ECONOMIC
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ASSOCIATES

The Potential of Regional Power Sector Integration

Literature Review

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Abbreviations and acronyms

ADB	Asian Development Bank
AC	Alternating Current
AICD	Africa Infrastructure Country Dialogue
CDM	Clean Development Mechanism
CIER	Comisión de Integración de Eléctrica Regional
CLECO	US power company
DC	Direct Current
DG	Directorate General
ECOWAS	Economic Community of West African States
EEM	Energie Manantali
EGAT	Electricity Generating Authority of Thailand
EHV	Extra High Voltage
EMS	Energy Management Systems
ENTSO-E	European Network of Transmission System Operators for Electricity
ERGEG	European Regulators Group for Electricity and Gas
ESCWA	Economic and Social Commission of Western Asia
ESKOM	South African electricity utility
ESMAP	Energy Sector Management Assistance Program
EU	European Union
FACTS	Flexible AC Transmission Systems
FERC	Federal Energy Regulatory Commission (USA)
GCC	Gulf Cooperation Council
GMS	Greater Mekong Subregion
GWh	Gigawatt-hour
HCB	Hidroeléctrica de Cahora Bassa (Moçambique)
HVAC	High-Voltage Alternating Current
HVDC	High-Voltage Direct Current
Hz	Hertz
IDA	International Development Association
IEA	International Energy Association
IEEE	Institute of Electrical and Electronic Engineers
IEG	Independent Evaluation Group

IEM	Internal Electricity Market
IFI	International Financial Institution
ISO	Independent System Operator
KEEI	Korean Energy Economics Institute
kV	Kilovolt
LMP	Locational Marginal Pricing
LOLP	Loss Of Load Probability
LRMC	Long-Run Marginal Cost
MER	Regional Electricity Market
MOTRACO	Mozambique Transmission Company
MW	Megawatt
NBI	Nile Basin Initiative
NEL	Nile Equatorial Lakes
NEPAD	New Partnership for African Development
NERC	North American Electric Reliability Council
NETA	Net Electricity Trading Arrangements
NORDEL	Organization for the Nordic Transmission System Operators
NT2	Nam Theun 2
OECD	Organization for Economic Cooperation and Development
OECS	Organization of East Caribbean States
OMVS	Organisation pour la Mise en Valeur du fleuve Sénégal
PGPEA	Problem Driven Governance and Political Economy Analysis
PJM	Originally Pennsylvania, New Jersey, Maryland, now company with bigger geographical spread called PJM Interconnect
PPA	Power Purchase Agreement
PPIAF	Public-Private Infrastructure Advisory Facility
PPP	Public-Private Partnership
PSC	Public Service Commission
RBOs	River Basin Organizations
RECI	Regional Electricity Cooperation and Integration
RPSI	Regional Power Sector Integration
RTO	Regional Transmission Organization
SADC	Southern African Development Community
SAPP	Southern African Power Pool
SARI Energy	South Asia Regional Initiative for Energy

SCADA	Supervisory Control and Data Acquisition
SEETEC	Southeastern Europe Electrical System Technical support project
SIEPAC	Central American Electrical Interconnection System
SOGEM	Société de Gestion du Barrage de Manantali
SRMC	Short-Run Marginal Cost
STEM	Short-Term Energy Market (SAPP)
TSO	Transmission System Operator
UAE	United Arab Emirates
UCTE	Union for the Coordination of the Transmissions of Electricity
UN-DESA	United Nations Department of Economic and Social Affairs
UNDP	United Nations Development Program
USAID	United States Agency for International Development
WAPP	West African Power Pool

1 Introduction

1.1 Purpose of the literature review

The case studies and this Literature Review Report are the main outputs of Phase 1 of the 18-month ESMAP project on the ***Potential of Regional Power Systems Integration***. The workshop at the end of Phase 1 will provide an opportunity to present the results of the case studies and the literature review and to discuss with the Task Team Leader, Bank staff and other participants the key features of power system integration which are to be further explored and elaborated in Phase 2.

The overall objective of the project is to develop a ***Guide to Key Features of Power System Integration*** which will help in the preparation of future World Bank-sponsored regional power sector integration projects. With this in mind, the literature review is focused on material that is relevant to those countries, but also presents research results and key issues from other parts of the world and insights from theoretical debates. It does not seek to be restrictive or formulaic in approach, but rather to document a range of experience and options which can be considered and deployed as appropriate in future project planning.

This review has identified some limitations and weaknesses in the literature on the theoretical underpinning for many of the claims made about the benefits of integration. Section 2.4 identifies certain gaps which warrant being addressed by future research.

1.2 Approach

There is a large body of literature on regional power system integration available in the public domain. Documents range from short, single-issue commentaries, through studies of specific integration initiatives, to highly detailed methodological and theoretical studies covering a spectrum of technical, economic, political and organizational aspects.

To make this more accessible to readers, there is a need to screen the breadth, volume and quality of this material. To this end we have adopted an approach which has three components:

- Summary entries for each of the reviewed papers in an annotated bibliography (Annex 1).
- More detailed summaries of selected references (Annex 2).[1]
- A summary of some cross-cutting themes, which is presented in Section 2.

The papers have been divided into nine categories in the annotated bibliography:

A1.1 Regional power sector integration (RPSI) major overview papers

A1.2 Economics of RPSI

[1] A full list of the Annex 2 papers with extended bibliographic entries is given at the end of Section 2.

A1.3 RPSI institutions and markets

A1.4 Technical aspects of RPSI

A1.5 Hydropower

A1.6 Environmental aspects of RPSI

A1.7 Support of outside agencies for RPSI

A1.8 Predominantly region-specific papers

A1.9 Case studies from this project

To give a sense of progression of ideas about regional power systems integration, the papers in each category of Annex A1 and Annex A2 are organized by date, rather than the usual convention of organizing alphabetically by author.

No claim can be made about comprehensiveness, as the literature on regional power system integration is voluminous. In particular, the category called "predominantly region-specific papers" could easily be expanded many times. The limited number of papers chosen for this section are either overview papers for the region to which they refer or are papers which are relevant for other regions or which contain interesting theoretical materials. For completeness, annotated bibliographic entries for the case studies of this project are also included in Annex A1. The bibliographies of these case studies give a much richer set of region-specific papers than is included in Annex A1.8 .

It was notable in carrying out the literature review that many of the papers on regional power are descriptive rather than analytic. There are comparatively few academic studies which have real theoretical depth. One exception to this is a collection of papers arising from the joint Cambridge-MIT Institute Electricity Project, which focused on coordinating transmission management across different electricity jurisdictions. The results of the project were published in 2005 in a special issue of *Utilities Policy*. This has a useful editorial introduction by David Newbery (see Annex A1.2).

Many if not most of the papers reviewed in Annex A1 cover a number of different dimensions of regional power system integration and thus do not fit comfortably in a single category. In order to draw out the cross-cutting nature of the literature review papers, we have developed a framework for presenting a discussion of salient aspects of the literature that has been reviewed. This is presented in the next section.

1.3 Literature review framework

Themes from the survey of writing about regional integration in the power sector can usefully be categorized into three main areas as follows:

- ***Motivations*** and ***barriers*** to integration
  - Benefits of integration (the expected ***outcomes***) and how these are to be shared
  - Barriers to integration (technical, political, economic)

- The ***outputs*** of regional integration, that is, the infrastructure created, which is essentially of two kinds:
  - *Institutional infrastructure and market development* (agreements, rules and institutions that make electricity trade possible)
  - *Physical infrastructure* (interconnectors and other hardware which make trade in electricity physically possible)
- ***Facilitation*** of the regional integration process. The following facilitation factors emerge as important from the literature surveyed:
  - *Political will* and desire for integration and trade
  - *Coordination* at the regional level with appropriate delegation to the national level
  - *Sequencing* of the regional integration process

Section 2 gives some key themes arising from the literature review, presenting these under headings conforming to the preceding framework.

2 Main themes from the literature review

2.1 Motivations and barriers to integration

2.1.1 The benefits of regional integration

The benefits from regional integration are widely recognized. Many of the papers surveyed list the potential benefits and several claim, on general principles, that they are significant (see for example RECI E7 Guidelines, 2000).[2] A number of them do so in an uncritical way, however. A critique of the papers reviewed in this section is given in Section 2.1.3 .

