SD for assessing electricity market integration

ISAAC DYNER, CeiBA, Universidad Nacional de Colombia, idyner@unal.edu.co
CAMILA OCHOA, CeiBA, Université de Lausanne, Switzerland, MariaCamila.Ochoa@unil.ch
CARLOS J FRANCO, CeiBA, Universidad Nacional de Colombia, cjfranco@unal.edu.co

ABSTRACT

Integration of electricity markets has started expanding under economic liberalization world-round. While some regions are managing better than others, lessons, both political and technical, highlight major challenges ahead to overcome.

In recent years, Panama, Colombia, Ecuador and Peru have decided to integrate their electricity markets; this will eventually create an enormous Latin American electricity exchange from Mexico to Chile. We developed a system dynamics model, linked to an iterative algorithm, to assess the likely effects of integration on both system expansion and security of supply. The model helps in understanding the logic of the long-term system behavior under different policies, assuming Market Coupling as the dispatch mechanism.

After analyzing simulations results under different scenarios, we conclude that integration of electricity markets may render great benefits regarding security of supply and efficiency; and consequently energy might be supplied at lower prices, using "cleaner" technologies. However, benefits largely depend on policy, regulation, and technical issues.

KEY WORDS: *Electricity Markets Integration, Simulation, System Dynamics, Market Coupling, Latin America.*

1. INTRODUCTION

Electricity markets have attracted interest among scholars in recent decades, since they have particular characteristics that make them different from other markets. Furthermore, as these markets are evolving all over the world, they still remain in transitional stages and far from equilibrium.

Given the importance of electricity in modern economies, electricity markets were initially developed as state-owned monopolies. However, intending to improve efficiency and to attract private investment, deregulation and privatization processes have taken place during the last 30 years (Barker et al. 1994; Borenstein and Bushnell 2000).

Recently, seeking to increase competition and to improve system reliability, many countries have developed cross-border interconnections (Pierce et al., 2006). Regions in the US, North Europe and Africa have moved to integrate their electricity systems; and more recently, Latin America is also heading in the same direction with the creation of three major blocks: MERCOSUR, Andean Community (CAN) and SIEPAC.

Even though the potential benefits of electricity markets integration include improvements in security of supply, economic efficiency and environmental quality (WEC 2005; Meeus et al. 2009; Gnansounou and Dong 2004; Hira and Amaya 2003; WEC 2008),), as well as the exploitation of complementarities regarding generation technologies and resource availability in each country, more research is needed to overcome the drawbacks of the integration processes (Bowen et al. 1999; WEC, 2005).

According to Wolak (2003), given the complexity of electricity networks, the optimum market design is still unknown; furthermore, it is not possible to infer the behavior of the system from experiences elsewhere. This paper investigates likely evolutions of electricity market integration under different policies, considering the particular characteristics of the region.

When it comes to real cases, there have been some successes in market integration - Nord Pool and PJM (Brunekreeft et al. 2005; Bowring 2006) -, but there have also been failures - Southern African (Gnansounou et al. 2007; Pineau 2008). Electricity integration is a long and complex process that involves technical issues related to transmission and generation, which may stretch from exchanges between two countries to the consolidation of a unique regional or supra-regional market (Serralles 2006; Meeus and Belmans 2008; OEA 2007).

In recent years, Panama and Colombia have agreed to integrate their electricity markets. This integration will link two significant regional markets: on the one hand the Central American market (SIEPAC), which includes Panama, and on the other hand, the Andean exchange that involves Colombia, Ecuador and Peru, which is already operating (CAN, 2002). The interconnection line between Panama and Colombia is expected to be in place by 2014, and will facilitate electricity flows between four countries: Panama, Colombia, Ecuador and Peru. When this happens, a great market will be created, incorporating countries from Mexico to Chile and also integrating Brazil, Argentina and the US.

Considering the agreement between the Andean Community and SIEPAC, the mechanism of integration between Panama, Colombia, Ecuador and Peru might be *Market Coupling*. While this integration will eventually include other countries in Central America and even Venezuela, in this paper we limit the analysis to the four countries aforementioned.

We developed a model to analyze the possible long-term dynamics of the integrated system. The analysis is mainly focused on the expansion of generation capacity under a market coupling mechanism, considering different policies regarding security of supply in neighboring countries and network expansion under different hydrological scenarios.

The model helps in understanding the behavior of the integrated electricity market from a systems point of view, with the novelty of an iterative dispatch algorithm –namely Market Coupling– linked to a system dynamics model; something that has not been reported in the literature before. The advantage is that it involves simultaneously a short-term model, that simulates the dispatch, and a long-term SD model of the evolution of installed capacity, facilitating the analysis of the long-term effects of a particular dispatch mechanism on the evolution of installed capacity and prices in the corresponding electricity markets.

Section 2 presents the rational for the integration of the four electricity markets in which the analysis is focused. Section 3 discusses the market mechanisms used to solve network congestion, particularly Market Coupling, which is the most likely scheme in the integration of Panama, Colombia, Peru and Ecuador. This is followed, in Section 4, by the description of the model that was developed to study the dynamics of this integration. Section 5 discusses simulation results and policy analysis; and finally, conclusions and recommendations are presented in Section 6.

2. WHAT MAKES INTEGRATING SIEPAC – CAN ATTRACTIVE

Panama, Colombia, Ecuador and Peru enjoy similar organizational structures for electricity, as they promote competition and are partly privatized, even though Ecuador is reversing reforms. They are also highly hydroelectric and they implemented a merit order dispatch mechanism. But what make integration between these countries interesting are their complementarities in terms of resources availability.

As shown in Figure 1, the integration of these four countries extends interconnection to two larger blocks – SIEPAC (Central America) and CAN (Andean countries) – and further expands to MERCOSUR and South America, as well as to Mexico in the north, which is also linked to the US. Since time difference between Mexico and Brazil is four hours, the peak time is extended for the integrated system making it more efficient from the perspective of load utilization.

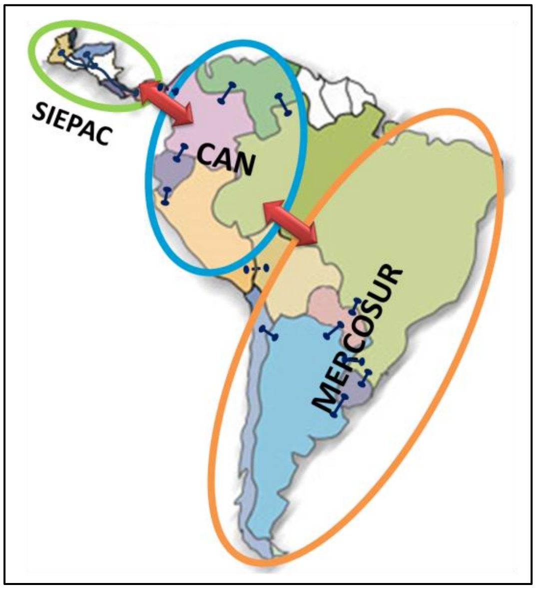

Figure 1. Latin America integration

Regarding generation capacity, the four countries are highly dependent on hydropower, as shown in the Table 1, so they must keep high margins of generation capacity to be able to satisfy demand during dry seasons.

