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International Power Interconnections

Moving from electricity exchange to competitive trade

J. P. Charpentier and K. Schenk

International electricity markets are complex, and experience with them is limited. Purely physical exchange between countries already occurs where interconnection lines are in place. But trade requires more sophisticated organizational structures and coordination. Harmonizing national organizational structures is a first step toward the freer flow of power across borders. Unbundling national power sectors could help further in breaking bottlenecks, particularly in transmission. But coordination needs much attention. Here, the key issue for policymakers is this: What terms and conditions are needed to establish competitive regional electricity trade in which buyers and sellers can, at any time and regardless of their locations, negotiate power and energy contracts covering a wide spectrum of commercial products? This Note suggests some answers.

A SHORT HISTORY OF POWER TRADE

Historically, it was the search for more reliability that led small independent systems to group or pool together. Later, this pooling was extended to regional, interregional, and international systems. The first recorded international interconnection was a tie-line between Canada and the United States in 1901. Europe's first was in 1929, between Austria and Germany. Now, many regional interconnected systems are in operation—in Western Europe (UCPTE), Scandinavia (NORDEL), the United Kingdom, Central Europe (CENTREL, formerly IPS), Eastern Europe (UPS), North America (three U.S. networks—East, West, and Texas—and four Canadian networks), Central and South America, southern Africa (SADC), and Asia. More systems are under construction or consideration. And recent sector reform efforts around the world are prompting a new look at trade issues. The European Union, for example, has looked at open access and free transit in electricity networks. It has in mind not just time-honored "gentleman's agreements" among utilities to supply emergency power, but *the systematic trade of electricity on a competitive basis across national borders.*

Rationale and typology of international interconnections

Countries, companies, and even complete systems all seek to interconnect for three basic reasons: (1) emergency support, (2) savings on operating costs as a result of the structural differences of load profiles, and (3) savings in investment (and operating) costs from complementary means of production. Utilities often expect and achieve considerable operational savings through their interconnections with neighboring countries. For example, UCPTE, an association of Western European companies, saves between 3 and 10 percent overall thanks to regional interconnection. Similar savings are achieved in the United States through interconnection. But the potential for savings on investment should not be exaggerated. Most generation companies still aim for self-sufficiency in their territories and so are committed to a certain level of investment in any case. Thus, when utilities assess the need for expanding their generating facilities and transmission networks, they seldom take systematic account of the pos-

Acronyms and abbreviations

UCPTE is an association of 22 Western European companies.

NORDEL, formed in 1963, is an association of companies from Denmark, Finland, Iceland, Norway, and Sweden.

CENTREL is an association of companies from Hungary, Poland, and the Czech and Slovak Republics. Before the collapse of the Soviet Union, the association was known as IPS.

SADC, the Southern African Development Community, comprises 12 countries in southern Africa. A Southern African Power Pool (SAPP) has recently been formed.

sibilities of importing and exporting—although, increasingly, they should.

At present, five main types of exchange take place between interconnected partners:

- Firm energy sales—a continuous exchange of base load energy, which may include slight variations provided for in the contract, as well as interruptible power.
- Backup exchanges for emergency support.
- Marginal exchanges of spinning reserves.
- Occasional or *à bien plaire* (economy energy) exchanges, in which no guarantee of capacity is given. These arrangements are designed to take advantage of excess availability at advantageous marginal costs.
- Compensation exchanges made in kind. In the case of UCPTE, the exchange also is designed to compensate for financial losses caused by lags between the supply and the payment for the electricity delivered.

No standard model of electricity export contract has yet been developed—though contracts include certain common features, such as the technical characteristics of the power and energy to be delivered, the financial rates and charges, the effective dates and duration, and the cases of *force majeure*. The great majority of exchanges take place under bilateral agreements, often on the basis of long-term contracts (more than 90 percent of UCPTE exchanges take place under these conditions, and about 50 percent of NORDEL exchanges). The most active exchanges occur between companies or countries with a history of cooperation and mutual trust.