Broadly, the benefit that is claimed for regional integration is improved economic efficiency. Specifically stated benefits include:

- Reduced or postponed costs. These include
  - short-term energy and operation costs (World Bank, 2008).
  - long-term investment costs through improved reserve margin and avoided investment in peak capacity (RECI, Module 1).
- Efficiencies are also gained through economies of scale as larger-scale plants are enabled by larger markets (Eberhard, 2003).
- Improved supply conditions (World Bank, 2008), including better reliability and security of supply due to access to imports during emergency situations (Eberhard, 2003, SEE Case Study).
- Fostering further development of country-level electricity markets where integration allows sufficient scale to support increased competitive participation (UN-DESA, 2005, SIEPAC Case Study). The extent of competitive market development that can be supported will depend on the degree of market power.
- Social benefits (including access to electricity); closely aligned with economic benefits (UN-DESA, 2005).
- Reduced environmental impact (including avoided air and water pollution, and displacing biomass which is often associated with deforestation; UN-DESA) and contribution to sustainable development resulting from more efficient energy use (Eberhard, 2003).
- Reduced fiscal strain due to reduced costs where private-sector investment is enabled (Eberhard, 2003, Argentina-Brazil Case Study).

[2] Details of the papers referred to in Section 2 can be found in the References section at the end of the section. Further details can be obtained from the annotated bibliographic entries in Annex 1, and for those marked ** in Annex 1 more detailed entries are available in Annex 2.

- Political benefits as a result of increased interdependence and integration among neighbors, and closer ties fostered by the experience of cooperating to develop the integration (Eberhard 2003; UN-DESA 2005, SEE Case Study).

- Strengthening the legal capacity and experience in countries participating in the process of creating legal structures to support power system integration. This process can also establish a precedent for trade in other energy forms or products (UN-DESA, 2005).

In addition to the direct positive effects, indirect benefits of integration include wider economic benefits as efficiencies flow on through the economy (including stimulation to local economies in the construction phases; UN-DESA, 2005), social and developmental benefits where new electrification is enabled, multipurpose benefits (e.g., flood control, irrigation), and increased regional security through economic integration (Eberhard, 2003).

Others have suggested that regional cooperation/integration, especially in the area of regulation, can help developing countries overcome costs and national limits in technical expertise by sharing skills, enhance the capacity of these countries to credibly commit to a stable regulatory policy, and ultimately can facilitate infrastructure investment. Kessides et al. (2008) argue that the benefits of developing regional regulatory frameworks in a multilateral context are analogous to those from negotiating trade reform in a multilateral forum. With a shift in focus from single domestic issues to a broader regional perspective, a more efficient outcome is likely, since the broad participation engendered by these projects dilutes the power of single-interest groups, thereby reducing political barriers.

2.1.2 Barriers to regional integration

The following barriers are commonly cited:

- Political and institutional barriers: These include political borders, national security, public opposition, poor institutional structure (RECI, Module 1), internal disunity, differing political systems, powerful interest groups, corruption (UN-DESA, 2005).

- Natural and technical barriers: These relate to the technical and economic feasibility of interconnection of transmission lines, as influenced by factors such as geography (distance, terrain) (RECI, Module 1).

- Environmental barriers: These are particularly important in the case of hydropower projects, which require the building of dams with large displacements of population and disruption of natural ecosystems (Bocking, 1998).

RECI (Module 1) notes that the political and institutional barriers tend to be particularly acute in developing countries. Natural and technical barriers may be insurmountable, while political and institutional barriers can, at least in theory, be overcome.

Even among more highly developed countries, significant barriers can inhibit the deepening of regional power system integration. For example, an analysis of barriers to trade in Southeast Europe carried out in 2006 focused on network operations factors (network access, pricing and congestion management) and wholesale market arrangements (market

concentration, transparency and market structure) (SEETEC, 2006; ERGEG, 2006). Uncertainty about these factors and the associated perception of risk inhibits private-sector investment, the expectation of which is what has driven much of the sector reform and the move toward regional electricity markets (Bunn et al., 2006).

Poor organization and management of the integration process might also be considered a barrier. All of the facilitation keys (see Section 2.3) are directed in some way to overcoming the barriers.

The Kessides et al. paper identifies regulatory capture (resulting from representation bias) and asset expropriation (creating a commitment problem) as the two outcomes of a weak regulatory environment and suggests that in many, especially small, developing countries the regulatory capacity and safeguard conditions (such as the strength of civil society monitoring and an independent judiciary) needed to reduce the risk of these outcomes may not be in place.

2.1.3 Critique of the literature on benefits and barriers

Several of the documents reviewed so far are representative of a genre of papers on regional power which is quite uncritical of positions presented, and fail to offer either a theoretical discussion or empirical evidence for the claims which are made. This is in many respects a form of advocacy rather than of analysis. The supposed benefits of regional power system integration certainly warrant more critical or at least nuanced treatment than is typically offered. For example:

- *Regional power system integration facilitates access to electricity.* In fact, no such attributable benefit has been encountered in any of the schemes surveyed. To the extent that market integration raises the price of electricity in the low-cost country, regional integration could even have a negative effect on access if affordability is an issue (though the opposite tendency would apply in the high-cost importing country). In circumstances where there is a barrier to expansion of capacity in the low-cost area (e.g., political constraints on investment in nuclear power stations) scarcity rents will accrue to the incumbent suppliers. Equity requires that these be returned to the customers in the low-cost area: mechanisms for doing this are discussed in Finon and Romano (2009).

- *Regional power system integration gives rise to positive environmental benefits.* This may be true when the electricity trade is based on hydropower (though dam development will typically involve significant negative environmental factors which need to be taken into account) or when regional generation is less polluting than plants which would otherwise be used to meet peak demands, but there are other cases where regional electricity trade expansion depends on high pollutant, high CO_2 sources (such as coal in Botswana or lignite in Kosovo).

- *Regional power allows the least-cost projects to be implemented.* Coordinated regional investment will typically involve significant savings in NPV terms, but low long-run kWh costs may often require high initial investments per kW, resulting in immediate fiscal challenges. Investing in a large hydro plant rather than a sequence of smaller CCGT plants may require more government guarantees and financing, because of the higher capital intensity of hydro, whereas fuel supply

does not generally need a government financial commitment (except for long-term LNG contracts).

- *Regional power interdependence leads to the deepening of regional integration in other spheres.* Energy interdependence is seen by almost all governments, even those which express enthusiasm for regional integration, as being a threat to energy security. An economic approach to energy security requires defining the level of energy security that a country is willing to pay for, expressed, for example, as the acceptable "loss of load probability." The politicians' instinct for equating the location of domestic generation on national territory with energy security is understandable, but it can have cost implications which prejudice other development objectives. A commitment to regional interdependence should mean higher security in the short run, because the regional system will provide higher levels of spinning reserves at lower cost (provided the system is operated competently from a technical viewpoint—the increased complexity does introduce new risks of cascading blackouts), and in the long run because the investment costs to meet growing demand will be lower and the problems of investment lumpiness will be smoothed through electricity trade.

The case studies carried out in this project have some interesting illustrations of the last point about energy security. In the Argentina-Brazil case study, it is noted that the parliament of Uruguay would not commit to a regional electricity trade agreement unless the country had sufficient installed capacity to meet maximum demand. Gas turbines were purchased to meet this requirement, on the understanding that these were never intended to be used as they were more expensive than imports. In the event, however, the parliamentarians' concerns were vindicated when political changes in Argentina undermined regional electricity trade and the gas turbines had to come into service in Uruguay.

In the SAPP case study, there is the contrasting case of the Zimbabwe government refusing to consider investments in generation capacity that were not on national territory (for example, giving up an opportunity in the 1990s to be a joint venture partner in the Kudu gas field development in Namibia), but finding during the post-2000 economic crisis that imports were the most reliable sources of electricity, even when the country was not able to pay its foreign suppliers, while production from domestic power stations collapsed due to lack of maintenance of the equipment. In an ironic twist, a reverse flow of power has recently been established: Namibia (which has not yet been able to complete the Kudu project and is short of power) has paid for the rehabilitation of some of the generation units at the Hwange power station, in return a contract for Hwange to supply firm energy to Nampower on favorable terms.

The UN-DESA (2005) report offers an expanded definition of energy security, which includes six dimensions: energy supply, economic, technological, environmental, social and cultural, and military/security aspects. The report noted that electricity interconnections will tend to have associated benefits and costs within these six dimensions.

Even where the benefits of regional power system integration are clear, there remains the difficult issue of how these are to be divided between the parties involved. The UN-DESA (2005) report notes that the incidence of social benefits (and costs) can vary between countries and between groups within countries. Likewise, the location of environmental benefits and costs varies. In this context, interconnections can also create seldom

acknowledged political costs, such as providing an excuse for internal political oppression along the route of the line, providing one country with political power over another, involving countries in each others' internal affairs (for example, by creating exposure to instability in a neighbor), creating opportunities for corruption (which can in turn affect the political balance of power within the country), creating political costs in protecting the line (where the line presents a hostage to be used in extortion by local groups), and creating political costs in the process of tariff rationalization (UN-DESA, 2005). Depending on how these costs are managed they can present barriers to integration, as for example when costs would be borne by politically powerful interest groups.

