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Measuring international electricity integration: a comparative study of the power systems under the Nordic Council, MERCOSUR, and NAFTA

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Abstract

Many regions of the world feel the pressure to interconnect electric power systems internationally. Regional integrations of the electricity sector have become part of free trade and common market initiatives, though the steps individual national jurisdictions take towards developing integrated systems vary. In this article, we review three regions concerned with common market initiatives and at different stages of integration processes that involve infrastructural, regulatory, and commercial decisions. First, we examine the North European countries in the Nordic Council, then countries in the Southern Cone of South America in MERCOSUR, and finally Mexico, the United States and Canada, linked under NAFTA. This comparative study highlights the potential, but also the many hurdles, that electricity sector integrations face. The study suggests a framework for measuring the level of electricity sector integration that could be applied to other regions.

Keywords: Electricity; Integration; International trade

1. Introduction

In many regions of the world, neighboring countries feel the pressure to take steps towards interconnecting their electric power systems. Not all national and sub-national jurisdictions, however, follow the same steps towards, or achieve the same degree of, electricity sector integration. To what extent, then, have major regions, or major groups of countries, integrated their electricity sectors? One might expect that North America would lead the way in such a process, but that is not the case. Our review of the international literature on this topic, our analysis of recent electricity trade statistics, and our examination of market initiatives, show markedly different levels of progress in integration from region to region. By taking these supra-national contexts into consideration, we found that, unlike the Nordic countries that have almost fully integrated their electricity market and are more advanced than the other regions in infrastructure interconnection and regulatory compatibility, North and South American countries have only partially integrated these aspects of their electricity sectors.

El-Agraa's (1989) conceptualizes regional trade and integration of markets as steps taken on a continuum towards full regional integration. We extend his insight to assess the steps that regions have taken to integrate key aspects (dimensions) of common electricity markets. In each region, by using a similar classificatory approach, we examine integrative developments such as infrastructure interconnection, progression towards regional regulations, and commercial integration as aspects of a common electricity market.

On our integration continuum, each region can be assessed as having developed its integration process along three select dimensions, each sub-divided into four stages (Table 1). For instance, in determining a particular region's degree of physical infrastructure integration, one can categorize it as consisting of isolated national systems, as having cross-border transmission capabilities, as demonstrating coordinated

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Table 1
Integration continuum for regional electricity markets with location of each region along three dimensions

	Infrastructural integration		Regulatory integration		Commercial integration	
No regional integration	Isolated national power systems		Independent national regulation	MERCOSUR	National markets with local ownership	
↓	Cross-border transmission capabilities	MERCOSUR NAFTA	Compatible regulation	NAFTA	Cross-border trade and ownership	MERCOSUR
	Coordinated effort in transmission investment	Nordic C.	Coordination of regulatory agencies	Nordic C.	Regional spot market (unique price reference)[a]	NAFTA
Full regional integration	Fully integrated regional system operation		Regional regulatory agency		Regional secondary/ futures market	Nordic C.

[a] We recognize that long distances may result in different local prices at distinct transmission nodes.

effort in transmission investment (taking prices at generation and demand nodes into account), and as having developed a fully integrated regional systems operation. Such a fully integrated region would be managed with a common set of rules.

Furthermore, on this continuum, each region can be assessed as to what degree its regulation of the electricity sector has become integrated. Regulation in a particular region can be seen as having reached the stages of independent national regulation, compatibility in regulation, regulatory coordination, and establishment of the same regulatory framework consisting of a regional regulatory agency.

In addition, each region's status of commercial integration can be assessed according to four stages: a national market wherein local ownership prevails, a market that trades electricity cross-border and allows international ownership, a regional spot market with unique price reference, and a fully regionalized power market in which electricity futures can be commercially exchanged.

Using international electricity sector documentation and data from the year 2000, we have discerned Northern Europe's, South America's, and North America's situation by making more precise each region's extent of infrastructure, commercial, and regulatory integration through employing several sets of indicators. We assess the degree of international *infrastructure integration* by employing two indicators: (1) cross-border transmission capabilities and (2) the ratio of each country's share of cross-border capabilities over transmission capacity (Tables 2, 6 and 10). To show the extent of *commercial integration*, we employ a second set of indicators: (3) electricity trade, or more specifically electricity import and export statistics, and (4) the share of each country's production capacity that can be exported or imported (Tables 5, 9 and 13). A third set of indicators we use to assess *regulatory integration* shows (5) the degree of coordination among national and sub-national regulatory bodies and (6) the main role such regulatory bodies play in regulating international electricity market integration (for example, in regulating exports and imports, approving transmission lines, insisting on international transmission line access reciprocity, and regulating wholesale and retail trading) (Tables 3, 7 and 11). In addition to identifying the stage each region has already reached, we highlight the obstacles each region faces in achieving full integration of its electricity market.

This article is divided into three main sections, each containing the analysis of a different region. Section 2 will examine the degree of integration among the Nordic countries, Norway, Sweden, Finland, and Denmark. As will become evident, the Nordic countries' path of electricity market integration has been largely influenced by the policies of the Nordic Council and the practices of the Organisation for Nordic Electricity Power Cooperation (NORDEL) and the strong Nordic tradition of cooperation both among countries and between public and private enterprises. Such Nordic integration principles guided the progressive regional electricity market integration that accomplished economic efficiency and implemented both innovative energy and environmental policies in the absence of international regulation. Section 3 will examine the degree of integration among the countries of Argentina, Bolivia, Brazil, Chile, Paraguay, and Uruguay. We will show how significant transmission linkages and electricity trade, often involving imports and exports from major bi-national dam projects, have developed. Should MERCOSUR (Common Market of the South), which contributed to electricity market integration, again