Strictly speaking, however, there still is no electricity "trade" in the full sense of that term—an immediate and competitive transaction between the buyer and the lowest-cost supplier, irrespective of geographic location.

Improved terms and conditions for trade

There are several prerequisites to achieving true electricity trade.

Need and willingness

Many governments have long viewed electricity as a specific strategic asset—one that, because it cannot be stockpiled, had to remain under state control. Therefore, governments have favored electricity self-sufficiency, often through vertically integrated, state-controlled companies. This concern goes a long way toward explaining the still quite limited volume of international electricity exchanges.

In many countries, however, recent restructuring in power sectors has introduced more flexibility into the operations of the entire electricity sector. For example, unbundling of power sector activities, along with increased competition in distribution, could well lead private distribution companies to look for the cheapest supplies—whatever their national origin. That could be a real stimulus to regional and international trade in electricity.

In addition, increased global competition is forcing electric utilities to operate their systems as economically as possible to maintain their country's or region's competitive edge. Under conditions of rigorous cost-cutting, self-sufficiency may be a strategic luxury that few utilities can afford.

Technical means

Whether transmitted by alternating current (AC) or by direct current (DC), electricity has two specific characteristics: it cannot be stored, and it does not flow according to the simple laws that apply to fluids and gases. Instead, electricity flows according to Kirchhoff's law, in the path of least resistance—a path that cannot necessarily be determined by contract. The same holds true during the accidental loss of a means of production. Therefore, correcting the disturbance requires close cooperation and good exchange of information between partners.

Synchronous AC network links are well adapted to short and medium distances and for heavily interconnected networks, but these systems are vulnerable. A major disturbance can lead to a system's complete collapse. Maintaining the stability of such a system requires great technical rigor and close cooperation between partners based on instant exchange of information.

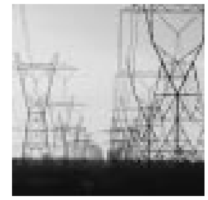
DC interconnection and transmission do not require such rigorous operation and cooperation. But the use of DC is reserved for exchanges over large distances and large transit capacities or for linking systems with different operational frequency or technical standards. Apart from the technical necessity of isolating networks with different technical characteristics, the decision about whether to use synchronous (AC) or asynchronous (DC) links is often purely economic. In general, a direct current line can be economically justified only beyond a certain distance (about 600 kilometers for aerial lines and 50 kilometers for underwater cables) and for high transit capacities. A DC line requires converter stations, which are expensive (about US$250 per kilowatt).

National institutions and regional operations

The accumulated experience of national structures for electricity exchange is very uneven.[1] Although it is therefore not possible to prescribe a universally applicable framework and industry structure to stimulate electricity trade, three factors seem to be critical.

First, it is essential to *harmonize the national power sector structures* of each partner country. This harmonization is even more important for the development of trade than is the type of structural organization. In NORDEL, for example, exchanges decreased rapidly in 1991–92 following the unilateral restructuring of Norway's power sector. Norway's net exports to Sweden dropped from about 12,000 gigawatt-hours (GWh) in 1990 to about 2,000 GWh in 1991 and 6,000 GWh in 1992. The deregulation and restructuring of the Swedish and Finnish electricity sectors along the lines of the Norwegian model, scheduled for 1995 and 1996, are seen as key to reviving and expanding electricity trading in the region.

Harmonized structures are particularly important for pricing systems. In a competitive market, only a pricing system based on bidding is viable because it does not require the publication and verification of detailed economic information. Traditional approaches based on marginal costs, profit-sharing, and "avoided" costs cannot work in a competitive environment because economic information will no longer be shared or easily verified.