The large body of literature discussing the benefits of regional power system integration is not matched by a similar-sized body of papers specifically discussing possible problems. Such papers are few and far between. Besides the papers on barriers discussed in Section 2.1.2, other papers encountered during the literature review which identify problems with regional power system integration cover instability, blackouts, fragmented markets and price spikes (Eynon et al., 2002; Verneyre, 2004; Joskow, 2002; Lerner, 2003). Turvey (2004) examines the less obvious costs of regional power system integration which could offset what he acknowledges to be the "undoubted benefits" of interconnection.

2.2 Outputs of regional power sector integration projects

2.2.1 Institutional infrastructure and market development

The institutional infrastructure, defining the rules and giving the structures for electricity trade, should include:

- a harmonized regulatory environment, grid codes and market rules (Eberhard, 2003)
- competitive access to both wholesale and retail markets (EU Commission, 2007)
- legal agreements on such issues as power purchase agreements (PPAs), liability for supply failure, environmental responsibility, physical security of the line, and the operation of the line (UN-DESA)

Competitive markets increase the complexity of market rules, which must accommodate third-party access to both interconnections and consumers. Incompatibilities in market design can impede competing suppliers from across borders, particularly where balancing markets are being developed, although the literature supports ways for facilitating competitive access to cross-border balancing markets (SNC-Lavalin Inc., 2004; Frontier Economics and Consentec, 2005).

Competitive markets are becoming the norm in regional trading arrangements in advanced regions (PJM and UCTE Case Studies in Annex A1.9). The emphasis in these regions is on economic efficiency, but they must also allocate the benefits of cross-border access fairly. In Europe, price convergence between markets is important but in North America, the market design does not target this (Synapse Energy Economics, 2007).

The creation of the complex legal structures requires legal capacity in the participating countries, including existing legal framework and legal human capacity among other factors

(UN-DESA, 2005). Assistance with legal capacity is a role that can be played by outside support organizations.

2.2.2 Physical infrastructure

UN-DESA 2005 notes that key technical factors influencing the design of integration include synchronicity of the interconnecting systems, size of the project and location (including terrain to be traversed), and constraints on transmission capacity (thermal limits, voltage regulation).

Whether transmission interconnection should be via AC or DC transmission lines is an important decision (RECI Module 5). DC is suitable for large loads over long distances, but how large and how long depends on a trade-off between lower unit costs on a DC line and the additional costs of conversion stations at each end and loss of flexibility to tap off power at intermediate points. Improvements in technology are reducing the inconvenience of DC while at the same time increasing the breakeven distance which would justify choosing DC, except in special applications (e.g., undersea cables).

2.3 Facilitating the process of regional integration

Facilitation of regional integration projects constitutes a major theme of the papers covered in the literature review. In this regard, the World Bank Independent Evaluation Group (IEG, 2007) report and the UN-DESA (2005) paper place particular emphasis on fair, inclusive and transparent processes to ensure that all groups and stakeholders are represented in the process of developing the integration project.

According to the World Bank IEG, successful programs require compatible rather than conflicting interests among countries. Three unique dimensions of regional programs are noted:

- The design and implementation of regional programs must account for relations between countries and the political economy within countries.
- Regional programs require division of labor between regional and national institutions which needs to be agreed upon and structured.
- Regional programs involve objectives on two levels, regional and national, that have to be harmonized and sequenced.

Unsuccessful initiatives are fail to deal with one or more of these issues. Given this, IEG identifies five factors found among successful programs (see IEG Chapter 5).

- Strong country commitment to regional cooperation
- The scope of objectives has to match national and regional capacities
- Clear delineation and coordination of the roles of national and regional institutions
- Accountable governance arrangements

- Planning for sustainability of program outcomes

On the basis of the papers being reviewed, we have grouped the conclusions on facilitation into three common themes: political will, coordination, and sequencing. These recurring themes provide three key focal areas for facilitating the development of regional power system integration.

2.3.1 Political will

If there is one overriding requirement for regional integration to be successful, it is that the countries need to have the political will to cooperate with their neighbors. This is relatively easy when what it is only cooperation and harmonization which are required, but the real test of political will comes when deeper forms of integration, which involve some ceding of national control, are contemplated. All too often, lack of political will (despite rhetoric to the contrary) translates into delays and constraints which thwart the growth of electricity trade.

Political will is a recurring theme in the literature reviewed; it is considered necessary to realizing the potential in the underlying economics. For example, IEG (2007) finds that strong country commitment to regional cooperation helps to achieve buy-in to specific regional programs. Achieving this cooperation requires evaluation of the costs, benefits and risks (winners and losers at the country and within-country level) and recognition of how benefits and costs will be shared. It is also assisted by the other two facilitation keys: coordination and sequencing.

Lack of political commitment to potentially mutually beneficial regional integration may arise from a range of factors, such as longstanding national rivalries and distrust, internal disunity, substantially different political systems, political strength of internal groups with interests in limiting competition from trade, and corruption.

UN-DESA (2005) suggests approaches to overcoming these barriers, including transparency, inclusiveness both between and within nations, information sharing, fairly distributing the benefits and costs, and using international agencies to assist in achieving and maintaining these objectives. When outside agencies are trying to facilitate, the aim must be to ensure that all parties take ownership of the final arrangement, thereby minimizing the potential for backsliding on regional commitments or, in more extreme circumstances, conflict.

IEG (2007) finds accountable governance arrangements to be a necessary investment to achieve country ownership and support, although such arrangements take time to develop. They are said to require significant inputs from the countries to encourage stakeholder participation, an appropriate level of representation given the project goals (e.g., ministerial representation for high-level integration), and effective coordination where there are multiple donors.

2.3.2 Coordination

Achieving and sustaining integration has been found to be, at least in part, an exercise in coordination. Coordination is necessary as a second best to overcome market failures and address the political concerns which tend to have greater prominence in regional than in national markets. Coordination is needed both during the process of developing the regional integration arrangement and thereafter in the operating phase. Formal institutions *may* be needed for this—a market operator, a system operator, a regional regulator and legal and

technical agreements—though when such institutions become necessary, and what their centralized areas of responsibility should be in relation to decentralized structures, is not well researched (see Section 2.4).

UN-DESA (2005) suggests that technical planning of a grid interconnection should be coordinated with economic, organizational, legal, and political aspects of a potential interconnection project from the outset of project consideration.

IEG (2007) finds that successful initiatives have used national institutions for implementation at the country level, and regional institutions for coordination and support services (such as data collection and sharing and dispute resolution). Country-level roles must be clearly defined and understood. Regional institutions should not be too dominant or too limited. The institutions at different levels should be adequately linked, but this takes time to establish.

The IEG paper notes that integration initiatives have been undermined by poor coordination among donor agencies. It also finds that regional partnerships have had less success than regional projects. Partnerships tended to be driven by donors and have poor links to national institutions. Incentives within the World Bank, which are aligned with individual country assistance, are found to be poorly suited to motivating successful regional initiatives.

Part of the response within the World Bank to the critique provided by IEG has been to establish a Problem-Driven Governance and Political Economy Analysis (PGPEA) framework (World Bank, 2009) to assist in analyzing complex development problems and formulating both national and sectoral strategies. In line with Rodrik's notion of "second-best" institutions (Rodrik, 2008), the PGPEA paper acknowledges that "first-best institutions" are technically superior only in a textbook sense, with the benefits being lost or even reversed if the real-world situation is one in which solutions are only partially implemented, stalled, or reversed. This may occur because the arrangements are politically unpalatable, or they trigger unintended consequences during implementation (such as privatization creating monopolies).

Rodrik's concept of "second-best institutions" is very relevant to regional power sector integration, where a one-size-fits-all approach is clearly not relevant. What is needed is to expand, not narrow, the range of institutional choices available to reformers and those seeking to coordinate regional integration initiatives.

2.3.3 Sequencing

The sequencing may be characterized as being organized into four overlapping phases:

- Demonstrating project feasibility, reaching agreement among participating countries, and arranging financing
- Developing the institutional infrastructure
- Developing the physical infrastructure
- Operating phase

Although this is an obvious sequence, it is not a necessary or even perhaps a desirable one, with the exception of the agreement aspect of the first phase, which is a prerequisite for the success of all other activities.

UN-DESA (2007) argues that the economic and financial structures should be in place before the physical interconnections proceed. The risk is that large investments in physical infrastructure will be inhibited or stranded if the parties to a potential integration fail to first reach consensus on and commit to the fundamentals of the trading arrangement.

The actual activity that happens within each of these stages will be determined by the current integration ambition. The institutional and physical infrastructure phases in particular can repeat at subsequent evolutions in the level of integration. For example, an integration beginning from less complex arrangements may see the institutions designed accordingly and the physical infrastructure put in place and made operational. A subsequent deepening on the integration would see the process return to a new stage of institutional development, and so on.

