South America's Dilemma: Sustainable Development and Renewable Energies – Can Transnational Power Grids Assist in a Solution?

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1 Introduction

The target of economic development has long been elusive for South America. Despite a common social and cultural heritage[1] among South American countries, there is a history of mutual political suspicions, lack of capital investment[2], and disparate approaches on crucial regulatory decisions. As a result, the region has not only become economically laggard, but most recently it has been placed environmentally at risk.

Critical to ensuring effective development, one of the key regulatory decisions for individual countries concerns the energy base upon which economic growth is to be grounded, particularly in consideration of the rising international prices for carbon-based fuels and significant climate change consequences of its burning. The pressing dilemma for South America then, is how to achieve sustainable development and avoid the path of industrialized carbon-based economies.

Operating in isolation, the majority of South American countries, if not all of them, have focused heavily on achieving the best configuration possible for their own respective energy matrices and development projects. Much less attention, if any, has been put into seeking a solution for this dilemma from the point of view of the economic and environmental usefulness of interconnecting power transmission networks throughout South America. Having this perspective in mind, the paper

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1 The paper assumes the homogeneous socio-cultural environment of Latin America. Thus, the paper excludes only the consideration of Suriname, Guyana, and the French Guiana's power systems and regulatory frameworks, as its analysis is deemed neither relevant in terms of installed capacity, demand or power output, nor entirely representative of the sociocultural evolution of Latin America. For general information about these countries see Central Intelligence Agency (CIA) World Factbook, available on the Internet at <https://www.cia.gov/library/publications/the-world-factbook> (last accessed on 8 June 2010).

2 This rather endemic lack of capital investment contrasts profoundly with the relative wealth and diversity of natural resources enjoyed by South America. Accordingly, the potential for renewable energy sources in the region is vast, particularly in terms of the world's water reserves. See more information from the International Energy Agency, available on the Internet at <www.iea.org> (last accessed on 5 June 2010).

addresses the relationship between energy matrix configuration and energy supply policies, and the effect on development opportunities in the context of the South American region. It explores whether the consideration of cross-border interconnection of transmission grids in policies and regulation could play a positive role in the region's efforts to achieve sustainable development, as well as the opportunities and barriers for renewables integration and grid interconnection.

The proposition to be tested here is whether, despite having dissimilar and even divergent regulatory frameworks influenced by neo-liberal or socialist approaches, the idea of transnational transmission networks would assist in resolving the aforementioned dilemma through achieving the regional policies' convergent goal of sustainable development.

This paper concludes that as long as regional countries both promote integration and give priority to a greater share of renewable sources into their energy mixes, they are capable of coordinating their energy policy instruments by removing relevant technical and legal barriers.[3] Furthermore, cross-border interconnection of transmission grids could play an invaluable role both in tackling the common threats[4] of energy supply, i.e. energy security, and climate change, as well as in the ultimate pursuit of sustainable development.

2 A Developing Dilemma: Sustainable Development in a Climate Change Context

A few decades ago, the answer to the problem of development in South America may have seemed easy. It would have involved, in one way or another with more or less adjustments, and according to different paces in implementation, the transplantation of lessons from the first world.[5] The adoption of these "lessons" based on consumption, productivity and the depletion of natural resources[6] into the South American context has generally been successful. However, for both pioneers and followers, the conditions upon which those lessons would normally apply have changed. Indeed, among other factors, the cumulative effects of climate change have significantly led to the need to foster the concept of sustainable development.[7] Un-

3 The network's expansion plans assume previous transparent information sharing.

4 Such as the consequences of climate change (transnational networks' projects considered CO_2 abatement mechanisms), energy supply concerns, declining market share, industry relocation, and emissions leakage.

5 Lessons learnt in currently developed countries when they were colonial empires first, or economic empires later.

6 Not depletion of their own resources, but those of the countries they politically or economically exploited.

7 Sustainable development as defined by the World Commission on Environment and Development, *Brundtland Commission Report: Our Common Future* (Oxford: Oxford University Press, 1987).

like developed countries, the region struggles permanently not only from the lack of capital investment and well-designed natural resources management plans, but also with economic weakness and even occasional political instability.

This section looks at South America's energy policies, focusing on the way in which its countries have addressed the integration of renewable energies into their respective energy matrices as a response to sustainable development programs, climate change abatement goals, and security threats to energy supply.

A South America's Approaches Towards Unified Energy Policy

In analysing South America's regional policy-making processes, the notion of national sovereignty and its implications for energy policy must immediately be addressed. Whilst in other places, sovereignty may convey a rather flexible and modular approach to supposedly inherent prerogatives of the state, in South America the understanding of its significance is formal and comprehensive.[8] As such, it is apparent that at the international level the possibility of mutual cooperation or any sort of subsequent integration between these countries is at first seriously constrained. If concerns of national security take priority, the sovereignty question becomes even more restricting. In order to get transmission networks transnationally interconnected, countries coming together in this new energy grid should not approach the change as being an erosion of their sovereignty. International frameworks for regional integration, such as UNASUR[9] or ALADI[10], and for market integrations like MERCOSUR[11], are attempts with still limited scope for overcoming all the effects of a rigid notion of sovereignty, and to explore joint paths to development. Further-

8 This is the case mainly for historical reasons. After the independence movement in the early nineteenth century, nation states needed to emphatically assert their newly acquired sovereign status. Over time, political evolution towards both strong presidential regimes and highly centralized political systems led to an even more inclusive sense of the notion of sovereignty.

9 South American Union of Nations Constitutive Treaty (UNASUR), Brasília, 23 May 2008, available on the Internet at <http://www2.mre.gov.br> (last accessed on 10 June 2010).

10 Montevideo Treaty 1980, constitutive of the Latin American Association for Integration (ALADI), Montevideo, 12 August 1980, available on the Internet at <http://www.parlamento.gub.uy/htmlstat/pl/tratados/trat15071.htm> (last accessed on 10 June 2010)

11 Asunción Treaty, constitutive of a Common Market between the Republic of Argentina, the Federal Republic of Brazil, the Republic of Paraguay, and the Oriental Republic of Uruguay (MERCOSUR), Brasília, 26 March 1991, available on the Internet at <http://www2.mre.gov.br> (last accessed on 10 June 2010).

more, not all South American countries take part in them or do so in full cooperation.[12]

Against this background, energy policy-making in South America is still confined by national state boundaries. Even worse, setting aside the Brazilian exception to be explained later, innovative energy policies – including the promotion of renewables – have been hesitant and erratic[13], and only very recently have studies been conducted to assess the potential generating capacity of renewable sources of energy.

South America lacks policies for both regional common energy and power transmission.[14]

B Transmission Networks and Renewables in the Energy Matrix of South American Developing Countries

Could the energy sector, and power transmission in particular, become a path to development worthy of exploration? The answer is affirmative, to the extent that the policy-making process is multilateral, focused both on efficiency and sustainability, and with steady and consistent implementation.

Why is it important to design a proper energy matrix? A main factor to answering this question is that energy investments have a maturation time in which the economic agents – either public or private – need to have an outlook towards future

12 This refers to the practice of making reservations to international agreements, in order to create exceptions to the application or even interpretation of certain clauses potentially in conflict with the reserving State's interests, position, or circumstances. In turn, politics has its own effect: in liberal developing economies, like those of Argentina, Chile, Colombia, or Uruguay, the role of regulation is to give markets appropriate and consistent signals about a joint policy shift to a more diversified energy matrix, including non-conventional renewable energies, as well as to provide interregional regulatory frameworks for interconnection. Renewable power should be integrated under a scheme of free entry and transparent information sharing. In turn, in centralized economies like those of Venezuela, Ecuador, Perú, and Bolivia, the diversification of the mix is part of the energy sector planning which the State is committed to carrying out with or without a variable degree of private participation.

13 This has been the case, for instance, for Chile's energy policy.

14 There is no common policy, but a few multilateral initiatives for conducting studies on the subject, that is, the feasibility of international power integration between Latin American countries. For instance, within the United Nations' framework a study has been presented to the United Nations Development Program (UNDP) on the power interconnection between Bolivia, Chile, Colombia, Ecuador, and Perú, which was coordinated jointly by the Energy Vice-Ministers of the Member States of the Andean Community of Nations (CAN) and of Chile (a non-Member State). Also, within the CAN's framework there is a similar project in the charge of the Technical Group of Planning Agencies (GOPLAN) of the CAN's Member States. Additionally, regional non-govermental organizations, although of international status, such as the CIER, are already conducting research on electric interconnections between Mexico, Central, and South America (CIER Project 15, phase II).

energy offer and demand that is as accurate as possible. A matrix is a flexible strategic policy tool that can serve that function while at the same time advancing legal reforms.[15] Estimates indicate that continuous economic growth in the region will be accompanied by rising energy demand[16] and a renewable energies overview in South America indicates that its main source is hydropower, accounting for 71 % of the region's total generation in 2007[17] and produced by three countries: Brazil, Argentina, and Paraguay. The former is analyzed in the following section.[18]

3 The Brazilian Case

At the regional level, the Brazilian case is an exception, being commendable on both the integrating of renewables and in its realization of the importance of cross-border power transmission interconnections. It also highlights the importance of a gradual and continuing public policy on renewables[19], particularly biomass and biofuels.[20] In spite of economic setbacks, periods where the crude oil price has fallen, or the price of sugar has risen in the international markets, successive Brazilian governments have persevered with support of renewable energy sources. Remarkably, they

15 Its methodology encompasses regular up-to-date information gathering processes on energy resources available (whether in use or as a reserve), macro-economical projection models acknowledging annual growth-rate limitations (including economic activities or sectors), energy sector structure and sector growth estimates, coefficients of energy equivalence/product, and energy consumption models.