Second, *a cooperative structure*—or *pooling arrangement*—between partners is necessary to provide a trading center and to oversee the physical stability of the entire system. International experience here is still limited. But the national experience accumulated in the tight and loose pools operating in the United States could be used as a model for international pooling arrangements. A *tight pool* is a group of production and transmission companies with a common dispatch center to ensure technical and economic management and coordination of the network. A *loose pool* arrangement, by contrast, has no common technical dispatch center. Instead, each company in the group has its own dispatch center. But a common information center supplies each member with information in real time on supply and demand and transmission constraints.

Whatever pooling arrangement is selected in a region, the most important technical objective is to ensure the physical stability of the entire system. At the international level, a common technical dispatch center seems utopian. A system of coordination similar to the American "loose pools" is more appropriate.

Third, *transit rights*—open access and free transit—are essential in both national and international systems. At the national level, ensuring transit rights requires separating production from transmission. Electricity transmission should be considered a transport service, not an energy activity. At the international level, to benefit from a regional competitive market, any buyer must be able to obtain supplies within the interconnected system from any location.

Regardless of the production and distribution structures in place, the transport sector enjoys a national monopoly because of the need for technical integrity and reliability. The transmission system must therefore be regulated to ensure that the pricing system provides correct signals to both the user and the transporter.

Wheeling rights, particularly their legal basis, need to be clearly defined. Trade will grow only if (1) transport is supplied by companies that specialize in this activity and therefore do not design their networks solely on the basis of local supply and demand conditions, as integrated companies do; and if (2) international or at least regional regulations are implemented to eliminate any possibility that transit will be refused by a third party.

Environmental issues are a potential constraint on transit. Electricity transporters have increasing difficulty getting permission for new lines. In the case of existing corridors, the transit capacity could be increased by using sophisticated electronic control, or the line could be transformed to direct current. DC lines have the dual advantage of allowing the transport of higher quantities of energy with less loss and reducing the need for right of way.

Pricing and contractual issues

In a framework that is more competitive than cooperative, prices based on marginal costs, profit-sharing, or avoided costs are difficult to use because competitors will no longer be willing to declare all their pricing information as they do in exchange-based systems.[2] Therefore, in an internationally competitive system, electricity pricing must be based on market bids, as in the British and Norwegian systems and in certain U.S. pools.

Setting tariffs for high-voltage transmission is a complex pricing issue. Several approaches to this issue are in use. In Norway, the pricing is based on transmission capacity. In the United Kingdom, prices are set on a lump-sum basis by geographic zone, similar to the principle used for setting taxicab fares in some cities. In Argentina, the price of transmission is based on the average marginal cost plus losses. Many formulas, most of them complex, are being studied.

Other issues still need to be resolved. Contracts must be carefully written, and probably standardized to accelerate their use. As in the gas sector, "take or pay" contracts for buyers that include penalties for the sellers may become the norm. One difficult problem will be monitoring the exchange of electricity and designing a system to resolve disputes. Proper metering will be essential, and it may be necessary to set up an international arbitration or court system to handle conflicts that arise. Experience in other energy sectors, such as gas, coal, and petroleum, and in the telecommunications and international banking sectors could help provide solutions.

This Note draws heavily from "A Review of International Power Sales," Industry and Energy Department Paper, Energy Series 42 (World Bank, Washington, D.C., 1991); and "Development of Regional Electric Power Networks" (World Bank, Industry and Energy Department, Washington, D.C., 1994).

1 The conclusions that follow are based mainly on the issues faced by such international interconnected networks as UCPTE, NORDEL, the U.S.-Canada links, and the England-Scotland links; the operating methods of a few large national networks, such as the NEPOOL (a tight pool in the eastern U.S. interconnected system) and MAPP (Mid-Continent Area Power Pool, a loose pool in the northwestern United States), the England-Wales interconnector, and some regional networks in India; and the results of a recent study commissioned by the World Bank.

2 If prices do not converge to marginal costs under bidding arrangements, this will be a sign that competition is not taking place.

J. P. Charpentier, Senior Energy Specialist, and K. Schenk, Power Engineer, Industry and Energy Department