Integration projects are less likely to succeed when there is poor planning and lack of real agreement in the development stage. All parties need to be united in their desire to see the project through to fruition. This requires shared incentives which will be undermined if the participants believe the benefits and costs are being shared unfairly.

Eberhard (2003) concludes that "To be able to realize the benefits, institutional and [physical] infrastructure development must be given time and priority." However, he considers sophisticated trading to be the last step, contingent on the introduction of choice and competition. This view is aligned with the recognition that the integration process is likely to start with second-best institutions and build from there.

IEG (2007) also notes the importance of sequencing program interventions (preparatory analysis, institutional design, physical infrastructure build, etc.). Neuhoff and Newbery (2005) have a more theoretical analysis of the counterintuitive possibility of prices rising when the number of generators first increases, and of the role of coordinated regulation in such circumstances. They show that, if markets are gradually combined into larger units, the choice of transmission allocation (coordinated auctions or market coupling) will affect the prospects of making further gains and hence could lead to incomplete reform.

2.4 Future research topics

The literature review has revealed certain gaps which warrant future research. The gaps include the following:

- empirical analysis of the extent to which the claimed benefits of regional power system integration have in fact materialized;
- theoretical analysis of the way in which benefits are distributed and how institutions such as regulatory bodies could intervene to make the benefit

sharing more equitable and hence make the deepening of regional power system integration more likely;[3]

- theoretical and empirical treatment of the structuring and financing of regional generation and transmission projects;[4]

- theoretical and political-economy analysis of how to justify and structure regional institutions, particularly with respect to ensuring that the advantages of coordinated regional investment actually materialize (in both the planning and implementation stages).

The last point is particularly important because empirical studies have shown that the biggest gains from regional integration lie in regional investment coordination, yet there is no example which has been encountered during the study where a regional agency has been empowered to do anything more than plan and advise. Investment responsibilities lie with the participants to the regional schemes, and when projects are delayed or projects which are not part of the agreed optimal sequence are implemented, there is no mechanism to protect other players. Specific questions to be addressed in this regard would include:

- In the spirit of the principle of subsidiarity, under what conditions is coordination needed, and is the best way of achieving this through the establishment of a formal institution? What institutional failures at the national level justify a regional approach? What mix of centralization and decentralization is best suited to furthering regional power system integration?

- In particular, in the context of planning, what minimum set of variables need to be set by a regional authority to ensure that national power development plans are consistent with the overall regional optimum? How best can flexibility be built into national plans to allow for deviations in the implementation of the overall regional investment sequence?

- Is there a justification for a regional corporation empowered to execute projects in a timely fashion, keeping the regional investment sequence on track at all times? To establish such an entity, what measures would be needed at the national level to facilitate structuring and financing, including, where necessary, sovereign guarantees?

[3] This gap is being addressed by the World Bank-sponsored study currently underway on the roles of regulatory agencies in further regional power trade in Southern Africa. Neuhoff and Newbery (2005) is also relevant to this issue and questions about the justification for regional institutions.

[4] There is useful material on these topics in Tomkins et al. (2008).

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Frontier Economics and Consentec (2005): *Benefits and Practical Steps Towards the Integration of Intraday Electricity Markets and Balancing Mechanisms*. (Annex A1.3)

Independent Evaluation Group, World Bank (2007): *The Development Potential of Regional Programs – An Evaluation of World Bank Support of Multicountry Operations*. Washington, DC: World Bank. (**Annex 1.7, Annex 2)

Joskow, Paul, and Edward Kahn (2002): *A Quantitative Analysis of Pricing Behavior In California's Wholesale Electricity Market During Summer 2000: The Final Word*. Cambridge-MIT Institute, University of Cambridge. (Annex 1.2)

Kessides, Ioannis, Roger Noll, and Nancy Benjamin (2008): *Regionalising Infrastructure Reform in Developing Countries*. Washington, DC: World Bank. (Annex A1.3)

Lerner, Eric (2003): "What's Wrong with the Electric Grid?" *The Industrial Physicist*, Vol. 9, No. 5, October/November, pp. 8–13. (Annex 1.4)

Neuhoff, Karsten, and David Newbery (2005): "Evolution of Electricity Markets: Does Sequencing Matter?" *Utilities Policy*, Vol. 13, No. 2, June 2005, pp. 163–173.

RECI E7—Regional Electricity Cooperation and Integration (2000): *e7 Guidelines for the Pooling of Resources and Interconnection of Electric Power Systems*. Montreal: RECI. (**Annex A1.1 and Annex 2)

Rodrik, Dani (2008): *Second-Best Institutions*. Cambridge, MA: John F. Kennedy School of Government, Harvard University. (Annex A1.3)

SEETEC (2006): *Study of the Obstacles to Trade and Compatibility of Market Rules*. Paper prepared as part of the Southeastern Europe Electrical System Technical support project. (Annex A1.3)

SNC-Lavalin Inc., in association with Manitoba Hydro and Power Budd LLP (2004): *Position Paper on Management of Balancing Mechanisms and Ancillary Services*. (Annex A1.3)

Synapse Energy Economics (2007): *LMP Electricity Markets: Market Operations, Market Power, and Value for Consumers*. (Annex A1.3)

Tomkins, Ray, Shane Avers, Peter Robinson, Catriona Cameron and Charles Groom (2008): *Trading Arrangements and Risk Management in International Electricity Trade*. ESMAP Formal Report 336/08, Washington, DC. (Annex A1.1)

Turvey, Ralph (2004): "Interconnector Economics." *Energy Policy*, Vol. 34, No. 13, pp. 1457–1472. (Annex 1.2)

UN-DESA–United Nations, Department of Economic and Social Affairs (2005): *Multi-Dimensional Issues in International Electric Power Grid Interconnections*. New York: United Nations. (**Annex A1.1 and Annex 2)

Verneyre, Francois (2004): "European Challenges, Overcoming Challenges." Presented at the KEEI & IEA Joint Conference on Northeast Asia Energy Security and Regional 191 Cooperation, Seoul, South Korea, 16–17 March 2004. (Annex 1.8)

World Bank (2008): *Building Regional Power Pools: A Toolkit*. Washington, DC: World Bank. (Annex A1.3)

World Bank (2009): *Problem-Driven Governance and Political Economy Analysis (PGPEA) Good Practice Framework*. Washington, DC: World Bank. (Annex A1.3)

Papers with extended annotated bibliographic entries in Annex 2

Chronological order

Charpentier, J.P., and K. Schenk (1995): *International Power Interconnections*. Viewpoint Note No. 42, The World Bank. (Annex A1.2, Annex 2)

RECI E7—Regional Electricity Cooperation and Integration (2000): *e7 Guidelines for the Pooling of Resources and Interconnection of Electric Power Systems*. Montreal: RECI. (Annex A1.1 and Annex 2)

UNDP/ESMAP (2001): *Regional Electricity Markets Interconnection Phase 1: Identification of Issues for the Development of Regional Power Markets in South America*. (Annex A1.8, Annex 2)

UN-DESA–United Nations, Department of Economic and Social Affairs (2005): *Multi-Dimensional Issues in International Electric Power Grid Interconnections*. New York: United Nations. (Annex A1.1 and Annex 2)

Independent Evaluation Group, World Bank (2007): *The Development Potential of Regional Programs – An Evaluation of World Bank Support of Multicountry Operations*. Washington, DC: World Bank. (Annex 1.7, Annex 2)

World Bank (2008): *Building Regional Power Pools: A Toolkit*. Washington, DC: World Bank. (Annex A1.2, Annex 2)

A1 Complete annotated bibliography[5]

A1.1 Regional power system integration major overview papers

****Regional Electricity Cooperation and Integration (RECI) (2000): *e7 Guidelines for the pooling of resources and interconnection of electric power systems*. Montreal: RECI.**

Available at http://www.e8.org/index.jsp?numPage=127

The RECI Guidelines are the output of an e7/ESMAP working group which was set up in 1998. The Guidelines consist of a short introductory volume plus eight modules giving comprehensive coverage of RECI feasibility market analysis, resource development, integrated operational planning, technical requirements, financing, market structures and integration institutions.

Key words: technical, economic and financing of electricity interconnections, market structures

****United Nations, Department of Economic and Social Affairs (2005): *Multi-dimensional Issues in International Electric Power Grid Interconnections*. New York: United Nations.**

Available at www.un.org/esa/sustdev/publications/energy/**interconnections**.pdf

This report is arranged into seven main sections with an executive summary, introduction and conclusions and recommendations. The report's premise is that international electricity interconnection projects are diverse initiatives composed of multidimensional issues, costs and benefits. These almost always include: technical, economic and financial, legal, political, social and environmental. Accordingly, these issues provide the framework for analyzing international interconnection initiatives, and the major sections of the report are dedicated to the analysis of each of these aspects. An additional section considers international grid interconnections and energy security.