	Hydro	Coal	Gas	Liquid Fuels	Peak Demand
Peru	3.145	0.438	1.981	0.425	4.199
Ecuador	2.017	0.498	0.807	0.540	2.785
Colombia	8.524	1.269	3.598	0.018	9.079
Panama	0.782	0.120	0.374	0.516	1.120

Table 1.Installed Generation Capacity (GW)

However, this fact may change with regional integration as the southern and northern countries of this region have complementary hydrological patterns, as shown in Figure 2, and the ENSO (El Niño Southern Oscillation) phenomenon has opposite effects in the four countries; that is, while droughts occur in Panama and Colombia high precipitations take place in Ecuador and Peru.

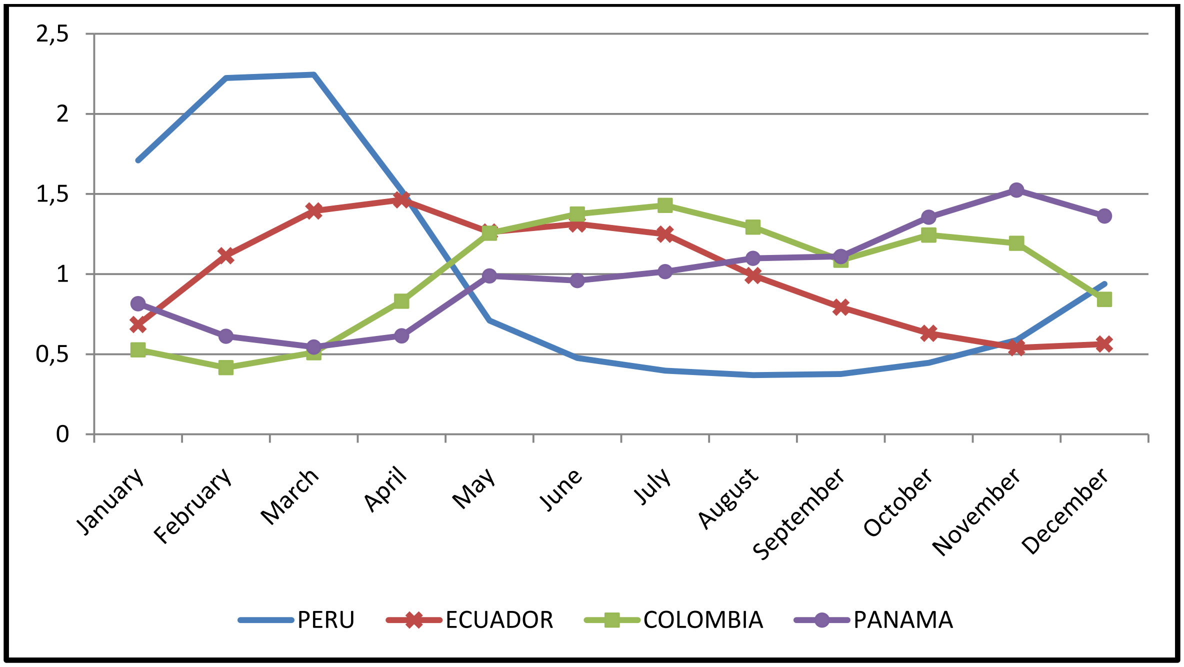

Figure 2. Hydrological Complementarities

To take advantage of these potential benefits, right policies ought to be designed and an appropriate market mechanism must be in place. Essential aspects of these have been discussed in previous works and presented in next section. This paper assesses the effects of implementing these through simulations, after presenting our model in Section 4.

3. MARKET MECHANISMS – CONGESTION MANAGEMENT

Given that transmission lines have limited capacity, congestion usually takes place, and capacity is not supplied to all the agents in the market place at the same price (Stoft 2002). To assign the available capacity and to assure system stability, a set of rules must be defined.

Considering that electricity prices are highly related to market structure (Wolak 1997), and that important signals are provided through prices; in order to achieve the objectives of market integration, mechanisms must be carefully design so they promote the *appropriate* expansion of transmission capacity (Rudnick and Zolezzi 2001).

There are different methods to assign transmission capacity in a congested network, including *Access Limitation*, *Priority Lists, Pro Rata, Implicit and Explicit Auctions, etc.* (ETSO 2006). For the SIEPAC – CAN integration, Market Coupling, a particular case of Implicit Auctions is proposed (CAN 2002; CAN 2009; ASEP - CREG 2009).

Nevertheless, there are concerns regarding its benefits, and the viability of the proposal is questioned because of the circularity problem involved in price calculation. This is why it is important to analyze the long-term effects of this mechanism taking into account, as stated by

Borenstein & Bushnell (2000), that short-term benefits are likely to be negligible or not-existent and the long-term benefits may be difficult to document in practice. This paper proposes an algorithm to deal with the circularity issue and to help assess the medium to long long-term effects of this on the system.

According to Stoft (2002), the architecture of the market must be specified before rules are set; however, it is necessary to prove the architecture during the design process, which requires the specification of rules. Likewise, the design must consider market structure as it can inhibit the proper development of some designs.

Against this background, model based methodologies seem appropriate for assessing the long-term effects of market integration. The interdependence of the elements involved suggest approaches such as system dynamics, that take into account feedback processes for representing and understanding system behavior and evolution. However optimization and econometrics have been the most frequently used tools to tackle problems related to market integration.

In this direction, Bowen (1999) develop a model to determine the optimal unit commitment and dispatch across the 12-nation pool of the Southern African Development Community; Gnansounou and Dong (2004) analyze the inter-regional integration of the electricity market in East China under three different strategies; Gnansounou et al. (2007) study the long-term capacity expansion in West Africa comparing regional integration with an autarkical strategy, using an optimization model.

Regarding econometrics, Amundsen et al. (1999) present an equilibrium model considering four countries: Denmark, Finland, Norway and Sweden, the model helps in evaluating the benefits of integration in the Nordic market under different policies for carbon emissions; Neuhoff and Newbery (2005) assess regulatory issues and compare market designs using game theory. Lundgren et al. (2006) present an econometric study of the price dynamics in the Nord Pool from 1996 to 2006. Ehrenmann and Neuhoff (2009) compare an integrated market modeled as a Stackelberg game and a separated market modeled as a Cournot game.

Yet, these approaches are largely static or present limitations to assess transitional stages or systems away from equilibrium; and they are unsuitable to analyze market behavior under these circumstances. We thus propose an innovative approach that deals with these issues and facilitates the analysis of the medium to long-term evolution of the integration of electricity markets. This involves a system dynamics model that simulates the capacity expansion in the four countries involved, linked to an iterative algorithm that simulates in each period the international dispatch of electricity.

The proposed system dynamics model allows the observation of the dynamic behavior of the system under different policies and scenarios, considering feedback processes; and the short-term dispatch algorithm overcomes the circularity problem in decisions, which cause problems for a game theory approach, giving as outputs prices and the electricity flows between countries and taking into account transmission constraints and the rules defined by the Market Coupling mechanism. A description of the model is presented in next section, followed by analysis of different policies and conclusions.