16 According to the <conventional translation of the name of this body required here> (*Comisión de Integración Energética Regional* or CIER), in 2007 Brazil generated 49.1 % of the total power produced in South America, Argentina 12.8 %, Venezuela 12.6 %, Chile 6.5 %, Colombia 6.0 %, Paraguay 5.9 %, Peru 3.3 %, Ecuador 1.8 %, Uruguay 1.0 %, and Bolivia 0.6 %. 2007 power production in South America, in GWh. See regional statistics published by CIER, available on the Internet at www.cier.org (last accessed on 17 June 2010).

17 2007 power production in South America, in GWh. See regional statistics on the CIER website, *supra* note 16.

18 Brazil (58 %), Argentina (5 %), and Paraguay (8 %). See regional statistics on the CIER website, *supra* note 16.

19 Such as the Incentive Program for Alternative Electricity Sources (PROINFA) which includes wind, hydroelectricity, and biomass. The program is designed to constitute a system in line with the Kyoto Protocol and the UNFCCC. See the Kyoto Protocol to the United Nations Framework Convention on Climate Change (Kyoto Protocol), Kyoto, 10 December 1997, in force 16 February 2005, 37 *International Legal Materials* (1998), 22; and the United Nations Framework Convention on Climate Change, 9 May 1992, in force 21 March 1994, 31 *International Legal Materials* (1992), 854.

20 See the National Program of Biodiesel Production and Use, PNPB, launched at the end of 2003, which substituted the National Alcohol Program, PROALCOOL, developed as a response to the oil crisis of 1973. Due to the success of PROALCOOL currently 70 % of the automotive park of Brazil is powered by ethanol. *Decree 76,593/1975*, PRFB, National Alcohol Program, PROALCOOL.

have done so along with programs aimed to create jobs, reduce inequalities and encourage social inclusion.[21]

Among the emerging economies of the South American countries, Brazil has the greatest potential to reach the status of being a developed country in terms of consumption, productivity and income.[22] Appropriate economic[23], legal[24] and political decisions in the past have led it to a promising situation, but new challenges lay ahead, particularly one of a sustainable economy with energy efficiencies.[25] With this in mind, in 2002 Brazil created a program to foster alternative electricity sources: PROINFA[26], aimed at increasing the share of wind-power, biomass and small hydropower systems in the grid through Autonomous Independent Producers. In 2004, the Brazilian government's legislation Act 10,847 authorized the incorporation of the *Empresa de Pesquisa Energetica* (EPE)[27], an agency to provide services in the field of research and studies to support energy sector planning. Among other functions, EPE is responsible for conducting research and estimates on the Brazilian

21 The programs are known as <English translation of the program names required here> (*Programa de Integração Social/Programa de Formaçao do Patrimônio do Servidor Público,* or PIS/PASEP), and they were particularly designed to promote cellulose-rich energy crops and biofuel-oriented agricultural feedstock. Information from the Institute for Agricultural and Trade Policy is available on the Internet at <www.iatp.org> (last accessed on 5 December 2011).

22 The Brazilian economy is astonishing in many ways. For instance, it finished the year of 2009 with the IPCA (Consumer Price National Index) at 4.31 % below the inflation target and with an economic growth rate near zero. See Eletrobras, *Administration Report 2009* – Insufficient reference information here (also not found in bibliography). However, in only four months (from January to April) of the first semester of 2010 it was capable of creating 962,000 new formal-sector jobs and in only a six-month period boost its annual growth rate over 10 %. Analysts forecast for 2010 a growth of 7 %. See also <title of article required here>, The Economist, May 22–28 2010, 43.

23 Like the monetary policy followed by the Brazilian Central Bank in regard to the Selic interest rate over the past three years. See <title of article>, The Economist, *supra* note 22.

24 For instance, the issuing of Decree 76,593 PRFB, of 1975, on the National Alcohol Program, also known as PROALCOOL, originated as a response to the 1973 oil crisis. This program was in force until 2002 and it was responsible for introducing ethanol in the Brazilian fuel matrix via mandatory programs to replace gasoline, the first measure attacking Brazil's dependency at the time on imports of foreign energy sources, particularly oil.

25 It is expected that by 2019 energy efficiencies derived from the Brazilian new energy mix will equal 12.5 % of the current domestic oil consumption. See Eletrobras, *Administration Report 2009*, *supra* note 22.

26 See information on PROINFA, *supra* note 19.

27 Lei 10.847, de 15 de Março de 2004, autoriza a criação da Empresa de Pesquisa Energética - EPE e dá outras providências, and Decreto 5.184 , de 16 de Agosto de 2004, cria a Empresa de Pesquisa Energética - EPE, aprova seu Estatuto Social e dá outras providências. The EPE depends on the Ministry of Mines and Energy. See also *Decreto 6,685*, de 10 de dezembro de 2008, dá nova redação aos arts. 2º e 4º do Decreto no 3.520, de 21 de junho de 2000, que dispõe sobre a estrutura e o funcionamento do Conselho Nacional de Política Energética – CNPE, e dá outras providências. - Translations are required for this reference material. All of these are available on the Internet at <http://www.prfb.gov.br> - Webpage not found. (last accessed on 12.06.10).

energy mix[28]; balancing national energy[29]; identifying and quantifying the potential of energy resources[30]; conducting necessary research for the planning of electric power generation and transmission expansion plans in the short, medium, and long-term[31]; performing studies to avail and increase the use of renewables[32]; assisting and taking part in interconnections as well as authorizing energy integration with other countries.[33] In May 2010 there was a release for public consultation of the preliminary version of a 10-year energy expansion plan for the 2009–2019 period, the Energy Plan (PDE 2019)[34], prepared by the EPE to be the main planning tool at federal level.

The Brazilian energy mix proposal places high importance on renewable sources of energy. At the end of 2009, the matrix was made of hydro (77.7 %),[35] thermo (12.8 %),[36] nuclear (1.9 %), and other renewable sources (7.4 %) of the installed capacity[37] in the National Interconnected System (SIN).[38] The PDE 2019, on one hand, maintains the mix's share of renewable sources at 48 %, the world's largest, by giving priority to hydro-generation and grid interconnections[39], the expansion in

28 Act 10.847, Brazil, 15 March 2004, Article 4(1).The reference information in the list of references is in Portugese – needs to be translated and cited in full in this footnote.

29 *Ibid.*, Article 4(2).

30 *Ibid.*, Article 4(3).

31 *Ibid.*, Article 4(7).

32 *Ibid.*, Article 4(13).

33 *Ibid.*, Article 4(14).

34 Plano Decenal de Expansão de Energia 2019 (PDE-2019). Ministério de Minas e Energia, Secretaria de Planejamento e Desenvolvimento Energético. Empresa de Pesquisa Energética (EPE), Brasília: MME/EPE, 2010. - translation required

35 As of 31 December 2009, the share of hydropower accounted for 71 % of the total generation capacity. See Eletrobras, *Administration Report 2009*, *supra* note 22, at 6.

36 As of 31 December 2009, the share of thermo was 23.59 % of the total generation capacity. See Eletrobras, *Administration Report 2009*, *supra* note 22, at 6. - Author to check this page number is correct.

37 This represented, on 31 December 2009, 103.598 MW of regular power generation connected to the national grid (SIN). See Eletrobras, *Administration Report 2009*, *supra* note 22, at 6. - Author to check this page number is correct.

38 <short form of translated name>, *supra* note 34, at 58.

39 <short form of translated name>, *supra* note 34, at 62 *et sqq*. For instance, in April 2010, a consortium of contractors led by Chesf – a state-owned hydropower generator – adjudicated themselves the procurement contract to build Belo Monte, the world's third largest hydroelectric facility (designed as a run-of-river dam) on the Volta Grande region of the river Xingu in the Amazon basin, a project requiring an investment of nearly US$ 11 billion and which has provoked massive environmentalist demonstrations because it will flood approximately 516 sq. kms of rainforest while desecrating others as well as forcing the relocation of aboriginal inhabitants.

the production of ethanol[40] and biodiesel[41], and the promotion of other alternative energy sources, particularly biomass and wind power.[42] On the other hand, in this PDE Brazil surprisingly lays the foundations to become a relevant actor in the oil market as an exporter of oil and oil by-products for the energy sector, seemingly a total accomplishment of its oil substitution policy of the 70s.

The Brazilian electricity regulatory model is almost entirely deregulated, through power-rates that are dictated by the government.[43] The normally low investment returns are, however, counteracted through soft loans schemes and tax-breaks[44] to lure investors, as well as through the government's ambitious public investment programmes.[45]

As to the network, the SIN[46] comprises the power transmission facilities[47] in four sub-systems, South (S)[48], South-East/Centre-West (SE/CO)[49], North-East (NE)[50], and part of the North (N)[51] region of Brazil; these account for 96.6 % of the country's electricity production.[52] Until recently the transmission sector was almost entirely

40 <short from of translated name>, *supra* note 34, at 219.