Key words: technical, economic, financial, legal, political, social, environmental, energy security, interconnection agreements

Tomkins, Ray, Shane Avers, Peter Robinson, Catriona Cameron and Charles Groom (2008): *Trading Arrangements and Risk Management in International Electricity Trade*. ESMAP Formal Report 336/08, Washington DC.

Available at
http://www.esmap.org/filez/pubs/113200824354_Trade_ArragnementFINAL_Web.pdf

The motivation of this report is to investigate the potential for internal and external electricity trade for the 10 countries from Central, West and Southern Asia which are signatories to the Economic Cooperation Organization. The content of the report goes well

[5] Selected references from the annotated bibliography in UN-DESA (2005) have been updated and integrated into Annex A1. The ordering of the entries in the annexes is chronological.

beyond that geographical area, however, presenting a comprehensive overview of regional electricity trade opportunities, governance arrangements and financing options. Particular attention is paid to distinguishing the different types of risks in international energy trade and how these can be mitigated. A typology of different types of international electricity trading arrangements is given and used as a framework for presenting four international case studies.

Key words: electricity trade, governance, financing, risk mitigation, regional power case studies.

A1.2 Economics of RPSI

Charpentier, J.P., and K. Schenk (1995): *International Power Interconnections*. Viewpoint Note No. 42, The World Bank.

This short but insightful paper identifies incentives for regional interconnections and types of electricity trade and outlines the institutional and pricing framework needed for a competitive market to develop.

Key words: incentives, institutions, pricing

Meslier, F. (2000): "Historical Background and Lessons for the Future." In J. Casazza and G. Loehr, eds., *The Evolution of Electric Power Transmission Under Deregulation: Selected Readings*. Piscataway, NJ: IEEE.

Meslier's article is part of a collection of articles on power transmission systems. The areas covered in the book as a whole include: an overview of deregulation issues; transmission system planning and design; transmission system operation; transmission transfer capacity; and restructuring, reliability and transmission.

Key words: North America, power sector overview, deregulation, transmission

Joskow, Paul, and Edward Kahn (2002): *A Quantitative Analysis of Pricing Behavior in California's Wholesale Electricity Market During Summer 2000: The Final Word*. Cambridge-MIT Institute, University of Cambridge.

Available as http://stoft.com/metaPage/lib/Joskow-KahnE-2002-CA-Mrkt-Pwr-Final.pdf.

The purpose of this report is to examine the price surge for electricity in California during the summer of 2000, and to provide an explanation for why this extreme price increase occurred. It begins by looking at normal changes to supply and demand in the market to determine how much of the price increase occurred naturally. The second section of the paper looks at how much of an effect the trading of NOx permits had on the price of electricity, while the final section of the report looks at whether or not the gap between the benchmark of competitive prices and the actual prices fits with the available data on supplier behavior.

Key words: North America, economic

Eberhard, Anton (2003): "The Benefits of Regional Power Trade and Its Contribution to Regional Economic Development." Presentation to the first meeting of the Nile Basin ministers responsible for electricity, Dar-es-Salaam.

This presentation considers both the direct benefits (to power sectors) and indirect benefits (economic, social, political, environmental) of power trade. It includes brief overviews of various integration projects around the world, with a focus on SAPP. After drawing a series of lessons from the surveyed projects, it outlines a suggested path to achieving regional integration.

Key words: SAPP, case studies, benefits of integration, lessons from integration, path to integration

Turvey, Ralph (2004): "Interconnector Economics." *Energy Policy*, Vol. 34, No. 13, pp. 1457–1472.

This paper examines why grid interconnection can at times be inefficient from an economic standpoint. Turvey explains that although there are undoubtedly benefits from interconnection, they may be difficult to quantify and may not cover the costs associated with it. This technical paper starts with a brief section on definitions and descriptions of terms in the context of the paper, and then examines the costs and benefits of international grid interconnections. The third and by far biggest section of the document, entitled "Interconnector Utilization," constitutes the bulk of Turvey's analysis.

Key words: economic, interregional power grid interconnections

Newbery, David (2005): "Integrating Electricity Transmission Systems." *Utilities Policy*, Vol. 13, No. 2, June 2005, pp. 69–71.

Available at: doi:10.1016/j.jup.2004.12.004

This is the editorial introduction to a special issue of *Utilities Policy* devoted to papers arsing from a joint Cambridge–MIT Institute (CMI) Electricity Project. The project commissioned papers addressing the range of problems involved in coordinating transmission management across different electricity jurisdictions. The range of questions addressed was wide, but the core issues were how transmission should be priced and compensated, so that each transmission system operator (TSO) has the right incentives to provide, manage access to, and develop the transmission system in an efficient manner.

In Europe, making better use of interconnector (and supporting domestic) transmission capacity to facilitate cross-border trade is an important aspect of achieving the EU goal of a single European electricity market. The paper notes that in the United States, the ''seams'' issue has been addressed by the Federal Energy Regulatory Commission (FERC) in its proposed Standard Market Design. Europe lacks a comparable overarching regulatory body, and instead in 1999 the European Commission encouraged the European Association of Electricity Transmission System Operators (ETSO) to help integrate the disparate national electricity markets. ETSO participated in the CMI project workshops to further its work on nodal pricing and cross-border congestion management. The paper comments briefly on ETSO's Flow-Based Market Coupling approach to cross-border congestion management, which was introduced in 2004.

Key words: transmission systems, integration, nodal pricing, congestion management

Brunekreeft, Gert, Karsten Neuhoff and David Newbery (2005): "Electricity Transmission: An Overview of the Current Debate." *Utilities Policy*, Vol. 13, No. 2, June 2005, pp. 73–93.

Available at doi:10.1016/j.jup.2004.12.002

Electricity transmission has emerged as critical for successfully liberalizing power markets. This paper surveys the issues and concludes that signalling the efficient location of generation investment might require even a competitive locational marginal pricing (LMP) system to be complemented with deep connection charges. Although a Europe-wide LMP system is desirable, it appears politically problematic, so an integrated system of market coupling, possibly evolving by voluntary participation, should have high priority. Merchant investors may be able to increase interconnector capacity, although this is not unproblematic and raises new regulatory issues. A key issue that needs further research is how to better incentivize TSOs, especially with respect to cross-border issues.

Key words: Transmission, regulation, LMP, merchant investment

Neuhoff, Karsten, and David Newbery (2005): "Evolution of Electricity Markets: Does Sequencing Matter?" *Utilities Policy*, Vol. 13, No. 2, June 2005, pp. 163–173.

Available at doi:10.1016/j.jup.2004.12.008

This paper addresses three questions that are relevant to integrating different regional transmission areas. Market integration normally increases the number of competitors and should therefore reduce prices, but the first section shows that prices could rise when the number of generators initially increases. Regulatory effort will also be affected by market integration. If the number of generators in either market is low, then the analysis in this paper suggests that the outcome depends on whether the regulators act independently or coordinate. Finally, if markets are gradually combined into larger units, the choice of transmission allocation (coordinated auctions or market coupling) will affect the prospects of making further gains and hence could lead to incomplete reform.

Key words: Oligopoly pricing, market integration, competition policy, regulation

Neuhoff, Karston (2006): *International Electricity Trade—Economic Considerations*. University of Cambridge.

Available at http://www.nautilus.org/DPRKBriefingBook/energy/neuhoff.pdf

This is a two-page note on some issues in international electricity trade. It comments on the implications of generator market power for transmission pricing arrangements. If the exporter is a monopoly, the paper suggests long-term contracting is essential. The importing country would be exposed to monopoly pricing in the short run since it is unable to build alternative generation. Unconstrained transmission capacity should be priced at marginal cost. The resulting overcollection of average costs due to the nonlinearity of losses can be used to partially cover fixed costs.

If transmission capacity between low- and high-priced systems is constrained, it should be auctioned with the revenues going to the regulator. This will avoid perverse incentives for

the transmission company to deliberately constrain the line to maximize revenue. The note does not comment on how this surplus should be distributed.

Key words: electricity trade, market power, transmission pricing

Bunn, Derek and Jens Weinmann (2006): *The Price of Uncertainty in Market Integration—Electricity Trading Risk in the Balkans.* London Business School.

This paper notes that a common institutional intent in electricity market liberalization is to achieve transparency, ease of new entry, and efficiency gains. The conventional view among policymakers is that with the right market structure, and some regulatory oversight, efficient competition and active arbitrage opportunities will drive spot prices close to marginal costs and forward contracts close to the expected spot prices. This report documents the extent to which this view ignores the cost of uncertainty and risk management in trading electricity, and that when an assessment of risk and return is made for an emerging electricity market, in a region such as Southeast Europe, the sources of risk are significant and inhibit investment. The development of traded markets with price reporting can reveal market risks in a more objective way through forward contracting premia, but, of course, they do not reduce the nature of the underlying risks.

