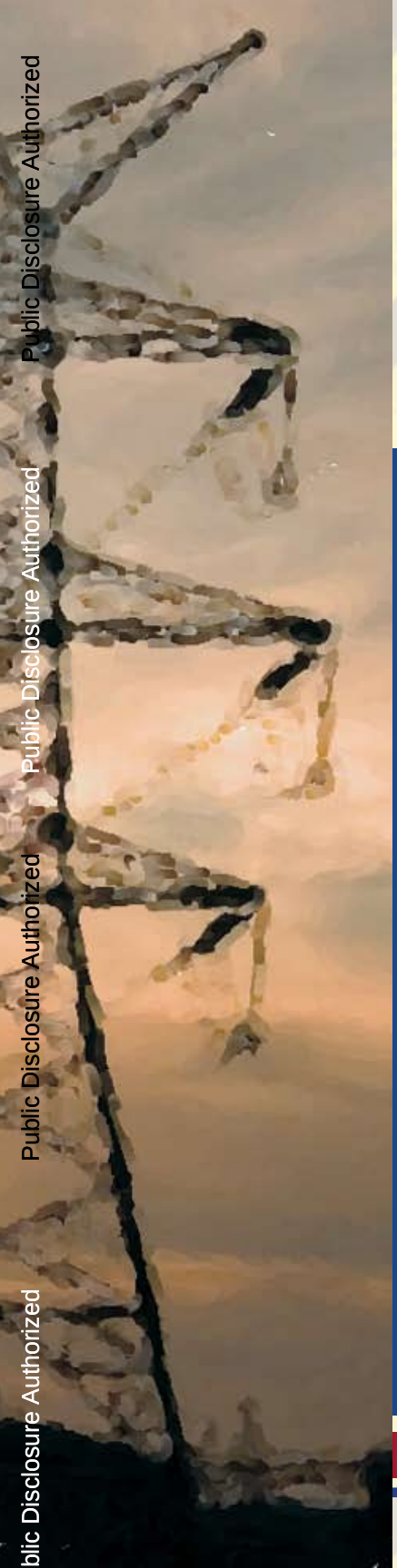

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Building Regional Power Pools: A Toolkit

Acknowledgements

This toolkit draws together resource material that has been developed and used primarily to facilitate wide-ranging dialogue between World Bank Group staff and their counterparts from the West Africa Power Pool (WAPP) organization; the original purpose was to inform the design of the WAPP Adaptable Program Lending Facility, endorsed by the Board of Executive Directors (in June 2005), as the umbrella under which several credits have been put in place by the International Development Association (IDA) to cofinance cross-border power transmission infrastructure among the member countries of the Economic Community of West African States (ECOWAS). The toolkit was prepared by staff and consultants of the Energy Anchor Unit, Energy Transport and Water Department of the World Bank's Sustainable Development Network. Funding for consultants involved in the preparation of this tool kit was provided from World Bank-administered "Consultant Trust Funds" of Denmark, Norway, and Switzerland. The authors would like to thank the WAPP organization and its member power utilities for their active cooperation in developing case study materials for this toolkit.

How to Use This Toolkit

Purpose: The purpose of the toolkit is to facilitate knowledge transfer among World Bank Group staff and clients on how to design and prepare projects that support the development of cross-border power transmission infrastructure within the framework of regional power pooling mechanisms.

Parts: The toolkit has a modular structure: The **"Road Map"** introduces the broad developmental context for the regional power pool initiatives, which the World Bank Group is supporting under the Infrastructure Action Plan. It describes the building blocks—a robust legal, regulatory, and organization, framework—for regional power pool initiatives and highlights critical success factors through a case study on the enduring experience of Nordic countries. The toolkit thereafter consists of an initial set of **"Modules"** that are intended to facilitate the transfer of know-how to World Bank Group staff and client country counterparts involved in the design, preparation, and appraisal of lending operations in support of regional energy integration initiatives in Sub-Saharan Africa, especially those associated with establishing fledgling power pooling mechanisms for Central, Eastern, Southern, and Western Africa.

Topics covered: This initial set of **"Modules"** cover such topics as (a) cross-border interconnection facilities (Module 1) and (b) system control and data acquisition/energy management systems (SCADA/EMS) (Module 2). Each of the two modules defines and discusses technical concepts underlying the application of performance-based project delivery approaches. For each module, case studies are also presented to illustrate key lessons of experience gained by some regional power pool organization in applying the concepts. An additional set of "Modules" is forthcoming to cover other key topics, such as the development of commercial "power exchanges" to administer bilateral and/or multilateral exchanges among three or more national power grids.

Getting the most out of the toolkit: Review the **"Road Map"** to get a general overview of critical success factors necessary to establish core legal, regulatory, and organizational building blocks of regional power pool mechanisms. Explore the NORDEL case study to discern some of the technical and nontechnical tasks that need to be collectively accomplished to put in place a common technical, operational, and commercial framework to underpin such regional power pool mechanisms. Identify key infrastructure development requirements for fledgling power pooling mechanisms of Sub-Saharan Africa, and ascertain from the relevant modules (technical concept notes and case studies) the "how to" of developing and applying, to the extent feasible, the appropriate performance-based project delivery approaches.

Building Regional Power Pools: A Road Map

Governments in several regions of the world are concerned that past efforts to develop national power grids capable of delivering reliable electricity supply to their citizens at affordable prices have fallen short of expectation. They are increasingly interested in new regional, bilateral, or multilateral approaches that emphasize better coordination and "pooling" of their efforts to create more robust regional power grids with the potential of lowering capital investment requirements across time and reducing system operational costs. Invariably, governments are pursuing a variety of potential benefits from developing a regional power pool, including:

- *Reduced or postponed costs.* These include lower operation costs due to economy energy exchanges and postponed and lower investments in power generation plants due to least-cost development of regional energy resources and reduced costs of maintaining power generation reserves.
- *Improved conditions on the supply side.* These include reduced coincident peak load of the regional power pool, compared with the sum of the individual peak loads for each national power grid; mutually utilized power generation reserves for the interconnected national power grids; increased robustness of power supply to meet unexpected events, such as load growth above forecast and/or delayed commissioning of power generation/transmission projects; and increased reliability.

Under the Infrastructure Action Plan, launched in July 2003, the World Bank Group in partnership with other international financial institutions is cofinancing regional infrastructure development projects that support developing country initiatives to integrate their respective national power grids so as to establish regional power pools. The focus of World Bank Group support currently includes regional power pooling initiatives in Africa (Southern Africa Power Pool and West African Power Pool), Southeastern Europe (Energy Community of South East Europe), East Asia (Greater Mekong Subregion Power Trade Organization), Central America (Central American Electrical Interconnection System), and South America (South American Regional Energy Integration Commission). The critical success factors for integrating the operation of national power grids through regional power pooling mechanisms are outlined below, in the form of a "Road Map" for establishing the core (legal, regulatory, organizational, and infrastructure system) building blocks.

A. Common Legal and Regulatory Framework

A critical success factor in creating regional power pools is the extent to which governments and the operators of their respective national power grids—*typically referred to as the transmission system operators or TSOs*—are able to define a common legal and regulatory framework to facilitate achievement of regional objectives. Based on global lessons of experience, the core building blocks in establishing a robust legal and regulatory framework derive from certain consensus-building activities that must be undertaken before any organizational activities get started. These involve the preparation, negotiation, and adoption of the following documents:

- **"Intergovernmental memorandum of understanding,"** granting permission for the utilities to make a contract and providing guarantees regarding obligations resulting from an interconnection contract, such as the release of convertible currency for the payment of energy purchases, binding arbitration, *force majeure*, and applicable law.
- **"Inter-utility memorandum of understanding"** among participating national power utilities, defining ownership of assets and other rights (for example, development of future substations and so on), and key principles to be followed on establishing, putting in place, and enforcing rules of practice covering technical planning, operations, and commercial aspects of regional power system integration.

B. Durable Framework for Systems Planning and Operation

Once consensus is achieved on putting place a common legal and regulatory framework, another critical success factor is to maintain flexibility in the setting up of a viable, multicountry, organizational structure to leverage the individual and collective capabilities of TSOs to (a) plan for and implement cross-border interconnection facilities, (b) harmonize the operational rules of practice for their interconnected national power grids, and (c) put in place a transparent, fair, and viable commercial framework for cross-border trading in energy services.