41 <short form of translated name>, *supra* note 34, at 267.

42 In this scenario, the optimal operational load dispatch prioritizes renewable sources: hydro, biomass, and wind generating units. At the same time, estimates of thermoelectric generation (including nuclear power) are low and deemed, mostly, back-up for emergency situations.

43 Power rates are capped at US$ 0.47 per megawatt-hour.

44 Like the IPI exemption policy (tax on Industrialized Products) or the passing of the Act 12.111, Brazil (9 December 2009), which permitted power companies with excessive fuel costs to operate isolated systems.

45 Act 8.666, Brazil (21 June 1993) regulates hiring in the public sector. However, provisional measure acts, like Act 450/09 introduced a simplified bidding procedure, making bidding rules flexible, for state-owned power companies, like Eletrobras, with regard to the acquisition of assets and the hiring of services.

46 The network delivers power in tensions between 230 kV and 750 kV depending very much on the distances at stake between generating units and consumer centres.

47 Transmission facilities are characterized and classified by ANEEL's Resolutions 67 and 68 (8 June 2004) - More source information required.

48 Encompassing Rio Grande do Sul, Santa Catarina, and Paraná. For general information see CIA World Factbook, *supra* note 1.

49 Including Espírito Santo, Rio de Janeiro, Minas Gerais, São Paulo, Goiás, Distrito Federal, Mato Grosso, Mato Grosso do Sul, Acre, and Rondônia. See Electrobras *Administration Report 2009*, *supra* note 22.

50 Including Piauí, Ceará, Rio Grande do Norte, Paraíba, Pernambuco, Alagoas, Sergipe, and Bahia. See Electrobras, *Administration Report 2009*, *supra* note 22.

51 Pará, Tocantins e Maranhão will be as of 2012 part of the Amazonas and Amapá; and as of 2014 part of Roraima will become part of this sub-system. See <short from of translated name>, *supra* note 34

52 Only 3.4 % of the country's power production remains outside the SIN, in small isolated systems, most of which are located in the Amazonian area. See <short from of translated name>, *supra* note 34.

under public control through both federal[53] and state companies.[54] Currently, there are about 40 transmission concessions in Brazil. Furthermore, the PDE 2019 considers a R$39 billion expansion plan[55] that includes interconnection projects between current domestic sub-systems[56] and current isolated systems,[57] and transnational interconnections with Argentina, Uruguay and Venezuela.[58] The expansion and interconnection of the transmission grid enables the efficient large-scale integration of renewable energy in the power system throughout the country. Moreover, since Brazil's energy mix is based predominantly on hydro-generation, the transmission capacity is essential to take advantage of hydrological diversity among sub-systems, which alternatively might experience droughts or rainfalls. A plunge in power production by one area or source could be balanced by higher production from another source or region regardless of distance,[59] a method of optimizing the use of natural resources.

Brazil's consistent policy on renewable power sources, coupled with a reinforced interest in transmission through the interconnecting of sub-systems and regional power markets, not only allows it to meet demand for power, but by averting bottlenecks also aids the promotion of power-price homogenization processes among sub-systems, and thus optimizing the load dispatch of the generating units.

53 The state-owned Eletrobras holding (through its subsidiary transmission companies: Chesf, Eletronorte, Amazonas Energia, Eletrosul, and Furnas) owns 53.148 kms of transmission lines (above 230 kV throughout Brazil) which represent 69 % of the country's total transmission lines. See Electrobras *Administration Report 2009, supra* note 22. The rest of the lines, operated in circumscribed concession areas, are owned by Copel (in the State of Parana, with 7,045 kms), Cemig (state of Minas Gerais with 21,184 kms), Terna Participacoes (a subsidiary of the Italian company Terna, in Brazilian and Maranhao), and CTEEP (subsidiary of the Colombian ISA, in the state of São Paulo, Goias, and Bahia with 11,837 kms).

54 Sao Paulo-CTEEP, Minas Gerais-Cemig, and Parana-Copel.

55 As to generation, the PDE 2019 considers a R$214 billion budget. See <short form of translated name>, *supra* note 34.

56 Regional interconnections South-East/Centre-West (SE/CO), North/North-East (N/NE), South-East/Centre-West/North-East (SE/CO/NE), South/South-East/Centre-West (S/SE/CO).

57 Interconnection South-East/Centre-West (SE/CO) – Acre/Rondônia, Tucurui-Macapá-Manaus, and Manaus-Boa Vista.

58 Setting aside the current Itaipú binational generation and transmission project involving Brazil and Paraguay.

59 The 2001–2002 power crisis affecting the South-East (SE) sub-system was not entirely due to a lack of generation, but also to an inadequate transmission capacity from the South (S) sub-system, which could have set off the SE generating deficit.

4 A Continuing Dilemma: Energy and Transmission Policy in South America

When considering policy-making processes at an international level, care must be taken regarding the acceptance of the general proposition that things can always be better and more efficiently done by acting jointly rather than separately. The energy sector generally passes this test, because while generation sources, particularly renewable ones, are commonly dissociated from consumption centres, transmission networks are inextricably associated to them. In fact, these networks function as the link by which customers are delivered power that might have been generated by distant sources.[60]

A The Security Approach and the Threats to Energy Integration

On the other hand, the main considerations of South American countries, when designing their energy policies in isolation, are still domestic and industry-related power demand coupled with concerns of national security and sovereignty. From the point of view of regional policy, interconnection of transnational grids is still viewed more as a means to overcome shortfalls of energy supply or to improve their own network reliability rate, rather than as a real alternative to energy integration based on the use of renewable sources distributed throughout the region.

B The Bolivia–Chile Case

This case illustrates what appears to be the general rule for South American when it comes to sovereignty concerns. Ancient political struggles[61] have often thwarted any attempt at integration on energy, despite favourable conditions for the trading of energy between both countries.

In Bolivia, the SIN encompasses generation, transmission and distribution facilities that operate in the Wholesale Power Market. In 2009, the total power generation reached 5,632.7 GWh, of which 2,264.3 GWh were produced by hydro plants and 3,368.4 GWh by thermo-generation units, which represents 40.2 % and 59.8 %

60 However, power transmission has a cost and this depends very much on the transmission capacity of the lines, the distance to be travelled, and the reliability and security of the supply (while being transported). So, local generation means efficiency, as does inter-local transmission also (particularly across borders).

61 Over many years, even simple economic relationships between Bolivia and Chile have been hindered by divergent views on Bolivia's claim of access to the Pacific Ocean through Chile's territory, an historical territorial claim dating back to the late nineteenth century.

respectively. The hydro-generating cluster is mainly made up of run-off river stations predominant in the north[62] and dam power stations in the centre-southern part of the country.[63] Thermo-generation is based on vapour-based turbines, natural gas, and diesel-fired units sited mainly on the East.[64] After Venezuela, Bolivia has the largest reserves of natural gas in South America[65] and it is currently the main exporter of it to Brazil and Argentina.[66] Mainly for political reasons, Bolivia does not export natural gas to Chile, though part of its exports to Argentina are sometimes then exported by Argentina to Chile.

The Bolivian Main Interconnecting System (STI)[67] transmission network is an essential part of the SIN and consists of 2,504.3 km of high-voltage transmission lines in 230 kV[68], 115 kV, [69]and 69 kV, and associated converting substations, capacitors, and reactors, while small isolated systems of 69 kV[70] lines mostly placed in the south complete the grid scenario.[71] Even though the interconnection with Chile's northern transmission network could be technically feasible, the political opposition seems to be insurmountable. Moreover, the performance of Bolivia's SIN is not

62 Run-of-river power stations are: Zongo, Taquesi, Yura, and Quehata, which in 2009 produced 299.8 MW accounting for 25.7 % of the total power production. Memoria Anual del Comité Nacional de Despacho de Carga. Resultados de Operación del Sistema Interconectado Nacional, 2009. Ministerio de Hidrocarburos y Energía - English translation required.

63 *Ibid.* Dam hydro stations are Corani and Miguillas, as well as the Kanata station which relies on the potable water reservoir of Cochabamba; they are all responsible for 178.4 MW produced in 2009 representing 15.3 % of the total power output.

64 In 2009, thermo-generating stations running on natural gas (opened-cycle) like Aranjuez MG produced 652.2 MW, the single vapour-based turbine running on sugar cane generated 21 MW, and the combined-cycle units running on natural gas and diesel produced 13.5 MW, accounting for 56 %, 1.8 %, and 1.2 % respectively of the total 2009 power production.

65 The natural gas industry was nationalized in 2006 by the left-wing government of President Evo Morales.

66 The natural gas pipeline to Brazil (GASBOL) entered into operation in 1999. Since then, natural gas exports have experienced continuous growth (in 2009, economic downturn led Brazil to cut imports, but heavy rains allowed it to substitute them with greater hydro-generation). In turn, as of 2010 Bolivia has exported 7.7 million cubic meters a day to Argentine, but a deal signed in March 2009 would expand that quantity to 16 million cubic meters a day by 2013 and 27.7 million cubic meters a day by 2021. See Diego Ore, 'Bolivia to boost natgas exports to Argentina', *Reuters,* 26 March 2010, available on the Internet at http://www.reuters.com/article/idUSN2621083120100326 (last accessed on 23 June 2010). Exports of natural gas to Chile have been on the table for a long time; however, political concerns mostly related to Bolivia's territorial claim to get access to the Pacific Ocean have hindered the materialization of such trade, even though Chile's power deficit represents a trade opportunity for both countries.