4. THE MODEL

The basic structure of the model is shown in Figure 3. The system dynamics model outputs, such as generation by technology and country and transmission capacities, are the inputs of the dispatch algorithm for each simulation period. The dispatch algorithm calculates the dispatch under Market Coupling. Likewise, the outputs of the dispatch under Market Coupling, basically prices and generation by technology and country, are the inputs for the system dynamics model.

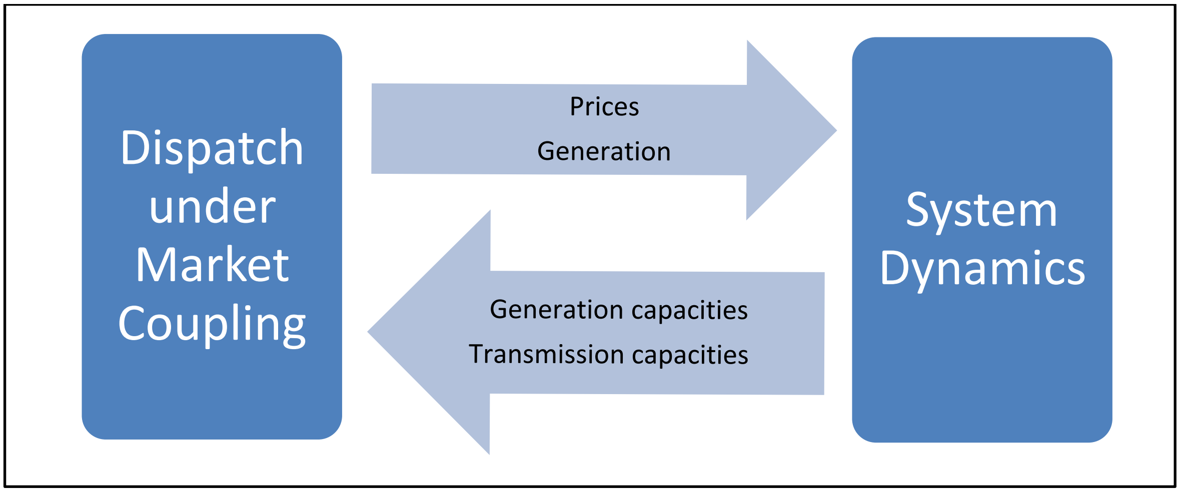

Figure 3. Basic Structure of the Model

The SD model was built in Vensim DSS32 Version 5.2a and the dispatch algorithm in Microsoft Visual Basic 6.5 for Excel. Both models are linked using a DDE (Dynamic Data Exchange) protocol. Details of the model components are presented ahead, beginning with the dispatch algorithm.

Dispatch under Market Coupling algorithm

When Market Coupling is used between two or three countries interconnected in serial, the flows and prices of electricity may be calculated using a relatively simple optimization model, or even analytically by crossing the offer and demand curves (Belpex 2009). Figure 4 shows how price is set when electricity flows between two countries A and B.

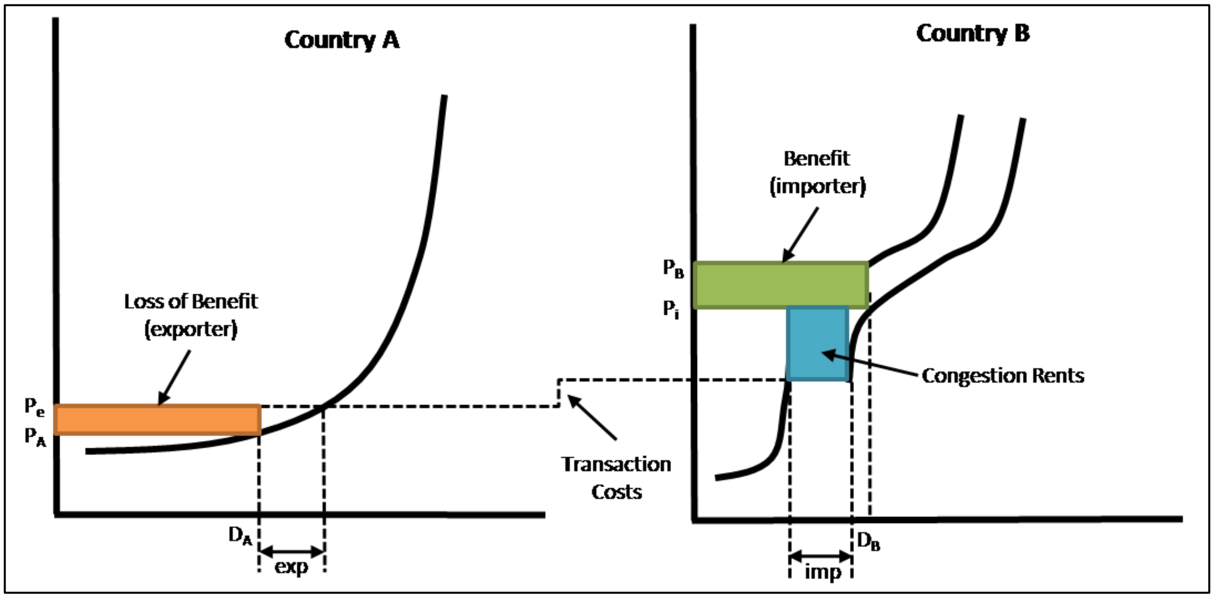

Figure 4. Analytical Calculation of Prices (two countries)

However, when four countries in serial are considered, as it is the case in this paper - Peru, Ecuador, Colombia and Panama - the direction of the flows cannot always be determined in a simple way, since the price in each country depends on the prices of the others, so the direction of flows between two countries depend on the flows between the other countries (a circularity problem) and thus, cannot be determined *a priori*.

For this reason, we decided to develop a model based on rules that iteratively calculates prices and flows between countries, taking into account international transactions according to the Market Coupling rules and transmission constraints. The structure of the algorithm is presented in Figure 5.