The basic mission of such TSO-led regional organizations is to promote equitable sharing of responsibilities for planning, developing, operating, and maintaining the technical hardware and software infrastructure required to assure safe, reliable, and cost-effective integration of national power grids. Invariably, such regional organizations evolve with time, as they build in-house capacity to accomplish their core responsibilities within clear, transparent, and harmonized frameworks for the following:

Box 1: Indicative System Planning Tasks

TSOs need collectively to identify prospective cross-border interconnection projects within the overall settings of national and regional least-cost power grid expansion plans, typically framed over a medium- to long-term planning horizon of 15 years or more. To achieve such goals, TSOs need to analyze collaboratively their national and regional electricity demand characteristics to underpin execution of the following system planning tasks:

◊ **Transmission master plan:** Prepare alternative plans for rehabilitating and expanding the interconnected national power grid and analyze these together with indicative power generation projects identified based on a regional least-cost power generation program, so as to select the most economic combination of generation and transmission expansion projects. Planning for prospective interconnection projects needs to take into account pre-agreed planning criteria, service quality, and reliability requirements and also include analyses of immediate and long-term measures to reduce technical and nontechnical losses in the interconnected national power grids. The outcome should include a list of recommended economically viable and environmentally sustainable projects, characterized to achieve both interconnection and reinforcement of national power grids, along with the sequence for their implementation and estimated costs.

◊ **Power dispatch system plan:** Evaluate the existing national capabilities for system control and data acquisition (SCADA) and associated telecommunications facilities for power system dispatching, and investigate any requirements to augment and/replace existing systems with state-of-the-art facilities, along with estimated costs and an implementation plan. Such reviews need to take into account the impact of recommended measures on the development of both the national and regional interconnected power grids.

- Planning and coordinating the development of interconnected national power grids
- Operating the interconnected national power grids to facilitate the exchange of energy services across borders.

Interconnection planning framework: Cross-border interconnection facilities (or simply, interconnections) are strategic assets for the integration of national power grids into a regional network. Adherence to proper electric power system planning approaches is fundamental to the role TSOs play in identifying and selecting cross-border interconnection projects for implementation in the context of regional integration of national power grids.

Benefits accruing from cross-border interconnection facilities, once built and put into operation, derive primarily from the multiplication of energy exchanges among national power utilities; in economic terms, such growth in cross-border energy exchanges should increase until the marginal benefits *from displacing more expensive capacity*

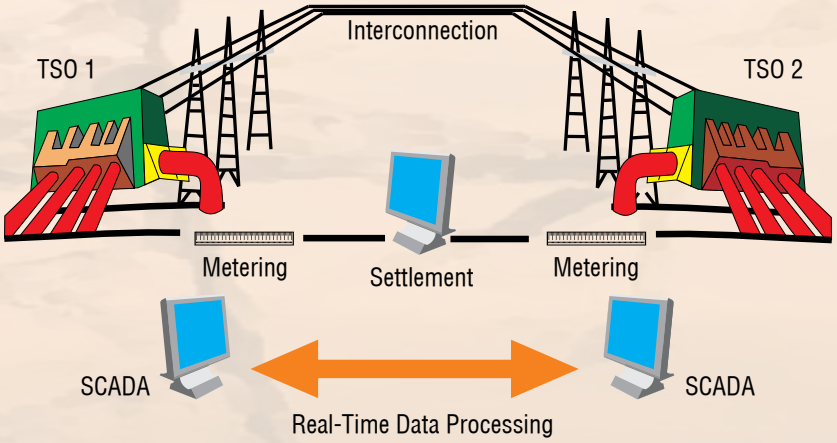
and/or from additional sales equal the marginal cost of transmission across the interconnected networks. The same applies to expansion of an interconnection, for which costs of new generation and transmission must be taken into account.

Systems operation framework: The integration of national power grids requires development of cross-border interconnection facilities through which national power utilities can exchange energy. Regional integration of national power grids also requires the acquisition and deployment of equally important hardware and software systems (metering, data collection, and real-time processing of information) necessary to ensure that the individual national power grids are able to function as one on a common operational and commercial platform (box 2).

Box 2: Operating Interconnected Power Grids

A cross-border interconnection facility basically allows electric power to be interchanged between two or more national power grids (see schematic below). A cross-border interconnection facility comprises not only a transmission line, but also ancillary facilities (switchgears, and control and protection equipment) in the adjacent substations or elsewhere in the national power grids to be connected. To compensate for the reactive power generated by the transmission line, additional reactors may be needed.

There is absolutely no guarantee that the adjacent national power grids can be operated together, no matter what the properties of the cross-border interconnection facility are. The operability of the interconnected national power grids do not depend only on technical properties, but also on decisions the responsible transmission system operators (TSOs) need to take on key nontechnical issues. TSOs perform a number of key functions in real-time, including (a) monitoring, control, and coordination of operations and (b) scheduling and settlement of energy exchanges between national power grids. To accomplish those tasks, TSOs rely on real-time data processing hardware and software systems, comprising supervisory control and data acquisition **(SCADA)** and energy management system **(EMS)**.



Although the physical costs of building and maintaining interconnections are fixed, operating costs typically increase as interconnections increase in voltage, length, and number; these costs must be borne whether or not the interconnections are used. In general, operating costs *arising from increased losses and maintenance costs, operating costs incurred to ensure greater harmonization of systems through adoption and enforcement of common standards of performance, and transaction costs from entering into, monitoring, and enforcing contracts* do usually increase as interconnections among national systems become more extensive. Moreover, the operation of interconnections will be affected by disturbances or unexpected load variations in each of the constituent grids. This makes necessary the development of a clear, transparent, and harmonized set of **"Operational Rules of Practice"** to be adhered to by the interconnected national power utilities, covering the following: (a) operation of the interconnection(s), (b) metering, accounting, and billing, (c) coordination of maintenance, (d) matching demand and capacity, and (e) determining and allocating losses.

C. Equitable Commercial Framework for Energy Exchanges

Once deployed, the operation of cross-border interconnection facilities inevitably opens up numerous opportunities for national power utilities to exchange a range of energy services that are germane to the delivery of reliable electricity supply at minimum cost, including the following: (a) lowering of generation capacity reserve requirements, (b) ability to achieve scale economies, (c) opportunity to interchange economy energy, (d) increased load and fuel diversity, (e) opportunities for sale of surplus firm energy, and (f) emergency support on major break-downs. Box 3 presents further details about the above types of energy services that can be exchanged.

In the early stages of creating a regional power pool, two neighboring TSOs usually initiate cross-border trading of energy services through a *bilateral cooperative framework,* which requires mutual sharing of commercial information on marginal operating costs and/or on the gains (cost savings) realized from energy exchanges. The basis for pricing bilateral energy exchanges for settlements under a "cooperative framework" is typically either the avoided costs of one national power utility or the sharing of savings between both national power utilities. Introduction of *multilateral energy exchanges,* however, inevitably increases the transaction costs of using such settlement approaches, because the degree of complexity increases, requiring greater requirements for verification. Eventually, with the unbundling and privatization of national power utilities, it becomes necessary to transition to a more competitive framework, that is, *multilateral competitive exchanges,* involving price setting based on bidding among buyers and sellers of energy services.

Regardless of whether cross-border trade takes place on the basis of cooperative or competitive frameworks, it is important for a clear, transparent, and harmonized set of **"Commercial Rules of Practice"** to be put in place and adhered to by the interconnected national power utilities, with the following aims: (a) set the commercial framework within which energy exchanges will be conducted, (b) agree on pricing principles, (c) oversee and settle transactions, (d) agree and enforce technical standards for metering, and (e) arbitrate between and among power utilities. Deployment of such commercial rules of practice also requires introduction of measures to enhance capabilities of TSOs (box 4).

Box 3: Overview of Cross-Border Exchanges of Energy Services

National power utilities can use cross-border interconnection facilities to exchange (or "trade in") the following types of services:

Reserve (generation) capacity supply services: Exchanges of reserve (generation) capacity among national power utilities may involve three types of services:

- ◊ Emergency supply at cost for a limited period (often about six hours)
- ◊ Scheduled outages to be covered by supply from another power utility
- ◊ A proportion of spinning (immediately available) reserve capacity.