67 Sistema Troncal de Interconexión (STI). - Reference information required.

68 There are 1,545.2 km of 230 kV transmission lines.

69 There are 773.8 km of 115 kV transmission lines.

70 There are 185.3 km of 69 kV transmission lines.

71 Three companies are agents in the grid: Transportadora de Electricidad S.A., Interconexión Eléctrica ISA Bolivia, and San Cristóbal Tesa.

exempt from supply reliability concerns[72], particularly in the north, considering the area's lack of dams for hydro-generation, and the need for regular significant power transfers from the central region. To address these problems Bolivia has embraced a centralized planning policy. Tight control mechanisms and a strengthened strategic role for the state do leave certain room within the planning's framework and goals for private initiative.

The expression of such an approach is the Expansion Plan 2010-2020[73], a planning instrument elaborated by the Load Dispatching National Committee (CNDC)[74] and aimed towards getting the most out of generation and transmission investment projects to meet power demand. The plan seeks to gradually diversify the energy mix by creating the suitable conditions, through the integration of non-conventional renewable energies[75], following criteria of economic efficiency and social progress, as well as reducing the domestic consumption of liquefied natural gas for thermo-generation.[76] The plan targets projects that strengthen and expand the transmission network to meet growing power demand[77], as well as attempting legal reforms to introduce economic incentives that promote investment in generation.

Such legal framework includes the Act 1,604, on Electricity.[78] The Presidential Decrees Nr. 29,894 on organizational structure of the Ministry for Hydrocarbons

72 <Short form of translated name>, *supra* note 62, at 22. The operational availability of the STI was 98.4 % in 2009. However, the capacity of generation facilities reached only 88.94 %.

73 In turn, the Expansion Plan 2010–2020 is based on the National Development Plan (*Plan Nacional de Desarrollo*, or PND) and the Power Sector Plan (*Plan Sectorial de Electricidad,* or PSE). Reference information for these plans is required.

74 The <English version of organization name required here> (*Comité Nacional de Despacho de Carga, or* CNDC) is a public body created by Article 18 of the Act 1,604 on Electricity (21 December 1994) - source information in English required, which belongs to either the centralized or the decentralized state organizational structure. Presidential Decree Nr 29,624, of 2 July 2008 - source information in English required set forth its organization and functions. The latter can be summed up in the following three mandates: 1. coordinating power generation, transmission, and load dispatch at the lowest cost in the SIN. 2. administering the Power Wholesale Market (Mercado Eléctrico Mayorista, MEM) through recording and valuing power transactions made in the SIN, and 3. planning the SIN's optimal expansion in line with the directions given by the Ministry for Hydrocarbons and Energy. The Presidential Decree Nr. 29,624 has been recently complemented by Presidential Decree Nr 071, of 9 April 2009 - source information required here, conferring veto power to the CNDC's President over any decision to be made by the Committee. In other words, no decision could be adopted by this body without the consent of the Ministry for Hydrocarbon and Energy's representative.

75 However, the plan is not explicit in how to achieve this, particularly taking into consideration the lowest-cost operation scheme contemplated.

76 While reducing the domestic consumption of natural gas used in thermo-generation, the government expects also to save the funds currently used to subsidize the cost of fuels used in power generation as well as to take advantage of the natural gas production saved for export to other countries.

77 In 2009, the power demand grew at a rate of 5 %. See <Short form of translated name>, *supra* note 62.

78 Act. 1,604, on Electricity (21 December 1994), *supra* note 74.

and Energy[79]; Nr. 29,624 on the role and organization of the CNDC[80]; Nr. 071, has recently set up a governmental agency in charge of overseeing the execution of power-related statutes and regulations.[81] At the international level, Bolivia is a State Member of the Andean Community of Nations (CAN), and therefore abides by the Cartagena Agreement.[82]

Chile[83] is not part of the CAN, and its political and regulatory frameworks for the electricity sector have evolved quite differently to that of Bolivia. Indeed, its power production[84] relies heavily on conventional energy sources (97.4 %). In 2008, the energy mix was 36.4 % hydro[85], 36.1 % natural gas, 15.6 % coal, 9.3 % diesel and fossil fuels[86], and only 2.6 % non-conventional renewable energies (NCREs) represented only by 1.3 % biomass amounting to 166 MW[87]; 1.2 % small-hydropower equal to

79 *Presidential Decree Nr 29,894*, of 7 February 2009 - Source information required, established the organizational structure of the Executive Branch of the Plurinational State as well as that of the Ministry of Hydrocarburants and Energy.

80 Presidencial Decree Nr 29,624, of 2 July 2008 - reference information required, approved the <English translation required here> *Reglamento de Funciones y Organización del Comité Nacional de Despacho de Carga*.

81 The agency is the <English translation of the agency's name here> (*Autoridad de Fiscalización y Control Social de Electricidad*), created by *Presidential Decree Nr. 071*, of 9 April 2009 Source information required. Its main roles are auditing, control, overseeing, and regulating the power sector in accordance with the Constitution and the statutes enacted thereto. The legal framework is complemented also by *Presidential Decrees Nrs. 29,549,* of 8 March 2008 and *29,624* of 2 July 2008 source information required.

82 This refers to the Andean Subregional Integration Agreement, on the promotion of a balanced and harmonic development of the Member States of the Andean Community of Nations in fair conditions through integration and socio-economic cooperation (CAN), signed 10 March 1969. The Andean Community of Nations (*Comunidad Andina de Naciones*, or CAN) was created in 1969 by the Cartagena Agreement (also known as the Andean Pact), but it came into force only in August 1997. It is a sub-regional international organization aimed at promoting commercial integration between its members as well as a common foreign affairs policy. CAN's member states are Bolivia, Colombia, Ecuador, Perú, and Venezuela. Its institutions form the so-called Andean Integration System (*Sistema Andino de Integración*, or SAI). One of its endeavors has been to achieve a Customs Union, a Free Trade Zone, Origin Denominations, uniformity in technical rules, sanitary measures, as well as transfer pricing regulations, rules for the automotive sector, and the liberalization of the services market among many others.

83 Chile ratified and is a Party to the *UNFCCC* and the *Kyoto Protocol*. It is also a Party to the *Agreement on Training to meet UNFCCC's Obligations*, administered by the UNDP. In such a context, Chile's first environmental statute is the *Act on Fundamentals of Environment*, enacted in 1994, which incorporates the notion of sustainable development and sets standards for several air and water emissions, directing interested parties to conduct environmental impact assessments on projects of relevant significance. However, it does not set straightforward standards for energy efficiency. The <English translation of organization's name> (Comisión Nacional del Medio Ambiente, or CONAMA) is the Agency in charge of developing and implementing the environmental policy as well as of supervising its compliance. Under the Kyoto Protocol, it is also the DNA for CDM purposes. *Act 19,300*, on Fundamentals of Environment (9 March 1994) resembles the U.S. National Environmental Policy Act (NEPA).

84 13.137 MW of installed capacity.

85 Both dam and run-of-river hydro power plants.

86 Chile obtains a significant part of its electricity production (48.5 %) from imported fossil fuels.

87 Biogas and biofuels (bioethanol and biodiesel).

129 MW; and 0.15 % wind power for just 18 MW.[88] By the end of 2009, NCRE's had a 4 % share, with a 10 % share expected by 2024. To this aim, legislative amendments have been introduced, a new policy on NCRE has been recently launched, and US$ 500 million have been destined to R&D, grant programs and promotion.

Chile's electric infrastructure is divided into the following four separate systems with included percentages of their share of the installed electric capacity[89]: a) the Interconnected System of the Norte Grande (SING) with 27.4 %[90]; b) the Central Interconnected System (SIC), with 71.4 %[91]; c) the Aysén Electrical System, made of five small isolated systems in the southern part of the country, 0.4 %[92]; d) the Magellan Electrical System, with only three small isolated systems to serve the Patagonia region accounting for 0.8 %.[93]

In general, the rise in international oil prices, increasing power demand, instability of supply[94] and pollution concerns have compelled the revision and diversification of Chile's energy mix with renewable energy technologies and also changes to the energy legal framework.[95]

As conclusions of this study-case, the electric interconnection between Chile and Bolivia, without regard to other kinds of energy integration, would require a radical change in the political environment between them. Although their commercial

88 <English translation of organization name is required> (*Comisión Nacional de Energía*), *Non-Conventional Renewable Energy (NCRE) Electricity Production Statistics 2008*, published on the Internet at <http://www.cne.cl/cnewww/opencms/06_Estadisticas/energia/ERNC.html> (last accessed on 28 August 2009). In 2007, hydro electricity accounted for 39.7 % of the total generation (22,223.5 GWh), closely followed by natural gas and coal-based thermo generation at 36.7 % (20,535.3 GWh), while fossil fuel-fired plants reached 22.2 % (12,408.7 GWh).