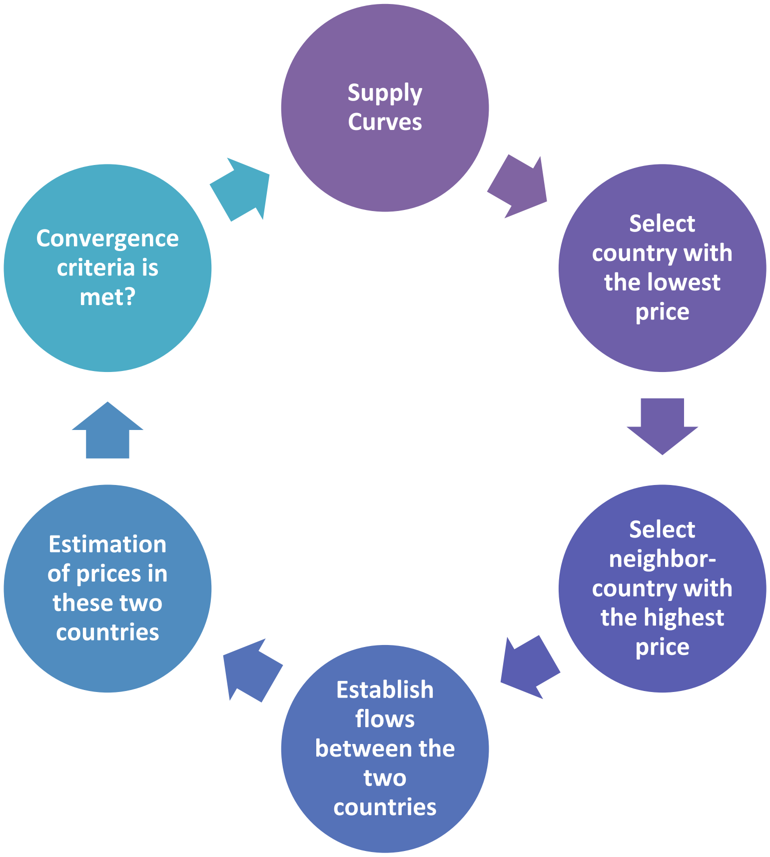

Figure 5. Structure of the dispatch algorithm

The algorithm incorporates an additional rule to the standard Market Coupling: it starts with the country that offers the lowest price and its neighboring-country with the highest price. This rule avoids "regretting" previous transactions, as there is no better option than buying for the least cost option and selling to the one that has the highest internal price, since congestion rents depend on the price difference between the two countries.

This model must be fed with the supply curves of the four countries involved and with an initial dispatch, without considering interconnections between countries, as a starting point.

System dynamics components

The system dynamics model is fed in each period with the outputs of the dispatch algorithm described above, and simulates the system expansion in each country. For each country we have a structurally identical component, differentiated by the initial conditions, i.e. development state of each country. The causal diagram describing generation capacity expansion in one country is presented in Figure 6. This structure is valid for each of the four countries involved.

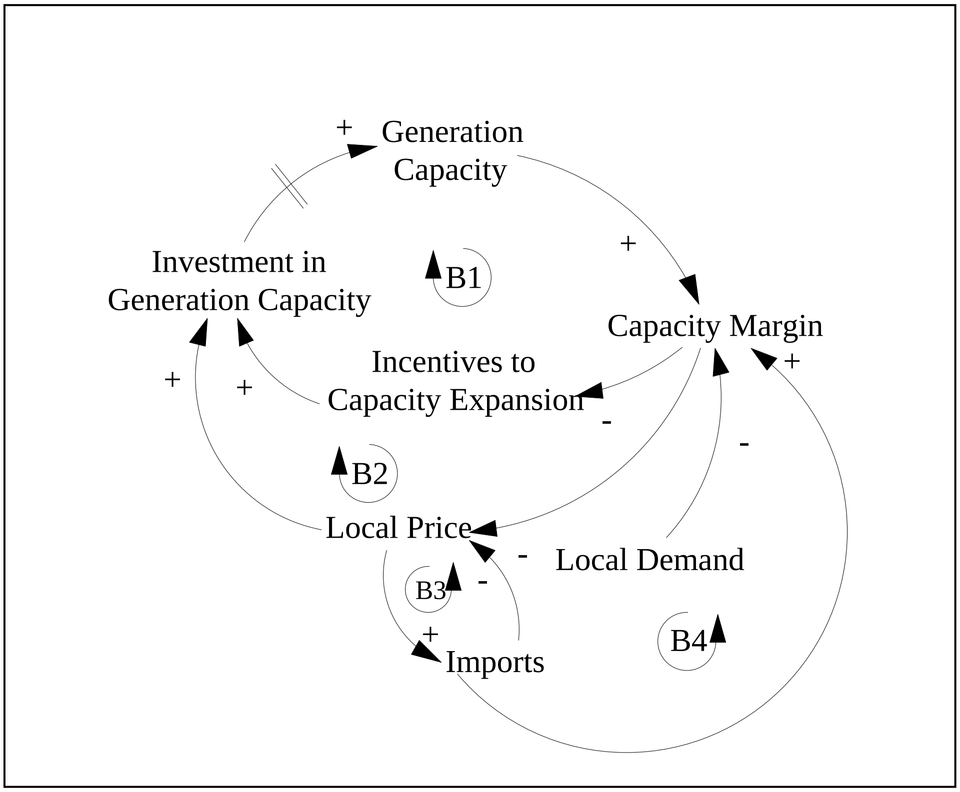

Figure 6. Causal Diagram: Generation Capacity Expansion

A country may rely on its neighbors regarding security of supply or may pursue a self sufficient policy, which determines the presence or not of the balance loop B4. Likewise, a country may expand its generation capacity considering the need of neighboring countries or just the local demand. Figure 7 presents the dynamics of the international network expansion.

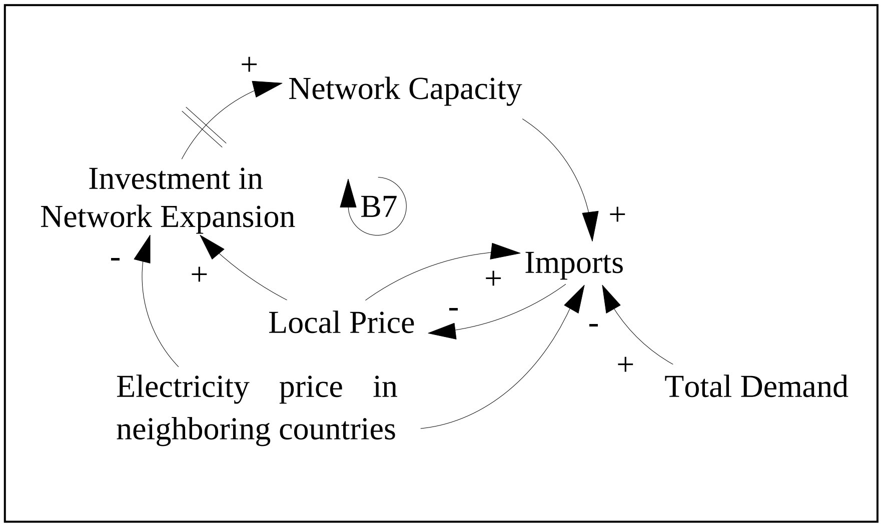

Figure 7. Causal Diagram: International Networks Expansion

Expansion takes place for economic reasons; however, when a country incentivizes network expansion (internationally) instead of new generation capacity, it may risk security of supply if other countries do not supply its required power, as it relies on interconnections instead of its own generation capacity.

Next section investigates the effect of integration in the mid to long-term dynamics of the electricity systems and assesses policy that seeks to attain certain levels of efficiency. For this purpose we use the model built with a time horizon of 15 years, from 2010 to 2025. This horizon is long enough to observe expansion of the different generation technologies (Hydro, Gas, Coal and Liquid Fuels), and the monthly step allows us to observe the seasonal variations of electricity supply, under different hydrological conditions.

5. POLICY ANALYSIS

There are two dominant themes in the region regarding electricity supply: mistrust on neighbor's dependency and openness to free market expansion. This is why we defined two axes for policy analysis: Networks expansion and Confidence on neighbors, which lead to the four scenarios shown in Figure 8.