Key words: electricity trade, regional markets, risk, hedging mechanisms

World Bank (2008): *Building Regional Power Pools: A Toolkit*. Washington, DC.

Available at http://siteresources.worldbank.org/EXTENERGY2/Resources/toolkit_book_final.pdf

This document has three main sections: a Roadmap, a Nordel Case Study, and Modules on establishing cross-border transmission facilities and upgrading SCADA/EMS systems. The paper lists the main benefits of regional power pools as being reduced or postponed costs and improved supply conditions. The requirements are adequate legal, regulatory, systems planning, operational and commercial frameworks.

Key words: power pools, postponed costs, system planning

Finon, Dominique, and Elliot Romano (2009): "Electricity Market Integration: Redistribution Effect Versus Resource Reallocation." *Energy Policy*, Vol. 37, No. 8, August 2009, pp. 2977–2985.

Available at doi:10.1016/j.enpol.2009.03.045

In countries with a significant amount of low-variable-cost generation capacity, the integration of electricity markets poses a real problem with respect to consumers' interests. In such cases, consumers face a significant price rise compared with consumers in countries where low-cost capacities are lacking. This paper analyzes this problem both in the short and long term, focusing on a market dominated by nuclear and hydro production.

When there are too many restrictions on new capacity developments in low-cost technologies, market integration will lead to surplus redistribution without any production reallocation. This really makes it legitimate to contemplate redistributive compensations towards local consumers in countries which benefited from low-variable-cost generators at the moment of liberalization. This paper examines two alternative ways of rent reallocation,

one by income with a windfall tax on nuclear producers and the allocation of this revenue to energy efficiency policy funds, and another by price by giving drawing rights on the existing nuclear generators' production to small commercial and domestic consumers, at a level equivalent to the one necessary to maintain regulated prices.

Key words: Electricity price setting, market integration, rent allocation, compensation

A1.3 RPSI institutions and markets

Rangeley, R, B.M. Thiam, R. Andersen and C. Lyle (1994): *International River Basin Organizations in Sub-Saharan Africa*. World Bank Technical Paper Number 250.

Available at www.riob.org/transfrontalier/dakar.../NIBO_nov_2004_conf.pdf

This paper deals with the main characteristics of rivers in sub-Saharan Africa, describes the various forms of international river basins organizations (RBOs), reviews past achievements, and gives future perspectives and recommendations. The authors state that while performance of RBOs varies widely, it is their collective role to "promote, through international cooperation, studies and the construction of works that will lead to an integrated, economically and environmentally sustainable, and technically sound development of the water resources of a river basin."

Key words: river basin organisation, Sub-Saharan Africa

Newbery, David M. (1998): *The Regulator's Review of the English Electricity Pool*.

Available at: http://www.econ.cam.ac.uk/faculty/newbery/files/UTILWEEK.PDF

The England and Wales market was designed in 1989 as a gross pool in which generators submitted bids into a clearing market in order to be scheduled to generate on the day ahead. This article is a critique of the regulator's approach to market reform in 1998. The regulator concluded that the market should be reformed, and the New Electricity Trading Arrangements (NETA) came into being in 2001. The NETA market is a net pool design in which generation is self-scheduled to fulfil bilateral contracts with a residual balancing market used to achieve physical balance.

David Newbery's article examines the case made for the reform and concludes that, while specific rules of the gross pool market could have been improved (particularly with regard to the governance arrangements), the regulator's review had not identified shortcomings requiring the reforms that were being proposed.

Key words: Gross pool, net pool, markets, UK

CLECO Power (2001): ***Electric Power System Interconnection Agreement between CLECO Power LLC and the Southwestern Power Company*****. Rate Schedule FERC No. 17, section 5.15.**

Available at http://www.cleco.com/uploads/RS17.pdf.

This document is a typical example of a power purchase agreement (PPA) between two companies in the United States and is therefore a good legal reference for what information is generally covered in a PPA.

Key words: North America, legal, power purchase agreements

IEA (2002): ***Security of Supply in Electricity Markets: Evidence and Policy Issues*****.**

Available at: http://www.iea.org/textbase/nppdf/free/2000/security2002.pdf

This study notes that reforming electricity markets can reduce investment in assets. Price signals may be insufficient to encourage sufficient long-term investment. Policy requirements that markets may not address (such as diversity) will remain. Transmission incentives may be absent (because transmission is a monopoly with investment not driven by market forces). Transitional issues as markets evolve can be important and may lead to inadequate investment in the interim. Ultimately, despite the extension of power pools, to an extent electricity markets remain local.

Key words: security of supply, investment, competition

Neuhoff, Karsten (2003): ***Coupling Transmission and Energy Markets Reduces Market Power*****. Paper presented in Prague.**

Available at http://www.iaee.org/en/students/best_papers/neuhoff_prague_2003.pdf

Transmission constraints fragment electricity markets and enhance the regional market power of electricity generators. In continental Europe, rights to access transmission between countries are auctioned to traders, who arbitrage separate energy spot markets of these countries. In Scandinavia, the system operator integrates these markets and simultaneously clears energy spot markets of several countries and decides on optimal energy transmission. In any unconstrained or partially constrained network, integration mitigates the market power of strategic generators and avoids inefficient production decisions. A testable prediction for both effects is applied to the Dutch-German and Norway-Sweden interconnection and supports the theory. In meshed networks, integration also mitigates market power when constraints are permanently binding. Le Chatelier's principle extends to electricity networks in the presence of market power. Demand is more responsive to price changes and aggregate output increases if markets are integrated.

Key words: Market power, transmission and energy market integration

SNC-Lavalin Inc., in association with Manitoba Hydro and Power Budd LLP (2004): ***Position Paper on Management of Balancing Mechanisms and Ancillary Services.***

Available at: http://www.seetec-balkans.org:8181/dl/997A.pdf

This SEETEC paper looks at how TSOs can develop a balancing mechanism in a liberalized market based on bilateral contracting. The TSO is responsible for physical balancing of its system and can do so using an administered mechanism that activates reserves or else uses a bid and offer stack with which to procure prompt reserves; the paper favors the market approach.

The paper discusses the possibility of a regional balancing market and the requirements in the case of Southeast Europe. The paper recommends that a balancing market is a prerequisite for a day-ahead energy market.

Key words: balancing market, reserve, ancillary services, Europe

Frontier Economics and Consentec (2005): B*enefits and Practical Steps Towards the Integration of Intraday Electricity Markets and Balancing Mechanisms.*

Available at:
http://ec.europa.eu/energy/electricity/publications/doc/frontier_consentec_balancing_dec_2005.pdf

This report to the EU Commission develops generic models for linkage between the markets for spot energy and balancing.

The first model relies on TSO-TSO trading but has problems defining an efficient price at which the TSOs trade. Other issues relate to access of the TSO to balancing energy with which to trade. Other issues relate to withholding interconnector capacity for use by TSOs in their trading.

The second model relies on a post gate closure integrated balancing market for clearing balancing bids. There are potential inefficiencies if the balancing and cashout regimes are different in the various TSO control areas (e.g., if there is a pay-as-bid regime in one market and marginal payment in another or if one market has a single imbalance cashout price while another has two prices). Different regimes for ancillary service can also affect the model.

The third model allows trading participants to offer balancing energy into other markets.

There are implementation and harmonization issues with each approach. The second model has potentially the greatest efficiency but requires the most coordination of balancing rules.

Key words: balancing, markets, system operation

European Regulators Group for Electricity and Gas (2006): ***The Creation of Regional Energy Markets—An ERGEG Conclusions Paper*****. ERGEG, Brussels.**

Available at http://www.energy-regulators.eu/portal/page/portal/EER_HOME/EER_PUBLICATIONS/CEER_ERGEG_PAPERS/Electricity/2006

This document summarizes the obstacles to electricity trade, giving the views in ERGEG's discussion paper, the responses received from its members and ERGEG's final view. The discussion of obstacles is under the headings network operations, wholesale market arrangements, regulation across a regional market, and interactions between markets.

Key words: electricity trade, electricity markets, obstacles, Southeast Europe

SEETEC (2006): ***Study of the Obstacles to Trade and Compatibility of Market Rules*****. Paper prepared as part of the Southeastern Europe Electrical System Technical support project.**

This report identifies and discusses in detail eight main obstacles to deepening power system integration in Southeast Europe (SEE). The issues are further divided into four categories (1) Issues linked to implementation of EC Directives/Treaty and already identified as priority by the Athens Forum (cross-border allocation procedure and inter-TSO compensation); (2) Other issues linked to EC Directives/Treaty (access to national networks and role of TSOs); (3) Issues linked to development of competition in generation and supply (market concentration and vertical foreclosure; operability of market rules at national level; (4) Issues specific to Southeast Europe reforms (tariff issues, harmonization/compatibility issues, licensing). Although having a strong SEE focus, the paper is highly relevant to the analysis of obstacles in other regional power schemes.