89 *Ibid.*

90 *Ibid.* Almost completely thermal-based, including coal, oil and diesel-fired turbines and motors; it is 99.6 % based on conventional energy sources, and only 0.4 % on NCRE. The main customers are mining and fishing companies.

91 *Ibid.* The SIC's grid is 96.7 % based on conventional energy sources, and only 3.3 % on NCREs. It serves approximately 90 % of Chile's population as well as the principal industrial and mining consumers. It includes the *Canela I* wind farm. After several years of studies, the government is about to make a decision on the interconnection SIC-SING.

92 *Ibid.* With a total installed capacity of just 50 MW. It includes the *Alto Baguales* wind farm.

93 *Ibid.* With a total installed capacity of 99 MW.

94 Particularly of natural gas from Argentina.

95 The Chilean Constitution guarantees the right to undertake any economic activity, see Article 19(21) - source information for the Chilean Costitution is required. The access to the generation market, thus, is open to any developers, who must comply with the relevant legal framework, which is composed mainly of the *General Act on Electric Services*, as amended by *Acts 19,940* of 13 February 2004, *20,018* of 19 May 2005 and *20,257* of 1 April, 2008, all available at the Official Gazette – source information required, and appurtenant *Regulations*. For the *General Act on Electric Services* see *Delegated Law-Decree 4*, Ministry of Mining, of 12 May 2006, which consolidates the Delegated Law-Decree 1, Ministry of Mining, 1982.

relationships are steady and normal, at political level Chile and Bolivia do not have a top-level diplomatic relationship. Even though both countries would gain trading power by (i) taking advantage of Bolivia's low consumption and surplus to alleviate Chile's power generation deficit and (ii) securing the supply of natural gas to fire Chilean combined-cycle stations, therefore reducing the uncertainty of Argentinean supply, political issues between them have long hindered energy integration or any other kind of integration.

Cases like that of Bolivia and Chile show that by setting aside political issues for energy integration and international cooperation to achieve sustainable development, three factors present an outstanding opportunity: (i) domestic energy matrix configurations, (ii) promotion, investment in, and use of transnational power networks, and (iii) share-management. All three are consistent with the goals of economic growth programs, climate change abatement targets, and securing threats on power shortages.

C The Cooperative Approach: An Energy Integration Case

The exploitation of bordering natural resources does not always lead to problems between countries, indeed it can help in solving them. A case will now be analysed to illustrate how cooperative transnational power-generation and transmission undertakings can be drivers of economic growth, shared-management, natural resource preservation and peaceful resolution of conflicts.

D Brazil–Paraguay. The Itaipú Dam or How to Manage Mutual Interests

Historical territorial conflicts between Brazil and Paraguay over the current site[96] of the Itaipú Dam date back to 1750. While even the 1872 Peace Treaty[97] did not solve the issue, the Iguazú Declaration of 1966 put a de facto end to the dispute when expressing the intention of both countries to jointly explore the feasibility of hydro-electric potential at the De la Plata basin; most of the area in dispute would consequently be flooded with the remaining area possibly declared a bi-national ecological reserve.

96 The area known as Salto Grande de Sete Quedas.

97 The 1872 Peace Treaty put and end to the so-called "War of Paraguay".

In the following year, a Brazil-Paraguay Mixed Technical Commission was created[98] to conduct feasibility studies for the proposed dam. At the same time, an international tender process was initiated to select the contractors to build the 14 GW Itaipú hydro-electrical dam on the Paraná River.

In 1973, the Parties agreed the Itaipú Treaty, which literally overcame the long-standing territorial dispute by flooding the area.[99] Despite much criticism, the Treaty is interesting for several aspects.[100] One of them is the treatment of sovereignty-sensitive water and territorial issues: firstly, it fully acknowledged the bi-national nature and co-ownership regime over hydro resources of the relevant track of the Parana River.[101] Secondly, it declared in a sovereignty-safeguard clause that the construction of the electric facilities shall neither alter the status quo ante regarding border delimitation, nor conferred any party jurisdiction or property rights over any part of the other's territory.[102] Also interesting is that it created the bi-national entity of the Itaipú Dam, to which both Parties granted a concession to exploit the hydro potential of the Paraná River[103] in return for royalties.[104] However, the treaty's central point is the power distribution agreement embodied in Art. XIII. According to the agreement, the entire Itaipú power production shall be divided equally between Brazil and Paraguay, with both parties (i) having the right to acquire excess power not consumed domestically by the other, and (ii) agreeing to acquire the entire installed capacity.[105] In turn, Art XV paragraph 3 establishes remuneration for the Party assigning its power surplus.[106]

In 1984 the Itaipú began operation, and with that came many new problems. Firstly, one of external security implications for a third country, Argentina, who feared Brazil's control over the floodgates and the potential flooding threat to Bue-

98 <English translation of organization's name> (*Comissão Mista Técnica Brasileiro-Paraguaia*) created on 12 February 1967. Itaipú Treaty (*Tratado entre a República Federativa do Brasil e a República do Paraguai para o aproveitamento hidroelétrico dos Recursos Hídricos do Rio Paraná, pertencentes em condomínio aos dois países, desde e inclusive o Salto Grande de Sete Quedas ou Salto de Guairá até a Foz do Rio Iguaçú*), signed in Brasilia on 26 April 1973, see Article 23, available on the Internet at <http://www2.mre.gov.br/dai/b_parg_91_1594.pdf> (last accessed on 30 June 2010). - webpage not found

99 *Ibid.* It is worth noting that the negotiation of the Treaty was conducted when both Brazil and Paraguay were governed by military dictatorships and that, once concluded, the Treaty was not sanctioned by democratically elected governments.

100 *Ibid.* For instance, the tax regime contained in Article 12 of the Treaty.

101 In other words, from and including Salto Grande de Sete Quedas (also known as Salto de Guairá) to Foz do Rio Iguaçú.

102 Article 7, *supra* note 98.

103 Articles 3 and 4, *supra* note 98.

104 Article 15, para. 1, *supra* note 98.

105 Article 14, *supra* note 98. In the manner set forth therein.

106 Article 14, para. 3 and Annex C, *supra* note 98.

nos Aires, which was then solved through a Tripartite Treaty.[107] Secondly, significant claims later made by Paraguay[108] about the limiting commercial consequences from a rigorous interpretation of the Treaty, particularly the "fairness" of the amount to be paid to the power-assigning party[109] and the supposedly exclusive nature of the power-surpluses acquisition right. Although Paraguay enjoys enormous power-surplus, it is not allowed by the terms of the treaty to sell it to third parties even if they are prepared to pay higher prices; it can only assign it to Brazil's public electric company Eletrobras. However, since 2008 Paraguay has led a strong diplomatic offensive to convince Brazil to renegotiate the Itaipú Treaty.[110]

Further developments might arise in connection with the 500 kV Villa Hayes transmission line, a project valued at USD 400 million and intended to be carried out by MERCOSUR's State Members[111] once funding has been agreed.[112] Despite its formal multinational nature, the Villa Hayes project would be a remarkable improvement to Paraguay's poor power-transmission infrastructure, which is made up of only seven 220 kV lines totalling approximately 3,566 km. Its huge generation capacity sharply contrasts with its scarce and unsophisticated transmission infrastructure; the most important lines belong to the bi-national stations that convey

107 Acordo Tripartite entre Brasil, Paraguai e Argentina para aproveitamento dos recursos hidráulicos no trecho do Rio Parana desde as Sete Quedas até a foz do Rio da Prata <English translation required>, signed on 19 October 1979.

108 Especially as of 15 August 2008, the date on which Fernando Lugo assumed the Presidency of Paraguay. Basically, Paraguay claims: 1. free disposal of power surpluses, meaning the possibility to sell them to Third Parties and not exclusively to the Brazilian public electric company Eletrobras; 2. a better price for the energy assigned to Brazil; 3. a financial revision of the Paraguay's account payable and financial passive restructuration; 4. effective co-management of the bi-national entity Itaipú; 5. joint supervision of Itaipú by the respective administrative organs: Paraguay's Contraloría General de la República and Brazil's Tribunal de Cuentas; 6. construction of pending facilities: an electric substation in Paraguay's territory and navigation facilities.

109 See ABC Digital – more information than this is required. Available on the Internet at <http://www.abc.com.py/abc/nota/132484-Lugo-deja-renegociaci%C3%B3n-de-Itaip%C3%BA-en-manos-de-%E2%80%9Cvoluntad-del-Brasil%E2%80%9D/> (last accessed on 15 June 2010).

110 Its strategy seemed to succeed when on 25 July 2009, by means of a Joint Presidential statement, signed in Asunción, Brazil's president Luis I. "Lula" Da Silva pledged a substantial rise in the amount that his country pays to Paraguay in return for the power-surplus assigned to Brazil. In fact, it has been informed that the then current payment of US$ 120 million would increase to US$ 360 million. See the Asunción Statement (*Declaração de Assunção sobre o aproveitamento de rios internacionais*) (3 June, 1971), Articles 5, 6. It was finally agreed that the Paraguayan network operator (*Administración Nacional de Electricidad*, or ANDE) could sell its power surplus to Brazilian companies other than Eletrobras and to third party countries as of 2023. Although Paraguay's Congress rapidly gave ascent to the Asunción Declaration, it has not yet been approved by the Brazilian Congress. See further information on ANDE available on the Internet at <www.ande.gov.py> (last accessed on 8 June 2010).