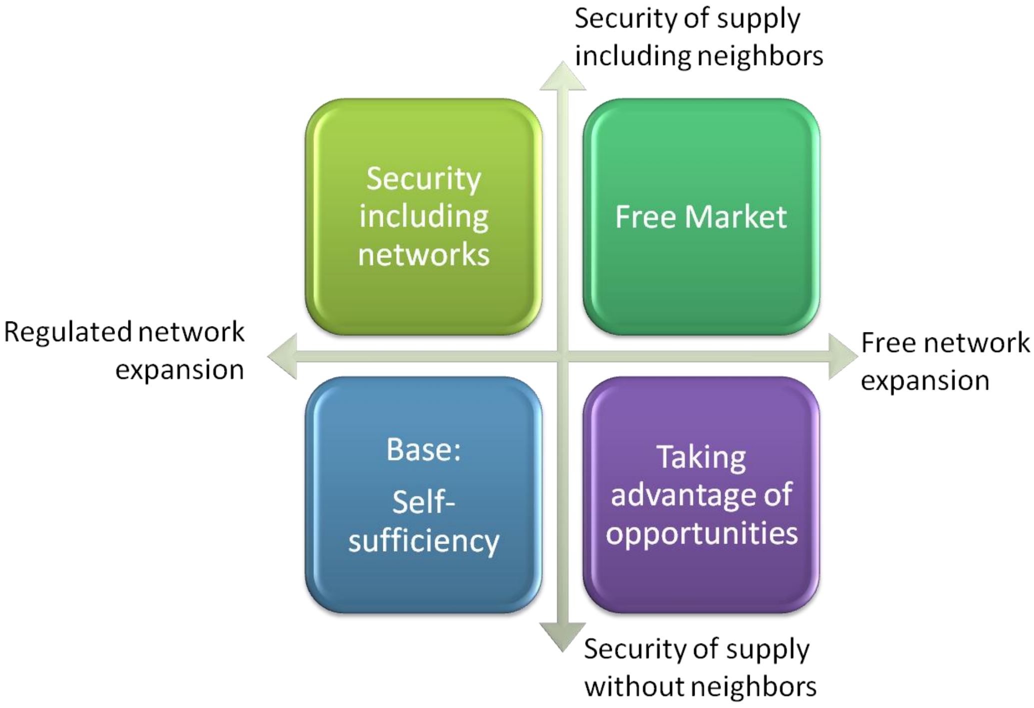

Figure 8. The Four Scenarios

In the *Self-sufficiency* scenario imports and exports are limited to the existing facilities and those under construction or in advanced planning stages. This has been chosen as the base-case scenario.

The *Security Including Networks* scenario considers imports and exports to calculate the capacity margin, which contributes to security of supply. However, as it considers only the already planned expansion of transmission lines, this scenario has little practical sense, and hence will not be analyzed in this article.

In the *Taking Advantage of Opportunities* scenario, the network is expanded for economical reasons and transactions take place according to price criteria; nevertheless, countries do not entirely rely on its neighbors, so the required capacity margin is preserved for independence without considering imports and exports.

In the *Free Market* scenario the network expands according to both economic and security of supply reasons, considering electricity imports and exports to calculate the system margin.

An analysis of these policies is presented next.

5.1. Base Scenario: Self-sufficiency

This scenario represents the actual state of the integration between countries and assumes that network expansion is limited to what has been committed at the outset. As shown in Figure 9, this does not support perfect competition among the countries involved, yet have significant benefits.

Figure 9 presents the average electricity prices in the region and the average utilization factor of networks. As may be appreciated, electricity integration is favorable in terms of prices, as most of the time the average price with interconnections is below the average price without these.

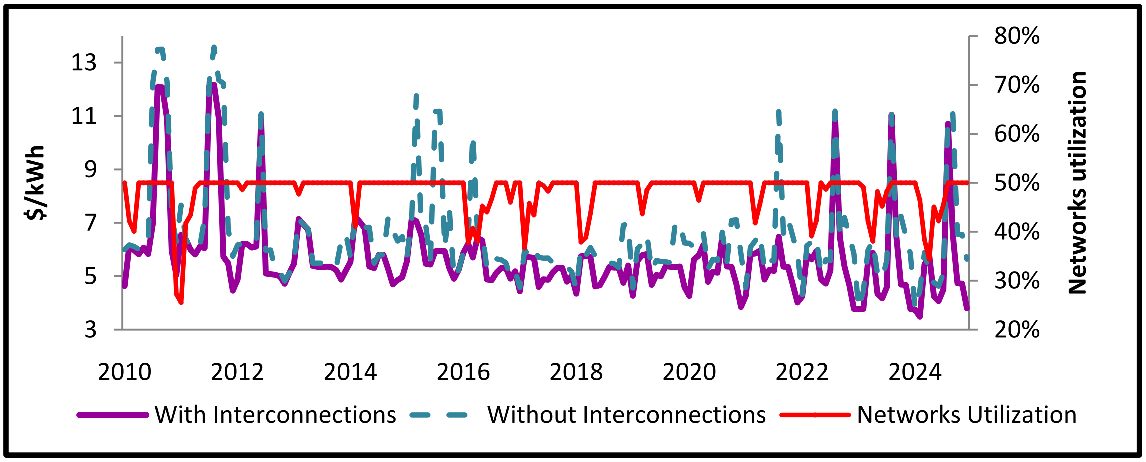

Figure 9. Average prices with and without integration and average networks utilization (Self-Sufficiency)

Regarding grid utilization, this is high considering that transmission capacity is only used in one direction between the two countries[1]. However, despite the high level of network utilization, there are price spikes in some periods due to grids congestion and/or lack of generation availability. We present next a scenario where network expansion is considered.

5.2. Taking Advantage of Opportunities (TAO)

In this scenario, generation is often substituted by imports, as shown in Figure 10. The transmission capacity between countries is expanded considerably because grid costs are lower than those of generation plants, what makes investment easy to recover, even at the expense of a low utilization factor.

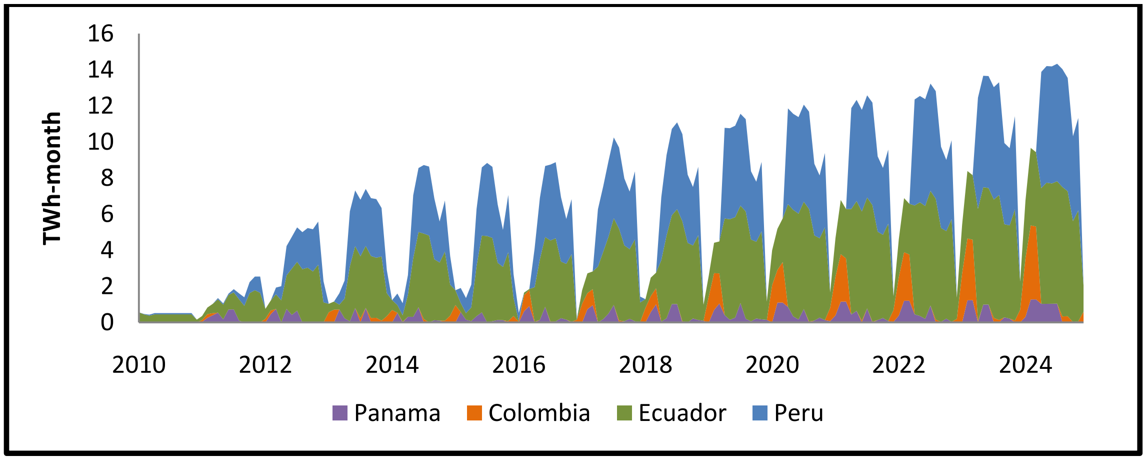

Figure 10. Imports by Country (stacked area graph)

Nevertheless, generation capacity is expanded in all countries, as shown in Figure 11. The reason is that there are incentives everywhere to keep energy independence.