In general, such reserve capacity exchanges enable each of the participating national power utilities to achieve acceptable levels of system reliability with lower reserve capacity margins than with independent operation of each system in isolated mode.

Economy energy exchange services: Exchanges in economy energy are mutually beneficial whenever a national power utility faces a higher than normal short-run marginal cost (SRMC) of generation at a given time, but can save costs by purchasing energy from another national power utility with a lower SRMC, after allowing for transmission costs. Differences in SRMC of national power utilities arise from lower fuel costs of generation and/or the availability of more efficient thermal generation units or from availability of hydroelectric energy in excess of firm (guaranteed) energy production levels, also referred to as "secondary energy."

Firm energy supply services: National power utilities can also make commitments to exchange a specified amount of electric power and associated energy on a "take or pay" basis in the medium or long term. Such firm energy exchanges usually contribute to base load supply or may be provided at a lower specified load factor in a given period. The actual cost per kilowatt-hour supplied is necessarily higher with firm than nonfirm energy, because the basis for pricing in the former (which is guaranteed and hence may require capacity additions) will be long-run marginal cost (LRMC), whereas the latter is typically SRMC. In general, long-term contracts for exchange of firm energy have a higher value than short-term contracts, because they can enable a power utility to defer building its own generation capacity.

Energy banking and interchange services: Opportunities for national power utilities to exchange energy in the long term may also arise from differences in both (a) the type and mix of generation capacity and (b) load shapes of each power system. For example, the required storage of a hydroelectric-based national power system in the dry season can be lowered by providing access to thermal power from another national power utility in the form of a commitment to supply a proportion of a fixed annual supply requirement during certain months or seasons. Alternatively, when the generation capacity of one power system is largely thermal based and the other is largely hydroelectric, the scope for cost savings through energy banking is also increased. Specifically, the thermal-based power system transmits energy to the hydroelectric-based power system during the former's off-peak periods, which in turn, obviates the need to produce hydroelectric power and thereby allows water to be stored ("banked") in reservoirs. At appropriate times, the banked water can then be used to produce hydroelectric power for transfer through a reverse "energy exchange" to meet peak demand in the thermal-based power system. For such energy interchanges, cash payments between national power utilities are made only if an outstanding balance remains at the end of the mutually agreed-on contractual period.

Power wheeling services: This is a separate service whenever energy exchanges involve three or more national power utilities, when the energy is being exported from one power utility, across another, for sale to a third. Wheeling charges include a contribution to fixed costs ("connection charge") and a charge for losses ("losses charge"), typically derived as follows:

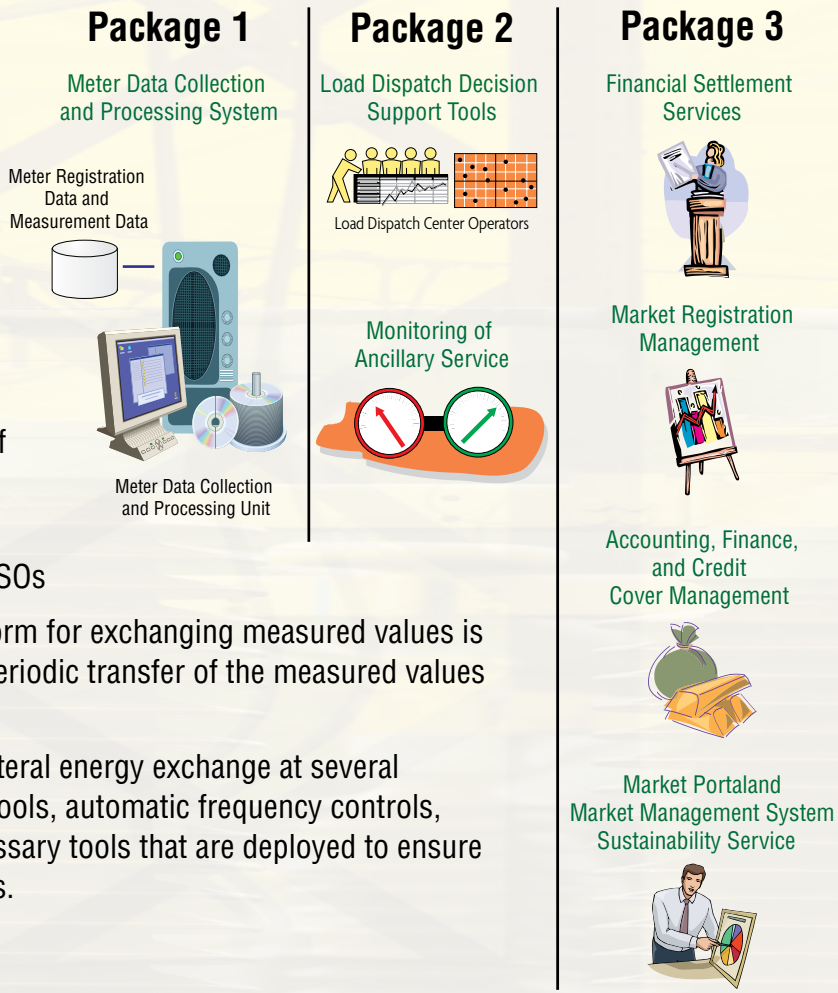
- **Connection charge.** The capital component can be met through an annual contribution to the depreciation of the particular interconnection line. This has the advantage that if the line ceases to be dedicated, for example, if other consumers along the line make use of it, the costs can then be shared among all beneficiaries.
- **Losses charge.** The losses incurred through wheeling can be met through a flat rate percentage of the energy transferred. This approach to short-run pricing is appropriate, although the actual measures used are relatively crude. They are based on a single estimate of incremental losses, which in practice are likely to vary and do not explicitly reflect the other short-run costs discussed above.

Box 4: Minimum Hardware and Software Required by TSOs

Transmission system operators (TSOs) need to acquire and use the following hardware and software packages, which enable them to implement bilateral and multilateral energy exchanges.

Bilateral cooperative exchanges. The complexity of the hardware and software needed for a bilateral power exchange arrangement depends on the existing infrastructure used by TSOs associated with any particular interconnection project. It usually is difficult for TSOs to reach agreement on all facets of data and information exchange required and to translate such agreements into detailed specifications for hardware, software, and communication infrastructure. TSOs, therefore, usually begin by defining minimum functional specifications for software and related hardware requirements:

- Production and consumption values from the parties (a spreadsheet can be used in the simplest cases and, in complex cases, outputs from the planning software are exchanged automatically)
- Real-time values for control and monitoring of the interconnection (e.g., supervisory control and data acquisition [SCADA] system values)
- Tools for tracking time deviation among the TSOs
- Metered values for settlement (the simplest form for exchanging measured values is a spreadsheet; complex solutions comprise periodic transfer of the measured values to the settlement platform).



When two TSOs have multiple agreements for bilateral energy exchange at several interconnection points, power system simulation tools, automatic frequency controls, and emergency management systems are all necessary tools that are deployed to ensure optimization of the cross-border energy exchanges.

Multilateral cooperative exchanges: In arrangements among three or more interconnected electrical systems that are planned and operated to supply power in the most reliable and economical manner for their combined load requirements, power pools are expected to achieve increased efficiency by selecting the least-cost mix of generating and transmission capacity, coordinating maintenance of units, and sharing operating reserve requirements. In the operation of the power pool, the complexity of the needed hardware and software, therefore, increases. Additional software for coordinating and dispatching ancillary services, production planning and monitoring, and economic analysis are required.

Multilateral competitive exchanges: The complexity of the energy exchanges, especially arrangements for pricing and settling commercial transactions on a real-time basis, increases dramatically when a competitive market regime is introduced. In addition to the above-mentioned requirements for multilateral cooperative exchanges, additional market management software systems are also required. The minimum software and hardware required for a multilateral competitive exchange include the following:

- Common metering solutions, automatic meter reading, and common settlement models. This includes definition of roles and responsibilities for all parties involved, definitions of protocols for data exchange, and creation of databases making the data available for users.
- Advanced SCADA and load dispatch tools. The market solution allows the participants a higher degree of control in scheduling their own resources. The dispatch will change character from being purely centralized to involving collection of a great deal of information from market participants before the dispatching.
- Monitoring of ancillary services (could be part of the SCADA solution).
- Power exchange hardware and software. This includes trading systems for the power exchange (auction trade or continuous trade), settlement systems, risk management systems, and systems for funds transfer.