111 Brazil, Paraguay, Argentina, and Uruguay.

112 Basically, through contributions to MERCOSUR's Convergence Structural Fund (*Fondo de Convergencia Estructural*, or FOCEM).

power away towards Brazil and Argentina, while the rest feeds the distribution system that is mainly focused in the eastern part of the country. In fact, its transmission capacity[113] is far behind that of Uruguay, which has much less power availability but enjoys a widespread transport network.[114] Apart from the transport coverage issue, the network is well known for having serious efficiency and reliability weaknesses. Total transmission losses[115] account for 33 % of the domestic demand, and also have the region's highest rate of system failures; most of these problems are attributed to the current economic and legal configuration of the power system and its management.

In the context of the bilateral relationships between Brazil and Paraguay in which the Itaipú issues are central, it is quite understandable why Brazil would be willing to promote the Villa Hayes' transmission line project and even to fund it either in whole or part. The Itaipú Dam is not only an example for cross-border interconnection, but also for a cooperative approach towards energy integration.

5 The Opportunities of Transnational Power Transmission

In a world in which the human population is currently almost 7 billion[116], of whom almost 400 million are in South America[117], the law of conservation of mass seems inescapable: resources are finite and the predicament is how to use them wisely and consistently. Although electric power is a commodity, with current technology[118] meeting energy demand depends on limited natural resources whose value varies

113 Paraguay has only 9 km of high-voltage lines per 1,000 km², totalling 3,566 km. Union Industrial Paraguaya, Centro de Estudios Económicos, *La energía eléctrica Paraguaya en un marco regional* (2009).

114 Even though they total only 4,330 km of lines, Uruguay has got 25 km of high-voltage lines per 1,000 km², and with this ratio are thus leading the regional transmission coverage ranking. See information published by CIER, *supra* note 16.

115 Both technical and non-technical transmission losses amount to 2,709 GWh, the highest losses in the region.

116 The world's population is predicted to reach 9 billion by 2050. See CIA, World Factbook, *supra* note 1.

117 *Ibid.*

118 Here, the paper sets aside the consideration of renewable energy sources, which, while potentially promising high natural availability in the future, at present are not widely available due to high costs and are not expected to be able to provide wide-scale power supply, even in the medium term. Such renewable sources include solar photovoltaic (PV) cells, which use solar continental irradiation (eg. the Desertec project), or tidal energy. Source: German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), *Renewable Energy and the Clean Development Mechanism. Potential barriers and ways forward: A guide for policy-makers* (Berlin: BMU, 2007).

according to locality[119], purpose[120], and circumstance.[121] Thus, in dealing with these factors, transmission networks play a decisive role.

Three main expressions of such a role will be analysed here: firstly, the opportunity for transmission networks to assist in achieving sustainable development and serve as a climate change abatement mechanism; secondly, its functionality in terms of the share-management of natural resources, and the integrating of renewable power sources; and finally, its potential for enhancing market access and configuring a single transnational electricity market.

A Contribution to Sustainable Development and Climate Change Abatement

The interconnection of power grids represents significant reductions in capital and operational costs, particularly for developing countries designing their matrices to suit renewable sources by inducing interconnected countries to export excess power, thereby generating economic income. Additionally, by means of the "flexibility mechanisms" of Article 12 of the Kyoto Protocol, Annex I countries can invest in emission reduction projects, i.e. Clean Development Mechanism projects in non-Annex I countries, contributing to achieve or enhance sustainable development. Furthermore, under Article 6 of the Protocol, transmission projects could also count towards a country's emissions reductions if they qualify under Joint Implementation, i.e. as emission reduction projects in other Annex I countries.

A highly controversial case can be found in Ecuador's Master Plan for Electrification 2007-2016, which has a scheme of compulsory planning for projects to be carried out to overcome the country's seasonal power deficits and lack of invest-

119 Natural resources are not geographically distributed equally.

120 Water is an extremely vital but scarce natural resource. It can be used to quench the thirst of the Indian population, to irrigate soya-beans fields, or allowed to run in a water stream and then activate the turbines of a hydro-electrical plant.

121 Once again, water serves to exemplify the "circumstance" factor, particularly when facing the threatening effects of climate change: of the total global water resources, 97.5 % are in the oceans (salty water not readily usable) and only 2.5 % consists of fresh water. Of this latter figure, 69.5 % is frozen in glaciers, ice caps, and permafrost; 30.1 % is groundwater; and only 0.4 % is water present on the surface (falling as rain, flowing in rivers, and sitting in lakes and reservoirs) and the atmosphere. Furthermore, over 60 % thereof that is hitting the ground as rain and/or snowfall cannot be captured due to evapotranspiration (ET) or because it runs into the sea or other saline underground aquifer. Out of the 30.5 % of surface, atmosphere, and groundwater resources, 67 % goes to agricultural irrigation, 20 % to domestic and other industrial uses, 3 % evaporates from reservoirs, and 10 % is directly used in power generation. See World Bank, *World Development Report* 2010 - More source information required.

ment in energy infrastructure.[122] Even though the plan uses renewable sources as its long-term energy supply solution[123], has a CO_2 abatement potential of 6.13 mils per year, and advocates for more active participation of the state in carrying out the projects[124], it has been subject to considerable criticism. While it is true that a project's funds must partly be used for improving the management of river basins, in specific programs for reforestation, or establishing mechanisms for the preservation and enhancement of biodiversity and local ethnic populations, the funding comes from Ecuador's contracts in the oil industry[125],and from the exploitation of sectors of the Ecuadorian Amazonia.[126]

According to a report by the Economic Commission for Latin America and the Caribbean (ECLAC)[127], even though Latin America[128] has the world's second lowest regional greenhouse gas (GHG) emissions after Africa, it is nonetheless suffering

122 The year 2006 saw a clear-cut change in Ecuadorian energy policy. The then newly elected government left behind neoliberal indicative policies and resolutely embraced a scheme of compulsory planning. The Master Plan for Electrification 2007–2016 pledges a further 3,800 MW of installed capacity to be added to the system, of which 80 % (3,040 MW) must come from renewable sources. In Ecuador, the energy mix is currently made up of hydro sources (17 %) mainly in the Amazonian region and natural gas-fired thermoelectric stations (3 %). The share of the hydro-generation in the mix is expected to be 95 % by 2017, according to the plan. In this manner, the use of the country's hydro resources would go up to 21 % in 2016. The challenge is large, for Ecuador's energy mix is still largely dependent upon oil. The participation of other non-conventional renewable technologies is still negligible. The plan is, in the short term, aimed to expand the hydro share through developing its generating potential on the Pacific Ocean side of the country. As a result, the plan also demands the reinforcement of the National Transmission System (SNT), including three main transmission expansion projects: a 500 kV line from Quito to Guayaquil, a 230 kV line to link Totoras and Quevedo, a 230 kV system comprising Milagro, Las Esclusas, and Trinitaria, as well as the 230 kV system Milagro-Machala, the funding of which is indexed to the government-regulated transport tariff through a specific factor. See U.S. Energy Information Administration (EIA), available on the Internet at <http://www.eia.doe.gov/cabs/Ecuador/Background.html> - page not found.

123 The Master Plan for Electrification 2007–2016 pledges a further 3,800 MW of installed capacity to be added to the system, of which 80 % (3,040 MW) must come from renewable sources.

124 Either in the generation, transmission, or distribution sectors. For instance, in the former one, the plan projects the construction of five hydro-electric dams: Mazar, Sopladora, Toachi Pilatón, Ocaña, and Coca Codo Sinclair. The environmental protection measures and the projects for rural electrification are also areas in which the planning conceives determined state participation.

125 All revenues originally going to the Ecuadorian Investment Fund for Energy and Hydrocarbon Sectors (*Fondo Ecuatoriano de Inversión en los Sectores Energético e Hidrocarburífero*, or FEISEH). See the currently abrogated Act creating the FEISEH, Official Gazette Nr. 386, of 27 October 2006; and specially the *Organizational Act for the recovery of the governmental petroleum resources use and the administrative reform of the indebtedness processes* (*Ley Orgánica para la Recuperación del Uso de los Recursos Petroleros del Estado y Racionalización Administrativa de los Procesos de Endeudamiento*), which redirects the FEISEH's funds, Official Gazette Nr. 308, of 3 April 2008.

126 The so-called Block 15: the joint areas of Edén-Yuturi and Limoncocha.

127 ECLAC, *Economics of Climate Change in Latin America and the Caribbean: Summary 2009*, published on the Internet at <http://www.bosquesmodelo.net/new/admin/links/Feb10/CEPAL%20Economics%20of%20climate%20change%202009.pdf> (last accessed on 11 June 2010). - page not found.

128 And the Caribbean.

the effects of climate change more than any other.[129] This denotes urgent need for technological innovation and financial support from developed countries towards the region's efforts for adaptation, mitigation, and sustainable economic recovery, which is taking too much time to arrive.[130]

The region needs to maintain strong growth rates while also turning onto a path of energy decoupling through a structure of energy intensity and decarbonization rates like those of developed countries such as the USA or the EU; keeping its per capita CO_2 emissions low; increasing the share of renewables in energy matrices, and promoting transnational transmission networks. More importantly, interconnected networks enable power to be transferred from one region to another to balance load across time zones and regional variations[131] enhancing energy efficiency[132], causing less overall harm to the environment[133], and facilitating a multi-renewables integration to function to its full generating potential when transnational power transmission projects converge.