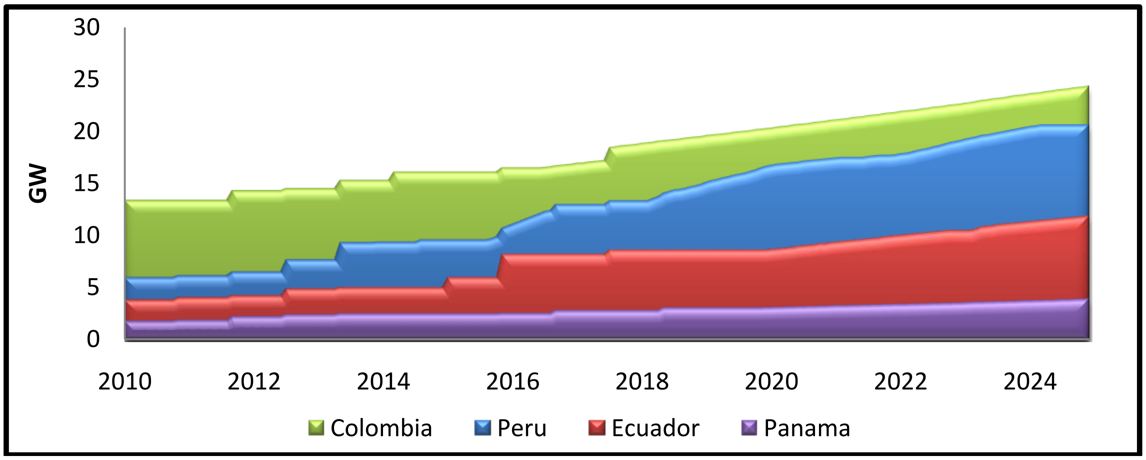

Figure 11. Expansion of Generation Capacity (TAO)

---

[1] Technical issues, such as the balance of the system, are not considered in this analysis.

As shown in Figure 12, integration leads to price fall in Panama, Ecuador and Peru; in some periods at the expense of marginal price hikes in Colombia. However, each country is capable of supplying its own demand without any problems most of the time.

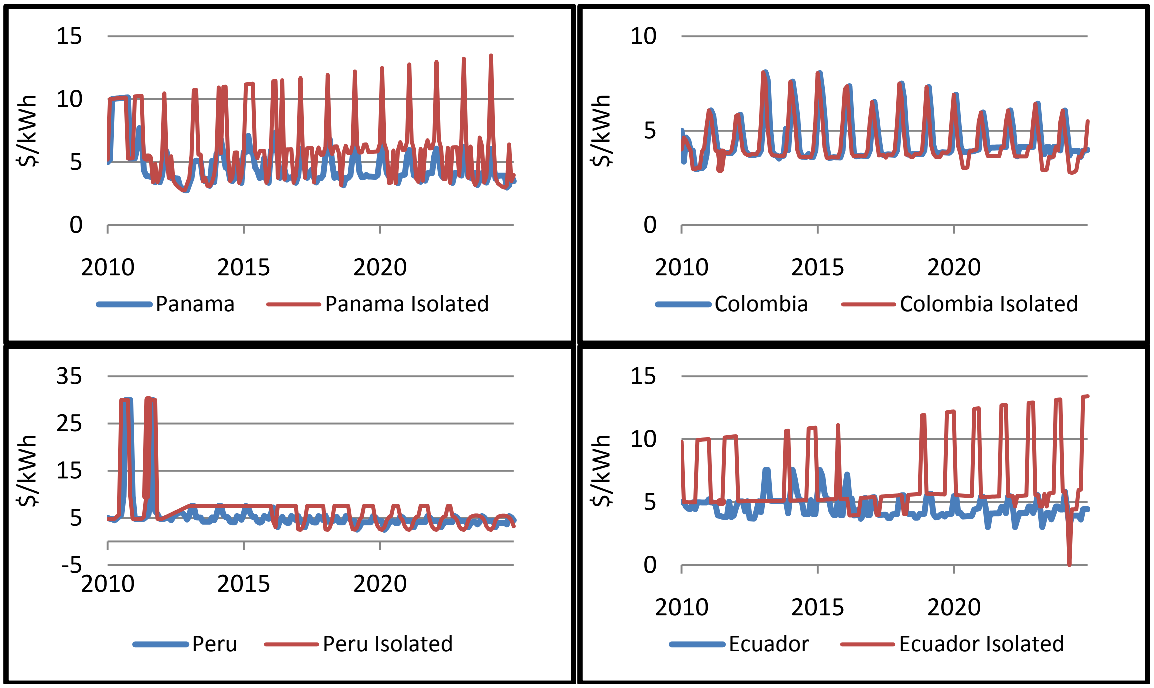

Figure 12. Prices (TAO)

As Colombia has the lowest generation costs, it covers a big amount of its neighbors' demands, and even Peru, that is not directly interconnected with Colombia, benefits from prices' fall in Ecuador due to imports from Colombia.

Figure 13 presents prices in Peru with and without considering interconnection between Colombia and Ecuador. Comparing these, we can verify that Peru benefits from the interconnection between Colombia and Ecuador, as stated before; this is caused by the fact that Ecuador has surpluses due to its imports from Colombia, which in turn may be exported to Peru.

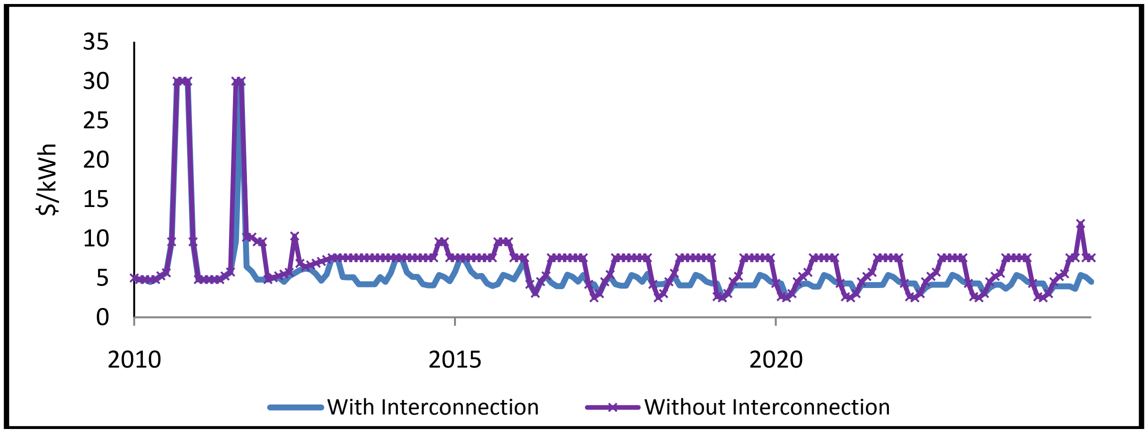

Figure 13. Peru Prices with and without the Interconnection Colombia – Ecuador (TAO)

Next scenario considers the possibility of relying on networks to maintain security of supply.