Case Study on Nordic Countries

NORDEL, a regional organization of the transmission system operators (TSOs) of Nordic countries, exemplifies a well-functioning, robust regional organizational setup that has evolved through all phases of the almost 40-year process underpinning development of a common Nordic electricity market. NORDEL, considered "best practice" for multicountry power pooling mechanisms, has accomplished the following:

- **Systems operation framework**
  - Better use of the aggregate generation capacity of the Nordic countries to achieve substantial savings
  - Reduction in the required operating reserves of Nordic countries
  - Improved collective preparedness of Nordic countries in the event of emergencies and shortfalls, such as hydrological dry years
- **Indicative planning framework**
  - Common dimensioning rules for extension both of interconnections and national grids of Nordic countries
  - Common technical specifications for design of major thermal power stations in all Nordic countries
  - Construction of suitable and optimally designed international interconnections among Nordic countries
  - Improved engineering, economic, and managerial expertise through systematic exchange of information among power utilities of Nordic countries

This case study of the NORDEL setup presents further details, which are intended to inform similar initiatives to adapt the "Road Map" to the specific needs of other regions of the world, including among developing country clients of the World Bank Group.

NORDEL: A "Best Practice" in Subregional TSO Cooperation

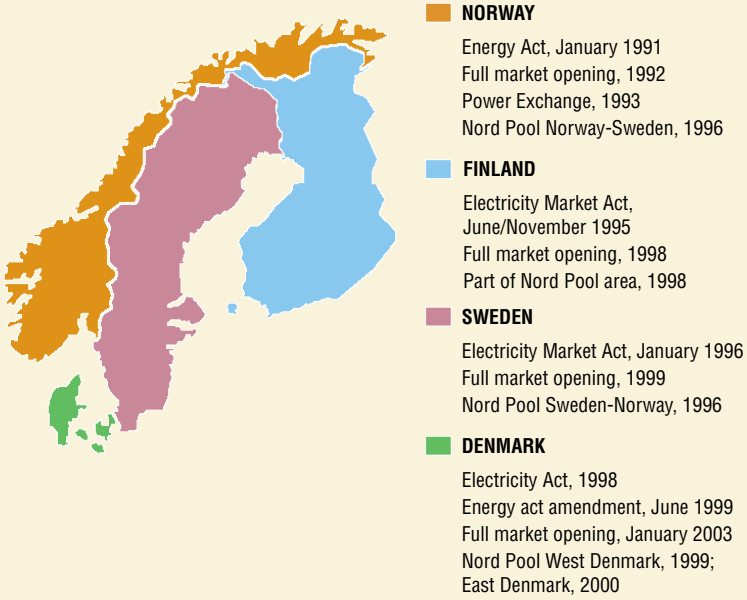
Evolution of NORDEL: This multicountry organization was founded in 1963 to promote cooperation among all power utilities of the Nordic countries (Denmark, Finland, Norway, and Sweden). NORDEL was established as a power industry advisory body, whose goal was to create and maintain conditions for efficient utilization of the interconnected national power grids of the Nordic countries to exchange hydro and thermal power.

From 1963 to 1990, the functions of NORDEL remained essentially unchanged. Whenever new opportunities or problems emerged, NORDEL was able to handle them and publish its recommendations for the benefit of participants in the national power grids of the Nordic countries. From 1990 onward, when Nordic countries began power industry liberalization measures, a debate also began about the future role of NORDEL. In 1995 the Nordic ministers of energy approved changes in policy to usher in the development of a common Nordic electricity market. It, therefore, became necessary for NORDEL to develop even closer cooperation among the Nordic TSOs by upgrading its governance structure from one based primarily on "gentlemen's agreements" to one based on a more formal legally binding agreement among all five Nordic TSOs. NORDEL focused its activities on resolving important technical and operational issues that were deemed necessary to facilitate formation of one common electricity market. A separate Nordic organization—Nord Pool—was set up to administer a common power exchange for the Nordic electricity market. Key milestones in the evolution of NORDEL to accommodate the changing Nordic power industry policy environment include the following:

- **1963–90:** A stable policy environment existed in this period for national power grids of Nordic countries.
- **From about 1990:** Power industry liberalization began. Politicians and regulators engage NORDEL.
- **1993 and 1998:** New by-laws were put in effect in both years. Large generators, mostly incumbents, remained members of NORDEL, but Nordic TSOs took over the leadership role.

Liberalization in the Nordic Electricity Market

Rapid electricity market opening in the 1990s



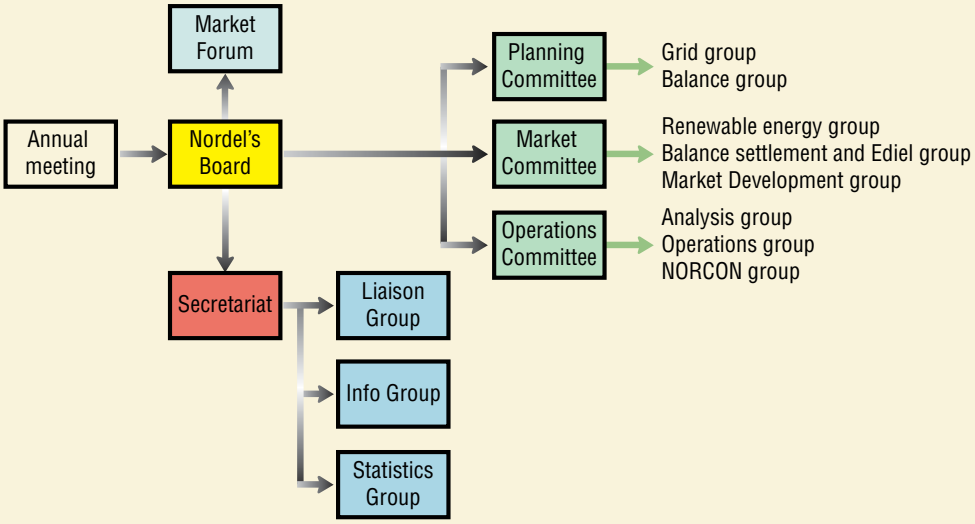
- **2000:** Changes were agreed to at the NORDEL annual meeting. From then on, NORDEL was reconstituted exclusively as an organization of Nordic TSOs and no other power companies were allowed as members.
- **Up to 2000:** NORDEL remained an advisory body in which the organization's governance structure was based primarily on "gentlemen's agreements."
- **From 2000:** NORDEL governance structure was transformed with introduction of legally binding agreements among the TSOs.

NORDEL's legal and regulatory framework: The inter-Nordic Transmission System Operation Agreement (TSOA) defines this framework, which incorporates the following main elements:

- Security standards
- Balance management standards
- Information exchange
- System protection schemes
- System services
- Principles for joint operation among the different subsystems
- Congestion management and managing capacity limitations
- Rules for power shortage
- Joint operation with other systems.

NORDEL's organizational structure: Even though the membership profile and governance structure of NORDEL

Nordel's Present Organization



had to change, the nature and scope of core tasks to be handled have remained almost unchanged. The NORDEL organizational structure has proven itself to be sufficiently useful and robust to handle the challenges of regional cooperation among TSOs.

The board of NORDEL is organized in the following way:

- Composed of one representative from each TSO, presently the chief executive officers
- Chairmanship shared, rotating every two years
- Chairman organizes the secretariat.

Nordel has three permanent committees:

I. **Planning Committee:** Its members are managers of planning functions for the various Nordic TSOs. The objectives and tasks of the Planning Committee include the following:
   - Achieve continuous and coordinated Nordic planning among the TSOs, so that the best possible conditions can be provided for a smoothly functioning and effectively integrated Nordic electricity market
   - Initiate and support changes in the Nordic power system enabling satisfactory reliability of system supply through effective utilization of existing and new facilities
   - Be instrumental in developing the Nordic power system in ways that are consistent with environmental sustainability. When planning transmission facilities, impact assessments must integrate the need to preserve and protect the natural environment.

