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Does size matter? Simulating electricity market coupling between Colombia and Ecuador

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ABSTRACT

Since the beginning of the liberalization era, the integration of electricity markets has been promoted in many regions, arguing that this will bring benefits in terms of security of supply and efficiency. However, little progress has been made in the last decades in most regions – with some successful exceptions such as the Nordpool – and more research is needed to determine under which circumstances those benefits are achievable. We develop a system dynamics model to analyze the potential benefits and risks of market coupling, and to improve the understanding of its implications on policy design. This model allows us to simulate the long term behavior of two interconnected countries under different interconnection scenarios and different policies regarding capacity payments. The analysis is focused on Colombia and Ecuador, which have been trading electricity for more than 10 years and offer an interesting case study given their complementarity in terms of hydropower supply. However, the results of the simulations show that this complementarity is not necessarily exploited. While the relative size of the countries determines the magnitude of the potential benefits of integration, the interconnector capacity plays a key role in achieving those benefits. Additionally, both factors significantly affect the outcome of policies such as the implementation of capacity payments. We conclude that capacity policies and integration policies need to be coordinated.

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1. Introduction

As part of the liberalization process, many countries around the world have decided to integrate their electricity systems. Motivations range from the desire to improve cohesion between countries – as in the case of the European Union, to requirements of the World Bank or IMF as a precondition for loans – as in Latin

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America and other developing regions [1]. But in terms of power supply, the objectives are quite the same in all regions: improving reliability, lowering supply costs, improving the use of resources, reducing carbon emissions, etc.

The achievement of these goals depends to a large extent on an adequate expansion of generation and transmission capacities, which in liberalized systems should be addressed through market design and the regulatory framework [2].

However, there is no agreement on what are the right policies, not even in terms of how much capacity is enough. Regarding transmission, some people argue that it is better to have ample capacity, while others are concerned about "gold-plating" the grid. The problem is that, on the one hand, too little capacity will endanger security of supply and could increase market power in generation [3]; but on the other hand, too much capacity will cost more than what people are willing to pay and will also affect the ability to recover fixed costs for both generation and transmission investments [4].

Regulation and appropriate incentive mechanisms are thus required in order to avoid, or at least limit, strategic behavior that may put reliability at risk, though some authors argue that a certain degree of market power must be allowed to enable recovery of fixed costs of infrastructure [4]; others claim this is wrong, since costs can be recovered by collecting scarcity rents and capacity payments [5].

The liberalization of electricity markets, which includes the unbundling of generation and transmission activities, creates new challenges for expansion planning, since a high level of coordination between agents is required in order to develop a system in which generation and transmission capacities are jointly optimal.

Furthermore, not only are generation and transmission investments interdependent, they are also affected by the regulatory framework. Thus, economic signals must be sent in order to coordinate both investment decisions. However, Pérez-Arriaga and Olmos [6] state that the interaction between transmission and generation expansion is a major unsolved problem.

But the regulatory issue gets even more complex when we consider cross-border transmission, as different market mechanisms and incentives may be adopted in each country. In this case, electricity flows and prices might be affected by these differences and a country may be adversely affected if it does not implement the right policies, since it could end up subsidizing its neighbors. This effect may be intensified when investment in generation is more profitable in one country than in the other, since the former will expand its generation capacity more and will thus be a net-exporter.

Therefore, national policies must take into account the interdependencies between neighboring countries, which may lead to unexpected and probably undesirable outcomes [7]. The implementation of price caps, fuel subsidies, taxes, and anything that may affect prices, is likely to have an impact on international transactions and to increase the risk of free-riders.

The aim of this paper is to improve the understanding of the implications of regional electricity market integration on the long term electricity supply, and on the effect of policies aimed at guaranteeing security of supply. For this, we developed a simulation model that allows us to analyze the evolution of two interconnected countries under different scenarios of interconnection and different policies regarding the implementation of capacity payments.

The analysis is focused on the particular case of Colombia and Ecuador; however, the model is easily adaptable to other countries by modifying the parameters (e.g. installed capacity, generation costs, etc.). Section 2 presents the main characteristics of the electricity system in these countries, which may have an impact on our results. Section 3 presents a brief literature review. The description of the proposed model is presented in Section 4, followed by the policy analysis in Section 5, the validation of the model in Section 6 and finally the conclusions and recommendations in Section 7.

2. Characteristics of the interconnection Colombia–Ecuador

The Colombia–Ecuador interconnection was inaugurated in March 2003, following the Decision 536 of the Andean Community [8]. This interconnection is part of a larger integration plan, which will eventually include Peru and Bolivia, which are part of the Andean Community, and also Chile and Panama, with which separate agreements are in place. However, the only interconnection that has operated fairly continuously, under market coupling, is Colombia–Ecuador. The others are either under construction (e.g. Colombia–Panama) or have been interrupted (e.g. Peru–Ecuador and Colombia–Venezuela) due to technical and/or political issues.

Colombia and Ecuador are currently interconnected by four transmission lines, with a total capacity of 500 MW, and are actively trading electricity. However, there are still some points under discussion, such as the allocation of congestion rents and the treatment of export demand. This is why a temporary agreement [9] is in place while the final rules are being defined.

The electricity markets in Colombia and Ecuador have similar technologies, dispatch mechanisms and transmission charges, among others, which has facilitated integration under market coupling. Nevertheless, in the last decade these countries have undertaken reforms aimed at guaranteeing security of supply without relying on imports from their neighbors, which may affect the further development of the interconnection as well as the benefits that may be achieved.

When the process of interconnection started, both countries where heading towards market liberalization and privatization. But the current situation is different. Ecuador is reversing the reforms, returning the responsibility of investments in generation to the state. This has led to very large hydroelectric projects, such as Coca Codo Sinclair (1500 MW), that would not have been

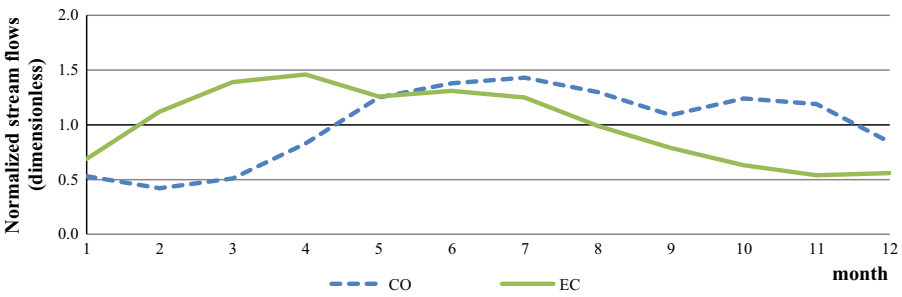

Fig. 1. Normalized mean monthly stream flows (each value in m^3/s divided by the mean of the series).