–691, Nov. 2013.

[37] UCI, "Venezuela construye 1 MW en una isla caribeña," 2015. [Online]. Available: http://www.pv-magazine.de/nachrichten/details/beitrag/venezuela-construye-1-mw-en-una-isla-caribea_100014003/. [Accessed: 08-Jul-2015].

[38] M. Pansera, "Renewable energy for rural areas of Bolivia," *Renew. Sustain. Energy Rev.*, vol. 16, no. 9, pp. 6694–6704, Dec. 2012.

[39] Datos, "Bolivia-Japón acuerdo por energía solar fotovoltaica," 2015. [Online]. Available: http://www.suelosolar.es/newsolares/newsol.asp? [Accessed: 25-Feb-2015].

[40] El Nuevo Diario, "Bolivia inaugura su primera planta de energía solar," 2015. [Online]. Available: http://www.elnuevodiario.com.ni/internacionales/331200-bolivia-inaugura-su-primera-planta-energia-solar/. [Accessed: 25-Feb-2015].

[41] BNamericas, "Planta Solar Fotovoltaica Cobija," 2015. [Online]. Available: http://www.bnamericas.com/project-profile/es/cobija-photovoltaic-solar-plant-cobija. [Accessed: 08-Jul-2015].

[42] MIEM, "Planta Solar Fotovoltaica 'ASAHI,'" 2015. [Online]. Available: http://www.dne.gub.uy/-/15-de-marzo-se-inaugura-planta-solar-fotovoltaica-asahi-. [Accessed: 08-Jul-2015].

[43] T. Group, "Inversiones Tecno Group," 2015. [Online]. Available: http://www.tecnogroup.com.uy/es/Pages/Investments. [Accessed: 08-Jul-2015].

[44] M. Humpert, "Suriname's Energy Market," 2015. [Online]. Available: http://blogs.iadb.org/caribbean-dev-trends/2013/11/20/surinames-energy-market/. [Accessed: 07-Jul-2015].

[45] L. Woods, "South America continues PV surge as ET Solar supplies 5MW plant in Suriname," 2014. [Online]. Available: http://www.pv-tech.org/news/south_america_continues_solar_surge_as_et_solar_supplies_5mw_solar_plant_in. [Accessed: 07-Jul-2015].

[46] REEEP, "Guyana Energy Sources," 2015. [Online]. Available: http://www.reegle.info/policy-and-regulatory-overviews/GY. [Accessed: 07-Jul-2015].

[47] R. Energy, "A DIAGNOSTIC STUDY OF PHOTOVOLTAIC SYSTEMS," vol. 10, no. 213, pp. 153–156, 1997.

[48] CARICOM, "Guyan Energy Agency (GEA) photovoltaic (PV) System," 2015. [Online]. Available: http://www.credp.org/Data/ADA-FS/GUY-GEA_PV.pdf. [Accessed: 07-Jul-2015].