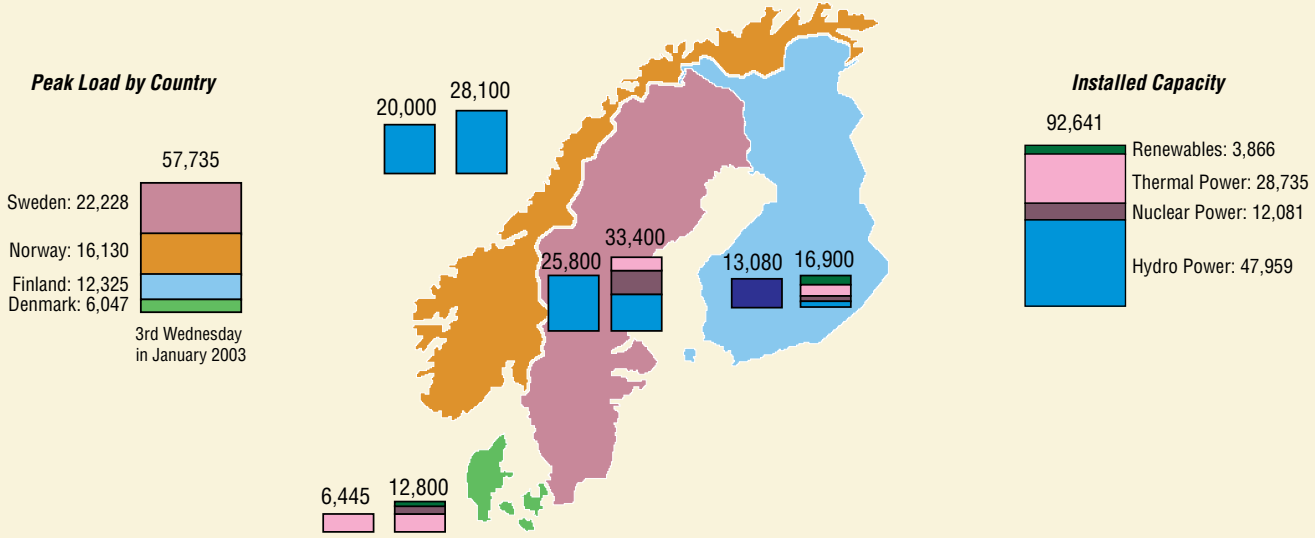
II. **Operations Committee:** The committee serves as a leading group for Nordic operational issues. Its members are the managers of operation for the Nordic TSOs. Committee objectives and tasks include the following:
   - Address technical system issues in the short term
   - Develop technical framework for grid operations
   - Encourage active dialogue with electricity market parties in their areas of responsibility
   - Coordinate operational cooperation among the TSOs
   - Promote utilization of the interconnected Nordic electricity transmission system for the market's needs, taking into account the agreed-on technical quality as well as operational and supply reliability.

III. Market Committee: Members are the managers of market divisions of the Nordic TSOs. The committee works with tariff and transit issues, congestion management, balance settlement, and renewable energy. Committee objectives and tasks include the following:

- ◊ Contribute to creating a borderless Nordic market for market players, thereby augmenting the market's efficiency and functionality.
- ◊ Contribute to formulation of rules of play in Europe to promote a positive market trend and efficient interplay within the Nordic market.

The figure below describes the 2003 power system characteristics of different Nordic countries that participate in NORDEL. Hydropower generation capacity in the region is significant, and due to variations in precipitation from year to year, it is profitable to exchange power between national power grids that have predominantly hydro-based generation capacity and those that have thermal-based generation capacity.

Installed Capacity and Peak Load in the Nordic Countries 2003 (Megawatts)



NORDEL Operational, Planning and Technical "Rules of Practice" (Precompetition Era)

I. **Operations:** These cover operational planning, load dispatch, system supervision, pricing of electricity exchanges, accounting for electricity exchanges, and information and statistics, as follows.

A. Rules and methods for operations: Dimensioning rules for the interconnected Nordic network have been laid down as the basis for the interconnected network planning and also as a guideline for interconnected system operations. The operating reserves in the Nordic network are pooled, and in this respect the networks are operated as one system. The operating reserves consist of spinning reserves and standby reserves. The spinning reserve is defined to cope with the regulating need within +/- 0.1 Hz and a single dimensioning fault likely to occur once every three years. A part of the spinning reserve, the regulating reserve is distributed among the countries in proportion to the annual energy consumption. The remaining spinning reserve and the standby reserve (the distributed reserve) are distributed among the three countries in proportion to the "dimensioning faults" that are defined for each country. The coordination has proved to be successful, and substantial economic savings are obtained due to the combined effect of coordinated network planning and operation.

In case of disturbances with greater frequency deviations, measures will be initiated automatically to prevent the system from disintegrating. These measures follow a coordinated plan that is based on continuous evaluation and adaptation. It covers automatic control of the high voltage direct current (HVDC) links, selective load shedding, and—in extreme cases—change over to isolated operation of the production units. Within the framework given by the required reliability of operation, total power production will be planned in such a manner that the costs of generation and unsupplied loads are kept to a minimum. The essential basic factor enabling correct decisions to be made as to the power exchanges with other utilities is correct calculation of the short-run marginal cost (SRMC) at any point in time, that is, calculation of the value of a small production increase or decrease in the system, assuming that the reliability of supply remains the same.

Comparison of the SRMCs of the various systems gives an indication of whether an exchange should take place or not and in which direction. This is always governed by the simple rule that exchanged power should always go from a system with a lower SRMC to a system with a higher SRMC. The variable production costs of a thermal power station can be divided into start-up costs, hourly costs (no-load costs), and MWh costs, all of which can again be divided into fuel costs and maintenance costs. The fuel cost used for operating optimization and SRMC calculation must, in view of what has been said about the meaning of the marginal cost, be the expected purchase replacement cost. Medium-term planning is necessary for overhauls, fuel procurement, and personnel requirements. The direct variable costs

of hydro power plants are so small compared to those of thermal power plants that they usually are disregarded in operational planning; however, a factor that must be taken into account is that the raw material, water, is not always available for power production at any given moment in unlimited quantities. If available, water is used instead of being saved in the reservoir, hydropower production must therefore generally be replaced by alternative production at a later time. The alternatives available are an increase in purchases from other utilities, a reduction of temporary power, or increased thermal power production if available in the system. The costs of these alternatives give a value of the water quantity in question—the "water value"—and it is assumed that the system will always be operated optimally on the basis of the knowledge of the situation available at any time. Since the system includes a number of random factors, above all the inflow to the reservoirs, the water value must be determined by probability calculations in the form of an expected value.

B. Load dispatch rules: The functions involved in an analysis of operational economy can in principle be said to include the whole planning process from the long-term planning of hydro and thermal power to load dispatching at any time. Hourly, weekly, and seasonal planning is mostly carried out differently depending on the varying needs of organizations within each utility company.

Economic production planning is normally made for different levels where the following factors are distinguished:

- Long-term planning of hydro and thermal power generation aimed at finding a strategy for three to five years primarily for hydro power production, special multiyear reservoirs, and thermal power generation.
- Seasonal planning, which means the tactics for the period from the next few weeks up to a little more than a year, often up to the spring floods. This power balance includes water released from reservoirs, overhauls, and consumption defined over narrower intervals of time.
- Weekly planning generally deals with how energy and power requirements are to be met during the coming week to achieve the best economy or operation. The state of the generating equipment, shutdowns, water volumes released, and grid constraints are some of the most important parameters, followed by the price of oil, coal, etc.
- Daily planning is intended to produce the optimum schedule for the generation equipment hour by hour throughout the day.

In systems predominantly based on thermal production, the daily and weekly planning determines which units should be in operation at which time and when the units should be run up or shut down (unit commitment). An extended unit commitment schedule also takes account of the problem of hydropower, drawn up according to power requirements. Economic dispatch calculation (EDC) programs perform economic distribution of the generation of thermal power. The load forecast, grid data, and generation data are used as input. Other functions belonging to this group include the following:

- ◊ A program for calculation of the transmission losses in the grid
- ◊ Calculation of the optimal power flow with respect to voltages, transmission limits and generating costs
- ◊ Optimization of reactive power and voltage
- ◊ Load forecasts.