The efficiency of an inter-regional policy depends on its ability to generate GHG emission reductions at the source and preferably through long-term, large-scale use of renewable energy technologies. This paper proposes that this could be achieved through interconnecting networks internationally.

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129 ECLAC, *Economics of Climate Change in Latin America and the Caribbean: Summary 2009, supra* note 127, at 35. For comparative purposes and warning about cautious treatment of the information due to occasional discrepancies with official emissions inventories, the ECLAC's 2009 summary relies on the Climate Analysis Indicators Tools (CAIT) version 6.0 (WRI, 2009) when stating that "Latin America's total emissions represent a small share at the global level and, moreover, decreased as a proportion of total emissions between 1990 and 2000. South America's share dropped from 11.5 % of the total in 1990 to 9.71 % in 2000; Central America's fell from 0.94 % to 0.71 % and that of the Caribbean edged up 0.28 % to 0.30 %". A pattern may be observed, the net results of which supposedly come from two opposing trends: "a steady rise in emissions from energy consumption and, recently, an overall reduction in emissions from land-use change'. The report adds that, '[i]n absolute terms, emissions are concentrated in a few countries, especially Argentina, the Bolivarian Republic of Venezuela, Brazil, Colombia, Mexico, and Peru, with the other countries accounting for a smaller proportion".

130 ECLAC, *Economics of Climate Change in Latin America and the Caribbean: Summary 2009, supra* note 127. Although in different ways, the 2009 international economic crisis was suffered by all South American countries. ECLAC's joint GDP estimates for Latin America show a decrease of 1.8 % in 2009 compared with the previous year. Negative results got Mexico -6.7 %, Paraguay -3.5 %, Honduras -3.0 %, El Salvador -2.5 % and Venezuela -2.3 %. Much better performance had Bolivia +3.5 % as well as Panama and Dominican Republic with +2.5 % each. Argentina grew 0.7 % whereas Chile got a result of -1.8 %.

131 Even at hemispheric seasonal variation scale.

132 Operation at high-transmission level voltages (110 kV and above) over long distances reduces load losses. It also increases the power system reliability and improves load management. Thus, long-distance power transmission (7,000 kms for direct current and 4,000 kms for alternating current) with existing viable technology (ultra-high voltage – UHV – transmission) means greater energy efficiency.

133 Whilst reducing demand for fossil fuels (coal, oil, gas) and the resulting contamination, transmission networks also contribute to a reduction in deforestation, topsoil and rainforest loss, as well as the spreading of deserts.

The contribution to climate change abatement of such an expansion is not only the integration of renewable sources into the grid, or the dispatching of the most efficient generating units according to marginal cost considerations, but also the possible utilization of existing power plants only as a back-up[134] as this would lead to the obsolescing of inefficient existing units no longer needed.[135] Renewable energies will contribute to slowing climate change by providing heat, cooling, transportation and power generation with none or only marginal direct and indirect CO_2 and other GHG emissions, as long as they can be integrated to existing power grids on a wide scale.

B Natural Resources Share Management and Integration of Renewables into Transnational Networks

At present, renewable sources of energy are only efficient and economically competitive when integrated into an existing network on a large scale. This acknowledgement is one of the major drivers for countries to discuss network interconnection and energy integration, particularly for those making renewables a relevant share of their energy mixes.

In South America, the current status at the multilateral level is only an external cooperation between governments to promote studies on electrical interconnections. However, outcomes have been faster and more productive at the bilateral level. This is due to a mutual need to exploit bordering natural resources, and the desire to share the benefits through bilateral political understanding. Examples of this are the Itaipú Dam between Brazil and Paraguay for the utilization of the river Paraná, as well as the utilization of the Uruguay River between Argentina and Uruguay to serve the bi-national 1,890 MW hydro plant Salto Grande,[136] at which production is distributed equally between both countries. Salto Grande also lies on an associated 500 kV transmission system operated by a bi-national body, the Mixed

134 Contributing in this way to a massive overall reduction in expensive spinning reserve and hot standby of conventional oil-fired generating units.

135 This is an explanation for why, in general, there is no great support from the traditional big agents, particularly generators, because a massive and faster integration of renewable generation sources into the grid would strand many of their assets and make it unnecessary to build new fossil fuel-fired plants which already have secure funding or are under construction.

136 See, for more information about Salto Grande, <www.saltogrande.org> (last accessed on 17 June 2010).

Technical Commission controlled by the foreign affairs ministries of Argentina and Uruguay.[137]

Although natural resources are locally appropriated and managed, non-local or distant users may still benefit from them, particularly in situations of power-generation surplus. Indeed, transmission or generating facilities associated with the exploitation of common natural resources, where management and preservation for future generations is regulated by international instruments such as a treaty on bi-national frontiers, are normally also subject to international bilateral agreements.[138]

Add to this that the long-term advantages of integrating renewables into transmission networks largely outweigh the shortcomings. One advantage is that it contributes to the gradual reduction of renewable technologies' high installation costs; for example, wind power costs are already competitive in many countries. Moreover, it might act as an insurance against the rising of prices of other energy sources, and as an incentive for domestic industrial growth. Once interconnected to a grid, the extremely low operating costs of renewables start competing with those of conventional sources. Theoretically, the two possible outcomes are that conventional sources are either displaced out of the market, or their pricing goes down to equal that of renewables. Local industries might then be better off by producing the equipment or parts required by renewable technologies. The state's role should be to ensure that entry-requirements are equal and non-discriminatory for any source of power.

137 The Uruguayan transmission network – as of 2004 – comprised 771 km of 500 kV open-air lines, 3,499 km of 150 kV and 230 kV of open-air and underground lines, and 97 km of 60 kV of open-air lines. According to CIER, Uruguay has the largest transmission capacity in South America (expressed in the ratio: high-voltage transmission line kms/1,000 km2), followed by Chile and Colombia. Uruguay has electric interconnections with Argentina and Brazil. The interconnection with Argentina operates in alternate current and consists of two 1000 MW transmission lines crossing the Uruguay river, linking 500 kV substations placed on the riverside of each country. One of the lines links the two substations belonging to the bi-national hydro plant Salto Grande and the other – placed south – tie the San Javier substation in Uruguay with the Colonia Elía substation in Argentina. There is only one interconnection with Brazil, which requires converter substations due to both power systems run on different frequency. Whilst the Uruguayan system runs on 50Hz, Brazil's runs on 60 Hz, rendering it not viable to interconnect directly on alternate current. Converter substations at each end of the line make possible the interplay between the 150 kV Uruguayan system and the 220 kV Brazilian power system. The 70MW transmission line links Rivera in Uruguay with Livramento in the Brazilian State of Rio Grande do Sul.

138 A. Boyle, "International Law and Protection of the Global Atmosphere: Concepts, Categories and Principles", in R. Churchill and D. Freestone (eds), *International Law and Global Climate Change* (1991); see also Part XI of the 1982 Law of the Sea Convention – more information required: which country does this law belong to?.

C Enhancement of Market Accessibility and Potential for a Single Transnational Electricity Market

In terms of market accessibility, the idea of a transnational transmission grid is appealing for many reasons.

Firstly, new energy sources could access and interconnect to the grid, thus creating more competition between generators and allowing cross-border power trading, i.e. the free movement of goods and services.

Secondly, it could theoretically integrate a multitude of small and very small energy sources, as even an individual could become a producer, gaining access and interaction in the grid when installing a solar panel or a co-generator.

Thirdly, it could help balance supply and demand at regional level, thus securing the power supply needed for driving regular economic activities, and also contributing to the stability and reliability of domestic grids.

Fourthly, a smart grid allowing widespread access results in power storage capacity that can offset periods of low energy generation.

Finally, multilateral energy interdependence, particularly between non-neighbouring countries, and the technical advantages of interconnection, makes such interdependence politically desirable in an international context and assists the development of enforcement mechanisms to ensure energy supply. Such a network could also play a stabilizing role in securing unsteady regions by removing the cessation of power supply as a political bargaining chip during regional conflict.

However, attempts to make a common electricity market a reality, like the EU's proposed Internal Energy Market,[139] are still only works in progress; the task seems to be even more difficult for South America. Nonetheless, trans-boundary transmission constitutes a fertile ground for the development of internationally enforceable legal mechanisms. Indeed, the operation of power grids calls for detailed regulation ensuring the fair and non-discriminatory access and use of their infrastructure.

D Barriers

It is necessary to provide at least a glimpse of the technical, economic and regulatory obstacles in the way of making transnational transmission networks a reality.

Firstly, grids should become larger and "smart". There is a need for a technical revolution in the transmission sector, ranging from the development of new super-

139 European Commission, *Completing the Internal Market: White Paper from the Commission to the European Council*, COM(85) 310, (Milan, 28–29 June 1985). See also European Commission, *The Internal Energy Market: Commission Working Document*, COM(88) 238 final (2 May 1988).

conductors able to both increase transmission capacity and reduce losses, for example high-voltage direct current (HVDC) technology[140]; the introduction of smart digital hacker-proof meters allowing instantaneous consumption-data transfer and electronic device interaction, i.e. feedback to the grid and energy-efficient response, coupled with better acute operation software to strike the balance between surplus and scarcity in grids where renewables are integrated and output is extremely difficult to predict.