Key words: electricity trade, electricity markets, obstacles, Southeast Europe

EU Commission (2007): ***DG Competition Report on Energy Sector Inquiry.***

Available at: http://ec.europa.eu/competition/sectors/energy/inquiry/index.html (*report is in four parts*)

The EU Commission launched an inquiry into competition in electricity and gas in Europe. The final report identified serious shortcomings in the electricity and gas markets:

- too much market concentration in most national markets;
- a lack of liquidity, preventing successful new entry;
- too little integration between member states' markets;
- an absence of transparently available market information, leading to distrust in the pricing mechanisms;
- an inadequate current level of unbundling between network and supply interests, which has negative repercussions on market functioning and investment incentives;

- customers being tied to suppliers through long-term downstream contracts;
- current balancing markets and small balancing zones which favor incumbents.

The study is specific to Europe but highlights what the EU Commission considers necessary for a regional competitive market and provides a wealth of analytical tools with universal application.

Key words: competition, balancing, markets, Europe

Camacho, Luis Olmos, and Ignacio J. Pérez-Arriaga (2007): "Comparison of Several Inter-TSO Compensation Methods in the Context of the Internal Electricity Market of the European Union." ***Energy Policy*****, Vol. 35, No. 4, April 2007, pp. 2379-2389**

Available at doi:10.1016/j.enpol.2006.09.004

Inter-TSO payment methods (ITC methods) provide the aggregate compensations and charges faced by countries in a region, because of the use that agents in each country make of the transmission grids of the other countries. These compensations and charges should modify local access charges in each country. The paper closely examines the most promising methods for computing ITCs currently considered in the Internal Electricity Market (IEM) of the European Union, namely the Average Participations (AP) method and the With and Without Transits (WWT) method. Some attention is also given to a third method that lies somewhere between the two previous ones: the Average Participations applied to Transits (APT) method. The performance of the AP, WWT and APT methods is compared with that of the temporary method currently applied to compute compensations in the IEM.

The three methods are closely examined both from a conceptual point of view and taking into account the numerical results they produce. Based on this analysis, the AP method is proposed as the best option to compute ITCs in the European Union. The paper draws on research projects carried out for the European Commission and the Florence Regulatory Forum.

Key words: Transmission pricing, cross-border tariffs, European electricity market

Synapse Energy Economics (2007): ***LMP Electricity Markets: Market Operations, Market Power, and Value for Consumers.***

Available at:
http://www.appanet.org/files/PDFs/SynapseLMPElectricityMarketsExecSumm013107.pdf

This paper is a critique of the practice of locational marginal pricing (LMP) as operated in practice. It was prepared for the American Public Power Association and looks at the implementation of LMP in the PJM Interconnection and New England ISO markets. Both markets are in the northeastern United States. It concludes that the theoretical case for LMP is strong, providing pricing signals of the local value of generation, transmission and demand management required for rational investment and operational behavior. However, the paper notes that in practice LMP allows significant local market power for generators that is not matched by significant demand-side response and that the signals for transmission construction are not leading to investment in relief of congestion.

Key words: locational marginal pricing, investment, North America

Kessides, Ioannis, Roger Noll and Nancy Benjamin (2008): *Regionalising Infrastructure Reform in Developing Countries.* Washington, DC: World Bank.

This paper argues that the regionalization of infrastructure policy can yield significant benefits that go beyond the exploitation of economies of scale through large regional projects. Regional cooperation/integration, especially in the area of regulation, can help developing countries overcome national limits in technical expertise, enhance the capacity of these countries to credibly commit to a stable regulatory policy, and ultimately can facilitate infrastructure investment.

The paper identifies regulatory capture (resulting from representation bias) and asset expropriation (creating a commitment problem) as the two outcomes of a weak regulatory environment and suggests that in many, especially small, developing countries the regulatory capacity and safeguard conditions (such as the strength of civil society monitoring and an independent judiciary) needed to reduce the risk of these outcomes may not be in place. The benefits of developing regional regulatory frameworks in a multilateral context are analogous to those from negotiating trade reform in a multilateral forum. The authors argue that by shifting the focus from single domestic issues to a broader regional perspective a more efficient outcome is likely.

Key words: benefits of integration, reducing barriers to integration, regional regulatory reform, case studies (ECOWAS, OECS)

Rodrik, Dani (2008): *Second-Best Institutions*., Cambridge, MA: John F. Kennedy School of Government, Harvard University.

Available at http://rodrik.typepad.com/dani_rodriks_weblog/2008/01/second-best-ins.html

This paper starts with the observation that "the focus of reforms in the developing world has moved from getting prices right to getting institutions right." The institutional reforms promoted by the multilateral organizations is heavily biased to the "best practice" model, but all too often this approach has proved self-defeating. A "second-best mindset" will help to identify reforms that might achieve the desired ends at lower costs or at the very least to keep the reform agenda moving forward. The well-known problem with moving from best practice, context-free institutions to the second best is that a very wide range of possibilities is opened up, but in the face of subtly interrelated institutional constraints, which change over time, confronting that complexity is precisely what is needed.

Key words: institutions, second best, reform

World Bank (2009): *Problem-Driven Governance and Political Economy Analysis (PGPEA) Good Practice Framework*. Washington, DC.

The premise of this paper is that governance and political-economy analysis has a crucial part to play in enhancing development effectiveness. It was written to respond to the widely shared perception in the World Bank of the need to gain a better understanding of the environments in which Bank operations are taking place and the recognition that governance and political economy factors play a powerful role not only for a country's

overall development path, but also for shaping policies in various sectors and how these are being implemented.

The paper advocates an approach which starts with identifying vulnerabilities and analyzes these in terms of institutional and governance arrangements and political economy drivers. It acknowledges Danny Rodrik's heterodox views on second-best institutions (see separate entry on related paper) and has an interesting discussion of patronage and clientelism, which have been extremely dysfunctional in some regions, but have actually produced (or at least not stopped) high rates of growth in others. There are instructive electricity sector examples from Zambia, India and Lebanon of "good enough governance and feasible approaches to reform" producing better results than thwarted attempts to achieve more complete reforms.

Key words: governance, political economy, electricity sector reforms

Søreide, Tina, Daniel Benitez and Felicia Haladner (2009): *The Politics of Cross-Border Electricity Supply—Some Experiences from Latin America*. Washington, DC: World Bank.

This paper reviews some experiences with cross-border electricity supply in the Latin American region and finds that the likelihood of success depends on broad economic and political dimensions in addition to the characteristics of the deal. The paper suggests that the most important determinants for successful collaboration on cross-border electricity supply are the economic motivation behind the deal, political consensus and support (which in part depends on resolving distributional issues), and private-sector involvement. The paper identifies collaboration on sector regulation as being important, but suggests that regulatory harmonization will not bring trade unless these other factors are in place.

The paper notes that cross-border electricity projects are complicated and have a variety of risks associated with them. It is not just at the start that the political factors need to be favorable, but also when governments/motivations and market conditions change during project execution. "Politics are decisive for cross-border supply at all stages of the projects." There is a rich set of illustrative political-economy examples from many specific schemes, including Itaipu, Salto Grande, Pasto, SIEPAC and Garabi. The paper also has data for electricity trade in Latin America, showing this to be quite limited (only about 7% of the total electricity generated in 2006), probably for non-market rather than economic reasons.

Key words: political economy, incentives, private sector participation, Latin America

Regional Electricity Regulators Association of Southern Africa (2009): *Guidelines for Regulating Cross-Border Power Trading in Southern Africa*. Windhoek, Namibia: RERA; Castalia (2009): *Manual for RERA Guidelines for Regulating Cross-border Power Trading in the SADC Region: A User's Guide*. Washington, DC:Castalia Advisory Group.

Available at http://www.innovasjonnorge.no/Sok/?SearchQuery=RERA

The RERA Guidelines are one of the responses to the mandate given by the SADC Energy Ministers in 2008 for the Regional Electricity Regulators Association of Southern Africa to address major regulatory constraints in the enabling environment for cross-border power trade in southern Africa. There are nine separate guidelines which:

- lay out the regulator's powers and duties in cross-border trading;

- address issues of compatibility, timing and transparency of regulatory decisions;
- stipulate how cross-border trade is to be licensed;
- provide procedures for approving cross-border agreements in importing, exporting and transit countries;
- provide guidance on the approval of nondiscriminatory transmission access, transmission pricing and the procurement of ancillary services by systems operators and control areas.

The Guidelines are to apply to any cross-border power facility that involves more than 20 MW of power, and the relevant power purchase agreement or transmission wheeling agreement is longer than one year.