As the structure of the power systems within NORDEL varies so much, different economic analysis (EA) functions are used in the different countries. ELSAM in Denmark has an EDC function that takes account of the district heating generation to optimize the electricity production for all generating units in half-hour periods. The results are used in the real-time system for monitoring power generation and for automatic control of DC interconnections. In Norway and Sweden, several program systems are used for daily, seasonal, and long-term planning. At Vattenfall (Sweden State Power Board), a new production optimization (POP) system has been developed that generates seasonal plans for both thermal and hydro power. A similar function is to be developed for weekly planning. Sydkraft (South Swedish Power Board) has installed an operational computer system to plan, manage, and control (in real time) the power plants on southern Swedish rivers. At Imatran Voima and Vattenfall, hourly load forecasts are worked out automatically and implemented by the operator one week in advance.

Several tools have been developed to assist coordinated operations within NORDEL with which the various utilities can test their marginal values and power exchange capacity.

C. System Supervision: A network of control centers supervises system security and exchanges. Each control center is equipped with the necessary technology to supervise that the joint criteria within its respective service area are met. There is intense communication among the control centers, but no single control center can supervise the network condition in the whole area.

D. Pricing of Electricity Exchanges: As described above, the magnitude and direction of an optimum power exchange for any given situation is determined based on SRMC considerations. This optimum is based on the assumption that the total savings achieved by the power exchange will be as large as possible and is clearly entirely independent of what rules are used to distribute the profit among the utilities.

Because this “Road Map” considers temporary exchanges, which are assumed in the long term to go as often in one direction as in the other, it is reasonable and generally accepted that the profit should be distributed equally between the two parties involved and that only the variable costs are included in the calculation. This equal division is achieved reasonably well if the exchange price is taken to equal the mean value of the SRMCs of the two parties. To achieve a division of the profit that is completely fair, the

calculation ought to take account of the cost elasticity, which need not necessarily be the same in the two systems. In practice, this is generally not done, because it would be far too complicated and also because, as already mentioned, transmission capacity often limits the exchange, so that the incremental costs do not change very much. For large power exchanges involving one party with only thermal power, allowance is usually made for the cost elasticity by calculating the thermal power value as an incremental cost for the amount of power to be exchanged (this can be applied to several thermal generating units).

The median price principle is also applied to special thermal power exchanges on the basis of the agreement that, for this purpose, the producer may purchase further fuel up to a given maximum price. In this case the incremental cost of the seller is calculated from the fuel price applying to these extra purchases. A condition for participation in a power exchange imposed by sellers and purchasers is that, in view of the element of uncertainty in the basis of calculations, the profit on the deal must exceed a certain minimum. It happens occasionally that a system has no defined incremental cost, for instance, in the event of a power shortage in a power dimensioned system (thermal systems). In energy dimensioned systems (hydro systems) on occasions when the probability of shortage of energy is great, an incremental cost that may approach the rationing price is reached. In such cases the median price principle may lead to unreasonably great profits to the sellers. There is therefore a very good case for introduction of some form of a price ceiling to prevent the cost of power exchanges becoming unduly great. For the time being, the profit of the seller is not permitted to exceed (Swedish Kroner (SEK) 75/MWh) or, if the purchaser declares energy shortage, SEK 50/MWh.

E. Accounting: The accounting for exchanges over each interconnection will be agreed on by the two parties involved. The accounting systems will therefore be different. The main components will be as follows:

- ◊ **Energy recordings:** Exchanges of energy in each direction will be accumulated for each period (1 hour or 15 minutes). Each day the recorded values are automatically transmitted to a computer that is capable of making the accounting immediately at the end of the day.
- ◊ **Schedules:** Several types of exchanges can be agreed on at the same time. For instance, firm power, conditional exchanges, and exchanges without guarantee.
- ◊ **Calculation:** On the basis of the schedules and recorded exchanges, the exchanges of the day are divided into the agreed types. Deviations from plan are classified as small and large deviations according to agreed tolerance.

F. Information and Statistics: Operating schedules are exchanged every day by telephone among the control centers. Schedules are exchanged once a week by telex. These schedules have the same layout, which gives each control center an overview of the total power and energy situation. NORDEL publishes quarterly operating statistics.

II. System planning: These cover criteria for system expansion and the application of common planning models and analyses to generation, fuel supply, and transmission systems, as follows.

A. Criteria for System Expansion

- ◊ **Generation:** The generation/production systems differ widely in the different NORDEL member countries and expansion of them follow national guidelines. A recommendation prepared in 1975 on dimensioning of the required reserve capacity ensures that the same overall economic principles are applied in all of the countries. Based on a common shortage cost, an optimum installed reserve capacity in the range of 15%-20% of peak load was applied, depending on individual system characteristics. Assumptions, methods, and criteria for the planning of the interconnected NORDEL system as a unity are currently being tested.
- ◊ **Fuel Supply:** NORDEL has no common rules.
- ◊ **Transmission Systems:** NORDEL rules for design and dimensioning of transmission systems were adopted as recommendations in 1972, and all interconnected systems within NORDEL adhere to these rules. The network criteria ensure that the interconnected networks can function as a whole and that the capability of the system to withstand specific disturbances is the same everywhere in the interconnected network. Common network criteria have proved to be a vital condition for efficient utilization of the daily power generation in the transmission system.

B. Common Planning Models and Analyses

- ◊ **Production System:** A simulation program for analysis of economic and operating conditions in a mixed hydro-thermal system with internal transmission constraints has been developed and came into use in 1986. The program provides useful results, which support the dimensioning of new generation plants and interconnections (e.g., in the form of marginal benefits).
- ◊ **Fuel Supply:** NORDEL has no common models.
- ◊ **Transmission Systems:** Following serious un-damped oscillations in the interconnected system in 1967, system data and stability models had to be mobilized at short notice. These have since been kept up-to-date and improved, so that today, NORDEL has the necessary tools ready for effective analyses of the properties of the transmission system. Analyses are made as required, both of operation and planning.

III. Technical design: These cover design of the major equipment in new plants, telecommunications, power frequency control, and protection systems, as follows.

A. Design of the main equipment in new plants: NORDEL adopted common rules for operating-technical specifications for thermal power plants (unit sizes greater than 200MW and on gas turbines) in 1975. These specifications determine the properties of the units when subjected to control actions and during abnormal voltage and frequency conditions. The specifications are needed to permit the system to cope in a controlled manner with major irregularities during operation.

B. Telecommunications: NORDEL has no common rules.

C. Power frequency control: From 1974 to 1979, NORDEL Operating Committee's Working Group on System Operation (NOSY) dealt with the question of common guidelines for frequency control. A number of full-scale tests were implemented during this period. Since 1979 common guidelines for frequency control have been followed by the NORDEL countries. The guidelines comprise detailed rules for normal operation and measures in the event of disturbances, and they apply to power stations, interconnections, and load shedding procedures.

D. Protection systems: The NORDEL guidelines for frequency control provide that national network separations that would seriously affect the operation of the main NORDEL network should only be resorted to after the load shedding steps have been fully utilized. Protection systems that do not affect the properties of the interconnected systems are not covered by the common rules.