5.3. Free Market

This scenario assumes that security of supply may rely on interconnections and generation capacity of neighboring countries. Figure 14 shows that in this case expansion in generation capacity, except for what is already undergoing in the expansion plans (until 2018), is allocated differently with respect to other scenarios; in this case according to profitability indicators. Panama and Peru bring to an end its generation expansion and rather invest in grid expansion in order to maintain security of supply.

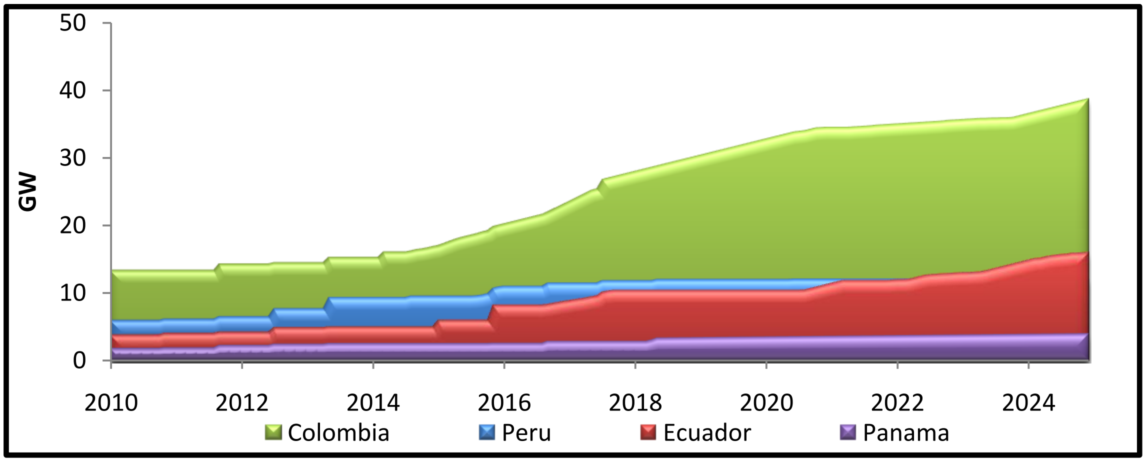

Figure 14. Expansion of Generation Capacity by Country (Free Market)

The allocation of the new generation capacity in this scenario is more efficient in terms of prices. This is observed in Figure 15 where average prices under the three scenarios considered in this paper are presented. The lowest average price, obtained under the Free Market scenario, is due to the fact that low cost hydro generation is largely expanded in Colombia and Ecuador. Further, given to the complementary hydrological patterns of these countries, it is possible to supply the entire region, most of the time, by using only hydroelectricity.

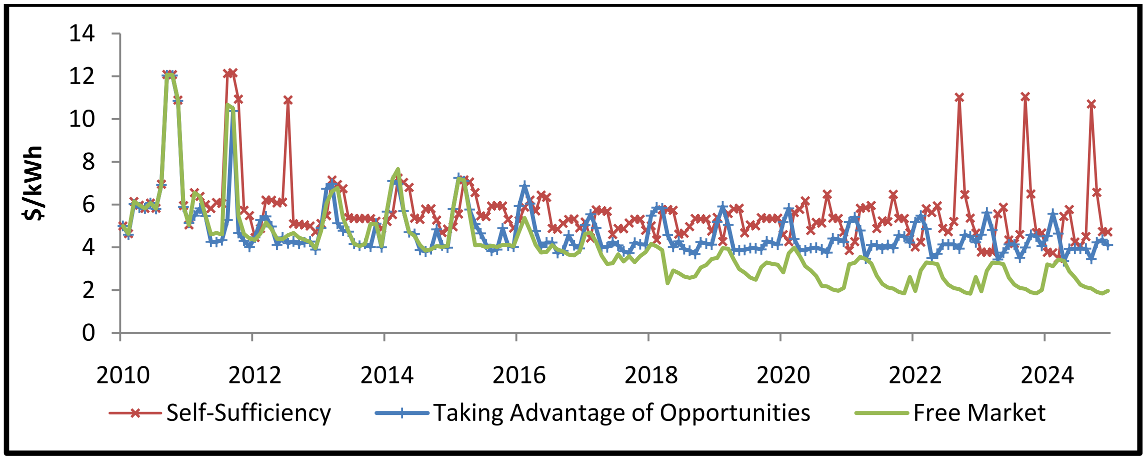

Figure 15. Average price in the region under different scenarios

As would have been expected in this scenario, countries may become energetically dependent on their neighbors. This is the case of Peru, as we may observe in Figure 16, which presents prices with and without interconnections (isolated) for this country under the Free Market scenario, compared with prices without interconnections under the two scenarios previously presented.

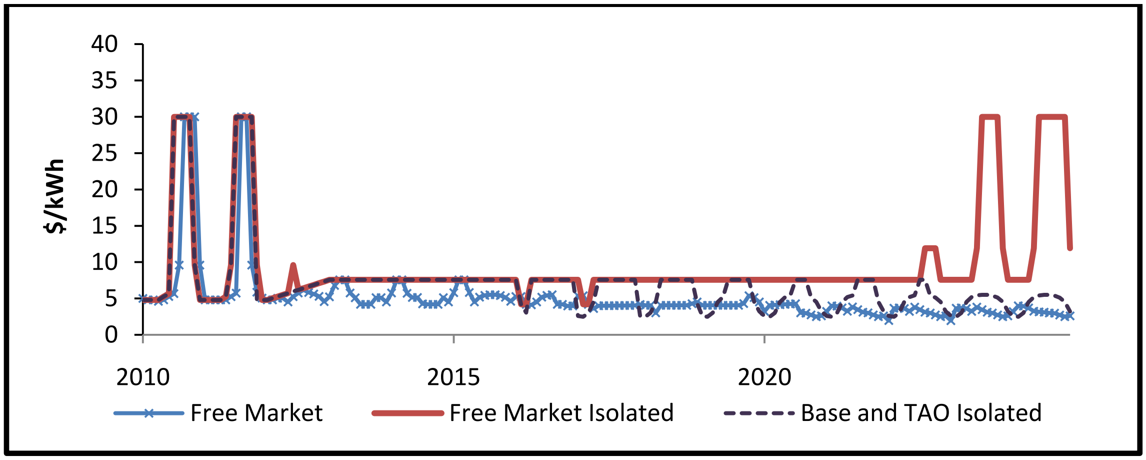

Figure 16. Peru's Energy Dependence

It may be observed that prices would be significantly higher if the country were suddenly isolated from Ecuador, and at the end of the simulation when internal capacity margin is low and no electricity may flow from its neighbor. This example shows the risks behind a policy of over-reliance in neighboring countries, which may lead to *overall* system efficiency at the expense of security of supply. In this sense, Jamasb and Pollitt (2005) states that "emerging regional electricity markets need to develop appropriate rules to ensure security of supply at the level of the region if the benefits of trade are to be realized, and free riding on the provision of joint security is to be managed".