Secondly, economic challenges must be overcome. Apart from the inherent costs of research, testing, and developing new technologies, and the externalities of dealing with either monopolistic or oligopolistic features of the transmission sector, a new grid would also require more flexibility in its economic operation. At the users' level for instance, the traditional pattern of supply based on consumption would evolve to adjust demand for an increasingly fluctuating load on the grid. Economically, this expresses itself through variable pricing models for electricity instead of uniform prices, premium convenience schemes for consumption, freedom to change power providers, and even prepaid power rates. At the private developers' level, the cost of construction of these types of networks demands large capital investments. Similarly, for states engaged in centralized planning, there could be a significant burden for domestic budgets. More broadly, using a renewables-based mix means bearing the cost of the decarbonizing of existing economies, mainly the phasing out of fossil fuel-related subsidies and the promotion of clean energy sources.

Finally, particularly in developing countries, a range of legal, institutional, and political barriers stand in the way of energy integration. Border taxes for instance, a common manifestation of the traditional sovereignty concept, are not only a permanent source of conflicts in the WTO's trading framework, but also a hindrance to the import of new renewable technologies. Intellectual property issues must also be addressed concerning such technologies to facilitate fast dissemination. Joint international legal arrangements, for the standardization and granting of a network's operation centres for both international status and independent management, are crucial for securing an unbiased and reliable power supply. It is also important to agree on a transparent tariff scheme that is legally binding, as well as on a controversy solution mechanism.

At present, South America's multilateral energy integration efforts are in an embryonic state: UNASUR, ALADI, CAN, PETROCARIBE, and MERCOSUR are all suitable regional frameworks to foster energy integration in their particular scopes, but

140 At present, the high-voltage grid's maximum capacity is 380 kV. New conductors are expected to have 740 kV of transmission capacity. The lines are mostly made of copper and each meter weighs 38 kl. High-voltage direct-current (HVDC) technology is suitable for long-distance power transmission, but requires converter substations to transform direct current into alternating current. Its loss rate is just 3 % of the power conveyed for every 1,000 km of line.

unfortunately none of them covers all of the region's countries, nor have they developed a common regional energy policy to address issues of transnational transmission. However, the topic has been much more successful in the context of bilateral relations, even if this has been in line with the states' individual concerns of security of power supply.

6 Conclusions

This paper was intended to advance the proposition that, in the South American region, transnational power networks could represent a step forward towards the common regional policy goal of achieving sustainable development. In testing such a proposition, the reasons explaining why many different countries have such a common policy goal was first analysed, with the conclusion that rather than the sustainable development concept being of a specific means-prescriptive nature, it is of a general non-prescriptive, one that therefore allows disparaging sectoral policies be a fairly regular outcome. However, two key options stand out that favour sustainable development and decarbonize economies: energy efficiency measures in the short term[141], and renewable energy technologies in the medium and long term.[142]

141 The consideration of the effects of implementing energy efficiency (EE) measures are outside of the scope of this paper, which instead focuses on those of renewable energy sources (RE) when integrated to energy mixes as well as on the suitability of transnational network interconnection for furthering sustainable development. Both EE and RE are mechanisms viable and available for climate change mitigation.

142 As this paper has demonstrated, the interconnection of transmission networks throughout South America would represent several opportunities for achieving sustainable development. Indeed, firstly, it would create the conditions for a common electricity market, consequently allowing the power needs of high-demand countries to be met by making possible cross-border power transmission from generating units to consumer distribution centres. This is of particular relevance not only because of the growing rate of total power demand in South America, but also most importantly, and not surprisingly, because the three power-deficit countries – Brazil, Argentina, and Chile – have the highest concentration of industrial-related power demand. Secondly, transnational power integration works as a means of optimizing the use of natural resources and, thus is suitable as a climate change abatement mechanism even under the Kyoto Protocol. Indeed, network integration allows the interconnection of different power sources – most importantly, renewable sources – as well as advantage to be taken of the interaction of geographical regions with dissimilar energy potentials due to particular morphological features and/or timing in power generation. All of these combine to enable countries to get the most from their resources, economic advantages in producing goods and services, international trade and ultimately to economic growth to achieve development goals, all while preserving the environment. Thirdly, cross-border power transmission integration resembles shared management of resources. As such, some large bi- or multinational power undertakings would not have been executed if participating countries had not agreed on how to use common resources, how the facilities involved would be operated, and how to distribute (and transport) power outcome. The latter does not mean much if it cannot be delivered where it is needed (the main problem of Paraguay, for instance). In fact, during the exploitation phase, the longest and much-awaited part of any power project, the issue of distribution is critical and always involves the transmission system. It can fairly be said that once the power is produced, who possesses the transmission lines also controls the power source. If, on

In most countries, particularly in those facing the pressing dilemma of sustainable development, the aforementioned barriers pose a considerable challenge; difficulties arise from a lack of technical, funding, and institutional capacity. In South America particularly, the promotion of new renewable energy sources is recent, limited and not always consistent. Although they have been progressively making their way into many countries' energy mixes, the region needs to realize that the best chance for the success of renewables is for nations to not confine themselves to their domestic realms, but to be integrated into a single regional smart grid.

As energy policies are a crucial factor for achieving sustainable development, and since the integration of renewable technologies is a central part of these policies, there is an inextricable link to the availability and feasibility of the technical means that can facilitate the efficient use of renewable sources with an acceptable risk and at a competitive level of cost. Do the transnational interconnection of South American power transmission networks represent such technically feasible, risk-acceptable, and cost-competitive means? The opportunities analysed by this research assist in answering that question affirmatively, while also highlighting the political and legal barriers that hinder its implementation. South America's energy generation schemes seemed to have internalized an urgent need for decarbonizing their respective economies and integrating renewables, despite countries acting individually and with different emphases and pace. Colombia, Brazil and Paraguay lead this trend by allocating renewable power a substantial share of their energy mixes, while Argentina, Chile, Uruguay, and Venezuela are not far behind[143], with Perú and Bolivia still further behind.

top of that, cross-border interconnections are involved, the matter becomes even more sensitive. This explains why, either in regard to relatively simple operational issues or the usually more complex question of outcome distribution, legal and practical arrangements between countries on the shared management of transmission systems facilitates the joint management of the power source. This is the case for Brazil and Paraguay in regard to the Itaipú hydro-electric station and the use of the river Paraná, and also for Brazil and Argentina in respect to the Garabí hydro-electric station and the use of the rivers Uruguay and Pepirí-Guazú. International interconnections normally serve as a guarantee for a country's own network's stability through the integration and interplay between the various components of the corresponding electric systems. The same configuration also improves the domestic network's reliability, for example, in terms of uninterrupted supply. On the one hand, countries enjoying a power surplus, either conventionally produced (Venezuela being an example) or coming from renewables (Uruguay, for instance) should fear nothing. On the other hand, deficit or non-energy producing countries should welcome reliable and steady supply, and be prompted to develop and integrate renewable energy-producing units into the common network.

143 The trend is even apparent in oil-producing countries like Venezuela, which although promoting energy integration frameworks abroad like PETROCARIBE, has also domestically considered introducing renewable sources into its mix.

This paper concludes that the transnational interconnection of transmission networks[144] serves effectively as a cooperative mechanism for energy integration and climate change abatement, and therefore assists in solving the dilemma of sustainable development.[145] Furthermore, the proposition of a simultaneous two-tier focus[146] by the energy sector in tackling such a goal is also confirmed.

144 South America has both vast and low-cost hydro, wind, and biomass power potential. Not surprisingly, the most favoured resource in the area continues to be hydropower, but wind power and biomass energy are progressively becoming cost-competitive. Geothermal and solar energy are also available, though at somewhat higher costs. This paper concludes that although promising, the efficient and rapid use of such potential for non-conventional renewable technologies in the region is jeopardized if adequate investment in power transmission infrastructure does not follow that in generation. This is particularly true when considering the intrinsic intermittent nature of renewable sources and because current marketable renewable sources meet their potential productivity and efficiency only when they operate on a large scale. The challenge of the so-called 'smart grids' is precisely this: to contribute to overcoming such limitations, through uniform regulatory frameworks, independent operation and international status, online data-exchange, improved load dispatching (aligning demand and supply) and coordinated operation, capacity and frequency back-up, enhanced quality and reliability of transport and storage capacity, as well as a timely and complete feedback process.

145 A major share of the potential for development lies in the energy sector, for it drives industrial productivity, boosts demand and indicates to economic agents the required capital investments, which are some of the reasons why a proper configuration of the energy matrix is of upmost relevance to a country. The paper's overview on this contended that, in terms of policy and in disregard to different macro-political approaches based on pre-defined development models (i.e., ranging from the centralized model applied mostly in Venezuela, Ecuador, Peru and Bolivia, through the social-market type models implemented by Brazil and Paraguay, to the more liberal forms used by Argentina, Chile, Colombia, and Uruguay), there is growing interest in the region for integrating renewables into the energy mix.

146 On one hand, domestically, by addressing energy matrix configuration issues. On the other, at the international level, setting up inter-regional power transmission networks.