Building Regional Power Pools: Modules

Under the Infrastructure Action Plan, launched in July 2003, the World Bank Group is partnering with other international financial institutions to cofinance regional infrastructure development projects that support integration of national power grids so as to establish regional power pools. In January 2005, the World Bank Group initially secured Executive Board approval to put in place a US$1 billion multiple-country infrastructure lending facility in support of the emerging subregional electricity market for the Energy Community (South East Europe). Since then, eight follow-on lending operations in eight countries have been approved for regional power infrastructure development; a 2006 review of the World Bank Group's experience with multicountry programs[1] concluded that "they offer substantial potential to achieve results." The review further concluded that the International Development Association (IDA) has a comparative advantage in supporting regional integration projects, especially in Sub-Saharan Africa, and in close partnership with the many donors working actively in this area. Recognizing the strong—and increasing—demand on the part of IDA client countries of Sub-Saharan Africa to work together to solve common problems on a regional basis, under the auspices of the New Partnership for African Development (NEPAD), a target has been set to dedicate 10% of IDA-15 resources to regional integration projects, under the Regional Pilot Program.[2]

The World Bank Group's Africa Action Plan has given its clients an added impetus to build up a strong and diversified lending operations pipeline targeting the fledgling power pooling mechanisms for Central, Eastern, Southern, and Western Africa; a common feature of these subregional initiatives is the priority being accorded to shared development of hydropower prospects in key river basins (e.g., Niger, Nile, and Senegal Rivers) to help smooth out electricity supply and price differentials among relatively small and isolated national power systems. Another is the extent to which these subregional initiatives facilitate development of critical cross-border transmission links ("interconnection facilities") alongside the acquisition and deployment of equally important hardware and software systems (metering, data collection, and real-time processing of

1. IEG: "The Development Potential of Regional Programs," 2007.
2. The Regional Pilot Program was initiated with the Board paper *Pilot Program for Regional Projects*, IDA/SecM2003-0532/1, October 24, 2003.

information) necessary to ensure that the individual national power grids are able to function as one on a common operational and commercial platform. Given the above context, the critical success factors must include measures that ensure timely delivery and deployment of required cross-border interconnection facilities and also help upgrade the capabilities of transmission system operators or TSOs of the respective national power grids.

Several of the regional entities that are now responsible for setting up regional power pooling mechanisms in Sub-Saharan Africa are exploring avenues to shift away from traditional input-based, design-bid-build project delivery approaches in favor of performance-based, design-build-commission approaches that may be better suited to the new challenge of bringing a cross-border infrastructure project from concept through feasibility to financial closure. The challenges involved in developing such procurement alternatives (Box 1) were further explored and addressed head-on during pre-investment activities for the West Africa Power Pool. This initial set of detailed knowledge-sharing materials (Modules) for dissemination to World Bank Group staff and clients have been prepared in that context.

Module 1: NIRAS Technical Concept Note: Establishing Cross-Border Transmission Facilities

This technical note transfers expertise on developing and applying functional specifications for performance-based procurement for build-maintain-transfer cross-border power facilities in Africa. Prepared by NIRAS Consulting Engineers and Planners, the note covers the following topics:

- Technical and nontechnical issues in performance-based procurement of energy, both of which must be solved satisfactorily for a successful project. Technical issues concern design requirements, electrical requirements, environmental impacts, and operation and maintenance. The note covers several types and combinations of transmission facilities and electrical interconnections when connecting two systems.
- Transformation of employer requirements based on prevailing conditions into parameters for the performance-based procurement process for use by contractors to optimize and suggest solutions. A related issue is protecting the contractor's intellectual property rights.
- Other topics covered are selection of bidders and the two-stage bidding process, which emphasizes transparency; contract provisions, for example, definition of milestones for payment purposes; and possible functional guarantees to incorporate in the contract.

The note concludes that performance-based contracting may be used for contracting cross-border transmission facilities, but it is not without technical challenges. It makes a number of suggestions on how performance-based procurement can be utilized effectively; for example, detailed system investigations and feasibility studies should precede decisions on a cross-border project, and parameters should be measurable, well defined, and follow commonly accepted international industry standards. Contractors should be responsible for operation and maintenance for some years after commissioning of the transmission facilities.

Case Study: West Africa Power Pool: Establishing the 330 kV Coastal Transmission Backbone

NIRAS has provided a case study that analyzes the Ikeja West (Nigeria) to Sakete (Benin) segment of the Coastal Transmission Backbone of the West African Power Pool. When completed, the Coastal Transmission Backbone will link the national power grids of the West African coastal states of Nigeria, Benin, Togo, Ghana, and Côte d'Ivoire. The project was selected for the case study, because it presents most of the difficulties that

can be encountered in establishing a cross-border interconnection facility. The case study describes the history of the project and presents lessons learned.

Module 2: COLENCO Technical Concept Note: Upgrading SCADA/EMS Systems

This technical note addresses general key issues and options on deployment of supervisory control and data acquisition (SCADA) system and energy management system (EMS) upgrade projects that are useful and applicable to developing countries that are beneficiaries of World Bank support. The note starts by describing the main tasks of a national control center, including key functions of data processing. The data processing system that enables operators to perform these functions includes both a SCADA and an EMS. A national control center permits operators and dispatchers to manage the national power system within its control area. The SCADA and EMS are tools for operators to supervise, control, and optimize the primary elements and power flows of a power system.

The note then covers a number of conclusions, including that a true performance-based procurement approach is not suitable or applicable for a SCADA or EMS and a traditional procurement approach should be applied. The note then concentrates on providing program instruction on preparing and deploying a SCADA/EMS project. It notes specific aspects of any SCADA/EMS project that should be considered:

- A typical SCADA/EMS is never a stand-alone system, but part of a mosaic of power plants, substations, telecommunication facilities, and metering; therefore, it is important to analyze carefully the entire technical environment, based on the goals to be achieved.
- The next step is to analyze and outline the scope and limits of supply, including its interfaces.
- The main aspects of current industrial practice for procurement in the SCADA/EMS sector should also be considered; these include performance requirements, system architecture, hardware, operating systems, training, long-term support agreements, evaluation procedures, and statements of work.
- Use of the standard bidding documents for supply and installation of plant and equipment in its latest edition is recommended.
- A realistic overall preparation and implementation time schedule should define three phases: preparation and conceptual design, procurement, and implementation.

Case Study: West Africa Power Pool: Upgrading the Volta System Control Center in Ghana

COLENCO has provided a case study that analyzes an approach to upgrading of the Volta System Control Centre, located at Tema, Ghana, which monitors and controls the balance between power generation and demand in the interconnected national power systems of Ghana, Benin, and Togo. The facility is owned and operated by the Volta River Authority (VRA) of Ghana. The case study illustrates the various steps taken by VRA from start of the project's preparation phase to award of the contract, including procurement approach, definition of the scope of the contract, prequalification, and the bidding process.

Additional Modules:

An additional set of "Modules" is forthcoming to cover other key topics, such as the design, acquisition, and deployment of hardware and software required to administer bilateral and/or multilateral cooperative energy exchanges among national power grids, and state-of-the-art modeling techniques to analyze the relative distribution of economic costs and benefits to national power utilities that engage in such cooperative power pooling mechanisms.

Complementary Reference Material:

In 2007, following the successful completion of a capacity-building program on regional infrastructure organized for the Greater Mekong Subregion, the World Bank–administered Public-Private Infrastructure Advisory Facility (PPIAF) and the Asian Development Bank jointly published a **"Toolkit on Cross-Border Infrastructure,"** which presents topics complementary to those covered in the above modules. Specifically, the four main focus areas in the **"Grid of Topics"** contained in the **"Toolkit"** are (a) policy and planning framework, (b) financing, (c) regulation and accountability, and (d) private sector participation.

Box 1: Procurement Options under World Bank-Financed Projects

I. Procurement Options under World Bank Guidelines

In the May 2004 version of the World Bank's guidelines, "Procurement under IBRD Loans and IDA Credits," regional power pool organizations have a choice of procurement methods to implement cross-border interconnection facilities, including *performance-based procurement* (PBP).

A. Input-Based Procurement

The supply and installation of plant and equipment for large transmission facilities financed by the Bank has been carried out mostly under input-based procurement (IBP), through which payment is made on the basis of inputs required to execute particular phases of the overall works. As the works are being executed, progress is measured and payments are made according to the verified work completed. The project is designed and illustrated in drawings and other documents, and bidding documents are prepared by the employer or his consultant or both. The bidding documents contain drawings and detailed technical specifications or a combination of these specifications with functional specifications of how the works will be constructed and/or the equipment will be installed and how the facilities will function. Bidding takes place among usually prequalified suppliers and contractors, and the employer or his consultant or both receive and evaluate bids. The contractor is engaged to do the work in accordance with the contractual documents. The contractor prepares detailed construction and installation drawings during project execution, which the employer approves before the contractor starts work. On completion and commissioning of the facilities and issuance of the completion certificate and operational acceptance certificate, the employer generally takes over the facilities for operation and maintenance. Risk is distributed between the employer and the contractor in accordance with stipulations of the contractual documents.