6. CONCLUSIONS AND RECOMENDATIONS

An innovative approach was developed, combining a system dynamics model with an iterative algorithm for the dispatch using a Dynamic Data Exchange protocol (DDE), which together simulate the long term behavior of the markets involving the short-term dispatch. The model can be used to analyze different policies considering different scenarios in the integration of four countries, such as Panama, Colombia, Ecuador and Peru, and observe the possible influences over the evolution of the installed capacity, which is highly related with security of supply.

The model helps in understanding possible behaviors of the system and also identifying key factors that should be taken into account when considering electricity integration. In the tested case, regional electricity integration might bring great benefits regarding supply costs by taking advantages from complementarities between countries if the right policies are in place. Additionally, it may create favorable conditions for investment in generation capacity with cleaner technologies, as it increases market size and competition.

However, a country may result adversely affected if subsides or systems price/cost are not carefully studied, as they may significantly impact international trading and countries may end up subsiding external generation or demand.

Given the high hydroelectric potential of the region, the variables related with hydrology and water valuation have important implications for the system behavior, and make it vulnerable to external and unpredictable factors such as the weather. However, it makes it possible to supply demand at low costs taking advantage of hydrological complementarities between countries.

Summarizing, a lesson learned from this exercise is that regional electricity integration may render great benefits if the system in question is well designed and if the right policies are in place. However, special care ought to be considered in terms of the limits of overconfidence in neighboring countries, as technical issues or otherwise may arise. Finally, the broad approach proposed in this paper may be extended for applications elsewhere.

REFERENCES

Amundsen, Erik S., and Lars Bergman. 2007. Integration of multiple national markets for electricity: The case of Norway and Sweden. *Energy Policy* 35, no. 6 (June): 3383-3394.

Amundsen, Erik S., A. Nesse, and S. Tjotta. 1999. Deregulation of the Nordic power market and environmental policy. *Energy Economics* 21, no. 5 (October): 417-434.

ASEP - CREG. 2009. Acuerdo entre la Comisión de Regulación de Energía y Gas de Colombia (CREG) y la Autoridad Nacional de los Servicios Públicos de Panamá (ASEP).

Barker Jr., J., Dunn Jr., W., & MK, S. 1994. Practical Considerations in Reestructuring of Electricity Supply Industries. In *From regulation to competition: new frontiers in electricity markets*, ed. M. A. Einhorn, 151. Springer.

Belpex. 2009. Market Coupling. http://www.belpex.be/index.php?id=4.

Borenstein, Severin, and James Bushnell. 2000. Electricity Restructuring : Deregulation or Reregulation ?

Bowen, B., F. Sparrow and Zuwei Yu. 1999. Modeling electricity trade policy for the twelve nations of the Southern African Power Pool (SAPP). *Utilities Policy* 8, no. 3 (September): 183-197.

Bowring, Joseph. 2006. The PJM Market. In *Electricity Market Reform*, ed. Fereidoon P. Sioshansi. Elsevier.

Brunekreeft, G., K. Neuhoff, and D. Newbery. 2005. Electricity transmission: An overview of the current debate. *Utilities Policy* 13, no. 2 (June): 73-93.

CAN. 2002. Decisión CAN 536. http://www.comunidadandina.org/normativa/dec/D536.htm.

---. 2009. Decisión 720. http://intranet.comunidadandina.org/Documentos/Gacetas/Gace1769.pdf.

Ehrenmann, A., and K. Neuhoff. 2009. A Comparison of Electricity Market Designs in Networks. *Operations Research*: 274–286.

ETSO. 2006. *An Overview of Current Cross-border Congestion Management Methods in Europe*.

Finon, Dominique, and Elliot Romano. 2009. Electricity market integration: Redistribution effect versus resource reallocation. *Energy Policy* 37, no. 8 (August): 2977-2985.

Gnansounou, E., H. Bayem, D. Bednyagin, and J. Dong. 2007. Strategies for regional integration of electricity supply in West Africa. *Energy Policy* 35, no. 8 (August): 4142-4153.

Gnansounou, E., and Jun Dong. 2004. Opportunity for inter-regional integration of electricity markets: the case of Shandong and Shanghai in East China. *Energy Policy* 32, no. 15 (October): 1737-1751.

Hira, Anil, and Libardo Amaya. 2003. Does energy integrate? *Energy Policy* 31 (July): 185-199.

Jamasb, Tooraj, and M.G. Pollitt. 2005. Electricity market reform in the European Union: review of progress towards liberalization & integration. MIT Center for Energy and Environmental Policy Research.

Lundgren, Jens, Jörgen Hellström, and Niklas Rudholm. 2006. Multinational Electricity Market Integration and Electricity Price Dynamics, no. iv.

Mañé-Estrada, Aurèlia. 2006. European energy security: Towards the creation of the geo-energy space. *Energy Policy* 34, no. 18 (December): 3773-3786.

Meeus, L., L. Vandezande, S. Cole, and R. Belmans. 2009. Market coupling and the importance of price coordination between power exchanges. *Energy* 34, no. 3 (March): 228-234.

Meeus, Leonardo, and Ronnie Belmans. 2008. ELECTRICITY MARKET INTEGRATION IN EUROPE. In *16th PSCC, Glasgow, Scotland*, 14-18.

Neuhoff, K, and D Newbery. 2005. Evolution of electricity markets: Does sequencing matter? *Utilities Policy* 13, no. 2 (June): 163-173.

OEA. 2007. Cooperación e Integración Eléctrica Regional en las Américas. http://www.oas.org/dsd/Documents/Cooperación e IntegraciónEléctricaRegionalenaAméricas.pdf.

OLADE. 2009. Sistema de Información Económica Energética SIEE. http://www.olade.org.ec/siee.html.

Pierce, Richard, Michael Trebilcock, and Evan Thomas. 2006. Beyond Gridlock : The Case for Greater Integration of Regional Electricity Markets. C.D. Howe Institute.

Pineau, Pierre-Olivier. 2008. Electricity sector integration in West Africa. *Energy Policy* 36, no. 1 (January): 210-223.

Pineau, Pierre-Olivier, Anil Hira, and Karl Froschauer. 2004. Measuring international electricity integration: a comparative study of the power systems under the Nordic Council, MERCOSUR, and NAFTA. *Energy Policy* 32, no. 13 (September): 1457-1475.

Rudnick, H., and J. Zolezzi. 2001. Electric Sector deregulation and Restructuring in Latin America: Lessons to be Learnt and Possible Ways Forward. *IEE Proceedings online no. 20010230*. http://web.ing.puc.cl/~power/paperspdf/rudnickzolezzi.pdf.

Serralles, R. 2006. Electric energy restructuring in the European Union: Integration, subsidiarity and the challenge of harmonization. *Energy Policy* 34, no. 16 (November): 2542-2551.

Stoft, S. 2002. *Power System Economics: Designing Markets for Electricity*. Ed. Wiley-IEEE Press. USA.

WEC. 2005. *Regional Energy Integration In Africa*.

---. 2008. *Regional Energy Integration in Latin America and the Caribbean*.

Wolak, Frank A. 1997. Market Design and Price Behavior in Restructured Electricity Markets: An International Comparison. *EASE* 8: 79-134.

---. 2003. Designing Competitive Wholesale Electricity Markets for Latin American Countries.