B. Performance-Based Procurement

PBP refers to the contractual relationship in which payments are made for measured outputs, instead of measured inputs. Payments are made in accordance with the quantity of outputs delivered at the level of quality stipulated. The scope of the technical specifications may vary, but they define the results, which outputs will be measured, and how they will be measured. These outputs are intended to satisfy a functional requirement, both in terms of quality, quantity, and reliability. The output of the facilities will be directly related to the stipulated requirements and performance parameters guaranteed by the contractor.

The bidding documents will stipulate, among others, the expected target thresholds of the different performance parameters to be guaranteed by the contractor. Such guaranteed values shall be indicated by the bidders in their bids, and the values indicated by the successful bidder shall be incorporated in

the contract. Additionally, the bidding documents shall specify the values of the different performance parameters below which the employer will have the right to reject faulty works and equipment and if necessary call for payment of the performance security. Usually a period of operation and maintenance by the contractor is stipulated, during which the performance parameters are measured. Risk is distributed between the employer and the contractor in accordance with the stipulations of the contractual documents.

The bidder/contractor is free to propose the most appropriate solution, based on state-of-the-art and proven experience and shall demonstrate that the level of quality stipulated in the tender documents is achievable.

The use of PBP in Bank-financed projects should result from satisfactory technical analysis of the different options available and should be included in a project appraisal document (PAD) or subject to prior approval by the Bank for incorporation in the procurement plan (see World Bank 2004b, pp 44–45, paragraphs 3.14 and 3.15).

II. Market Survey for PBP

Because the PBP approach is relatively new for electricity transmission projects, it is important that the owner conduct a market survey to assess the interest of potential contractors for the types of projects to be implemented under the PBP approach. The survey should outline for potential contractors the essential stipulations related to technical and commercial aspects, such as the payments schedule and duration of the performance guarantee period and of the contractor's responsibility during the operation and maintenance period. The comments made by the potential contractors about any of the mentioned aspects should be taken into consideration in the subsequent preparation of the prequalification and bidding documents to minimize the risk that potentially interested contractors may not eventually tender.

III. Bidding Process for PBP

This process includes prequalification of bidders, requests for proposals, proposal evaluation, and award and negotiations of contracts.

A two-stage bidding procedure is adopted, because the bidding documents will not include a complete set of technical specifications, but will incorporate minimum requirements and performance specifications along with performance parameters. In the first-stage bid, bidders are required to submit an unpriced technical scope of work (rehabilitation of existing facilities or new facilities) that are subject to technical as well as commercial clarifications and adjustments, to be followed in the second stage by amended bidding documents and submission of technical proposals and priced bids.

For a new facility, the bidders will submit a first-stage unpriced bid with technical scope of work based on conceptual design, employer's requirements, performance parameters, and minimum performance

specifications. The bidders shall in the second-stage bid provide a lump-sum quotation for the basic scope of the rehabilitation of a facility or construction of a new facility. In addition to the lump sum price for the basic scope of work, the price schedules will include estimated quantities of labor, equipment, and materials, which the bidders shall quote on a unit price basis. Bid evaluation and contract award will be based on (a) the second-stage bid lump sum plus the estimated quantities in the bid price schedule multiplied by the corresponding unit prices and (b) other factors stipulated in the bidding documents. The civil works will be included in the case of new facilities and as needed in the case of rehabilitation of existing facilities. The geological risks will have to be considered.

A. Prequalification of Bidders

The prequalification documents will be based on the Bank's standard procurement document "Prequalification Document for Procurement of Works and User's Guide," May 2004. Modifications may have to be made to accommodate the specific requirements of PBP. Because the Bank has no standard documents for PBP, the employer and its consulting firm will have to prepare ad hoc documents to accommodate the requirements for rehabilitation of existing projects and for new projects under the PBP approach. The employer will present said documents for Bank review.

The time allowed for preparation and presentation of the prequalification documents should be not less than 10 weeks. The qualification criteria and requirements must be clearly stipulated for a single entity and for a joint venture and members of the joint venture. The applicant must meet all requirements regarding eligibility, financial situation, and experience.

If prequalification results in receipt of no or only a few applications, the reasons for this should be evaluated. One reason could be that few or no potential contractors are willing to accept the PBP approach for the specific project and associated responsibilities for its operation and maintenance and long-term performance of the facilities; another could be that qualification criteria and requirements specified in the prequalification document are too strict.

If these problems occur, the employer should reassess the procurement approach, considering, among other actions, reducing the contractor's responsibilities and risks or, if only one or two qualified applicants are found, to see if this reduced competition is acceptable by the employer and the Bank.

B. Bidding Documents

The bidding documents will be based on the Bank's *Standard Bidding Documents for Supply and Installation of Plant and Equipment* (World Bank 2004c). Because the Bank has no standard documents for PBP, the employer and its consulting firm will have to prepare ad hoc documents to accommodate the requirements of rehabilitating existing projects and of new projects under the PBP approach.

In general, the bidding documents shall contain the invitation for bids, instructions to bidders for two-stage bidding, information to bidders, general conditions of contract, special conditions of contract, employer's requirements (including drawings, if prepared, and work programs), bid forms, and contract forms (form of contract, securities, and so on).

The intention of the employer's requirements is to leave maximum freedom to the bidders in proposing in their first stage bid the technical solution they consider most suitable and beneficial to the employer. The bidders, therefore, shall detail in their first- and second-stage bids the characteristics of the facilities proposed (rehabilitation, replacement, new, or combination of the three) on the basis of their own assessment of the proposed facilities. The employer's requirements establish the rights of the employer in the various activities, which will cover, among others, the following:

- Scope of work and limits of supply (site location, access, environmental control, works to be carried out, and interfaces)
- Standard of quality (useful life of the facilities, and standards for equipment, materials, and civil works)
- General requirements (required performance parameters and work program foreseen by the employer)
- Functional specifications of the equipment (monitoring and control, and tests on the facilities)
- General technical specifications of the equipment (minimum quality standards to be applied by the contractor in execution of the work)
- Specifications for civil works (minimum quality standards to be applied by the contractor in the execution of the work)
- Required submissions (detailed work plan, progress reports, design submissions, test results, quality assurance and quality control documents, operation and maintenance manuals, and as-built drawings and documents)
- Training of the employer's personnel (employer's personnel to be trained, on-the-job training for erection, operation, and maintenance of relevant facilities)
- Employer's monitoring during construction (of construction progress, civil works, equipment erection, commissioning, and performance tests)
- Measurement of performance parameters (according to the nature of the facilities that are the subject of the contract)
- Operation and maintenance period (contractor's duties and responsibilities, performance guarantee period, defect liability period, operation and maintenance responsibilities, employer's responsibilities for operation and maintenance of the facilities, and operation and maintenance costs).

Bonuses and penalties (procedures and calculations) shall also be specified.

The documents shall further stipulate, among others, the performance parameters to be guaranteed by the contractor, performance guarantee period after completion/commissioning of the facilities, period and scope of responsibility of the contractor for operation and maintenance of the facilities, and terms of payment, including initial payment as a percentage of the total contract price and portion of the total contract price linked to the performance parameters and paid according to the performance guarantee period and performance security agreements.

The available documentation (engineering studies, and environmental and social studies) on projects to be tendered should be made available to the bidders at the time of preparation of tenders and eventually to the contractor.

IV. Organization for PBP Implementation

A regional power pool organization may, at the outset, organize a dedicated project coordination unit (PCU) and put in place specific procedures for PBP implementation. The PCU should comprise engineers; financial, procurement, and legal experts; and so on with adequate supporting staff, under terms of reference for carrying out their functions. The PCU should select and contract a consulting firm with experience in PBP to work jointly with the PCU/regional organization in all aspects.

The PCU should prepare an implementation plan. This plan should include the selection and contracting of a consulting firm and the PBP contractor. The PCU shall be jointly responsible with the consulting firms for preparing the solicitation documentation, evaluating the prequalification of bidders and of bids, awarding and negotiating the contract(s), and overseeing implementation of the facilities in accordance with the contractual documents.

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