The intention of the RERA Guidelines is to provide an enabling framework for cross-border trade and investment in infrastructure that will reduce some of the earlier uncertainties deterring investment and undermining efforts to improve security of supply through cross-border trading. Some of the key issues covered are regional market operations, control area services, balancing markets, grid codes, power purchase, transmission and wheeling agreements and associated pricing.

The Regulatory Guidelines are complemented by a separate manual which expands on the purpose, scope and proposed implementation of the guidelines and provides a detailed rationale for each guideline. The manual is intended as a practical "user's guide" to the Regulatory Guidelines.

It starts with a useful characterization of the barriers and risks to cross-border power trading, some of which will be overcome by rigorous implementation of the ***RERA Regulatory Guidelines***, but the manual suggests that there is also need for two further elements which are dubbed:

- ***SADC High-Level Principles,*** which are a formal commitment from SADC states to the promotion of cross-border electricity planning and trading, the coordination of regional decision making, the empowerment of regional organizations and working toward greater harmonization;
- ***SAPP Technical Checklist***, which is a review of the technical aspects of cross-border electricity trading, including how these transactions are to be accommodated in the regional, interconnected electricity system.

The manual goes on to covers the purpose, implementation and scope of the guidelines, but the bulk of the document (50 of the 60 pages) is devoted to a detailed, insightful commentary on each of the nine guidelines.

At the time of writing, the Regulatory Guidelines have not been formally approved. Once in the implementation stage, it is anticipated that the guidelines will evolve in response to regional trade realities, and this will trigger updates in the manual. If at least the main elements are implemented by all the SADC members, the guidelines will represent a significant move toward harmonizing national regulatory systems in southern Africa and thereby encouraging large cross-border transactions and possibly also regional investments

involving private capital. In time, the guidelines may come to be looked back on as providing the first step toward a true regional regulator, which would have discretionary powers over-riding national regulators in matters pertaining to regional trade. At present, RERA is an association of national regulators, and is not a regional regulator as such.

Beyond southern Africa, the RERA Guidelines and Manual provide an important example of what can usefully be done to further regional power integration in circumstances where politicians are not yet willing to grant the autonomy needed for a fully fledged regional regulator to be established. The documents contain both general principles and specific details of the regulatory requirements to foster cross-border electricity trade and the deepening of regional power sector integration.

Key words: Regional regulators, harmonization, political commitment

A1.4 Technical aspects of RPSI

Happ, H. (1973): "Power Pools and Superpools: A Description of the Methods for the Second-to-Second Control of Generation in Large Power Systems." ***IEEE Spectrum*****, March, pp. 54–61.**

Available as: http://blackout.gmu.edu/archive/pdf/power_pools.pdf.

This reports looks at how generation is controlled in large power pools. It starts with a review of the development of power sharing and pools, their benefits, and the key components necessary for them to function efficiently. The report then presents three different methods for controlling the generation of pools and superpools, addressing the positives and negatives of each.

Key words: technical, regional power pools, generation dispatch

Stevenson, W. (1982): ***Elements of Power System Analysis*****, 4th edition. New York: McGraw-Hill.**

This textbook, used often in university-level electrical engineering classes, provides an in-depth examination of the electrical theory behind generation, transmission, system protection, and power flow and system stability analysis.

Key words: technical, power sector theory

North American Electric Reliability Council (NERC) (1995): ***Transmission Transfer Capability: A Reference Document for Calculating and Reporting the Electric Power Transfer Capability of Interconnected Systems*****. Washington, DC.**

Available at
ftp://ftp.nerc.com/pub/sys/all_updl/docs/pubs/TransmissionTransferCapability_May1995.pdf.

This report looks at the capability of transmission transfers from the standpoint of a transfer system's physical limitations and core characteristics. Various definitions, concepts, technical issues, and simulations used to calculate and report transmission transfer

capability are also presented to provide background information related to transfer capability.

Key words: North America, technical, interregional power grid interconnections, transmission transfer capability

Grunbaum, R., J. Charpentier, and R. Sharma (2000): *Improving the Efficiency and Quality of AC Transmission Systems*. Joint World Bank-ADB Paper.

Available at http://www.worldbank.org/html/fpd/em/transmission/efficiency_abb.pdf.

This report looks at the opportunities and challenges presented by the changing electricity supply industry, which largely stem from the significant increase in inter-utility power sharing, deregulation of the electricity market, and the political, economic and environmental aspects of building new transmission lines. The paper addresses other solutions, known as "Flexible AC Transmission Systems (FACTS)," for overcoming capacity and quality limitations as opposed to following the more traditional path of building new lines.

Key words: power sector, interregional power grid interconnections, Flexible AC Transmission Systems (FACTS)

Glover, J. Duncan, and Mulukutlas Sarma (2001): *Power System Analysis and Design*, 3rd edition. Thomson.

This textbook is designed to provide a general overview of the basic concepts of power systems and the tools and skills needed to apply these concepts. Basic theories and modeling techniques are presented, giving the reader a foundation which can be easily extended towards understanding some of the new and more complex issues facing the industry today. Several updated case studies are incorporated in the textbook.

Key words: technical, power system design

Lerner, Eric (2003): "What's Wrong with the Electric Grid?" *The Industrial Physicist*, Vol. 9, No. 5, October/November, pp. 8-13.

Lerner looks at the physical components of electric grids, and the economic rules that govern them, to examine the reasons why power transmissions systems fail. Lerner looks at the case of the blackout in the Northeast United States of 2003. It is his premise that to avoid such blackouts in the future, the US system must either transform to accommodate the new economic rules governing power systems, or create new rules to match the physical structure of power grids.

Key words: North America, technical, economic, system failure

A1.5 Hydropower

Von der Fehr, N.H.M., and L. Sandsbraten (1997): "*Water on Fire: Gains from Electricity Trade.*" *Scandinavian Journal of Economics*, Vol. 99, No. 2, pp. 281-297.

Available at http://www.jstor.org/pss/3440557

This paper explores the potential for complementarities between hydro and thermal systems which potentially giving rise to larger gains from electricity trade than those traditionally associated with comparative advantages and economies of scale. The paper considers three trading regimes, which may arise either endogenously or because of trade regulations: day-night power exchange, seasonal energy banking, and unbalanced trade. The analysis suggests that gradual trade liberalization may be costly.

Key words: hydropower, complementarity, power exchanges, seasonality, energy banking

Pearce, Fred (2000): "Water-Reservoirs and Greenhouse Emissions." *The Independent*, 13 October. London, UK.

Available at http://www.rivernet.org/general/dams/greenhouse.htm.

This article examines the environmental impacts of reservoir dams, with a specific focus on greenhouse gas emissions and the resulting effect on global warming. It argues that hydroelectric power, once touted as a "green" energy source, produces significant quantities of carbon dioxide and methane, making many of the large reservoir dams as pollution-causing as a typical fossil-fuel burning plant.

Key words: hydroelectric, environmental, greenhouse gases

Kalitsi, E.A.K. (2003): *Problems and Prospects for Hydropower Development in Africa*. Presented at the Workshop for African Energy Experts on Operationalizing the NEPAD Energy Initiative.

Available at http://www.un.org/esa/sustdev/sdissues/energy/op/nepadkalitsi.pdf.

This paper outlines the prospects and problems of hydropower development in Africa and focuses on recommending concrete proposals to help facilitate the development of this sector of Africa's energy infrastructure. These policy proposals and strategies fall under the auspices of the New Partnership for African Development (NEPAD) initiative. The various sections of the paper outline Africa's power sector, the current hydro initiatives underway in Africa, the benefits and environmental and social costs associated with hydropower, funding issues, and an action plan for the development of hydropower in Africa.

Key words: Africa, hydropower

McCully, Patrick (2004): *Tropical Hydropower Is a Significant Source of Greenhouse Gas Emissions: A response to the International Hydropower Association*. Paper presented at the 10th Session of the International Conference of the Parties to the United Nations Convention on Climate Change (COP10), Buenos Aires, Argentina, 13 December.

Available at
http://www.irn.org/basics/conferences/cop10/pdf/TropicalHydro.12.08.04.pdf.

This paper is a response to information provided by the International Hydropower Association regarding the emissions of greenhouse gases from hydro facilities. It examines the effects that large reservoirs have in terms of methane gas emissions, and also cites and critiques several reports written on greenhouse gas emissions of hydropower plants.

Key words: hydropower, environmental, greenhouse gases

McCully, Patrick, and Susanne Wong (2004): *Powering a Sustainable Future: The Role of Large Hydropower in Sustainable Development*. Presented at the UN Symposium on Hydropower and Sustainable Development, Beijing, China, 27-29 October.

Available at http://www.irn.org/basics/conferences/beijinghydro/pdf/irnbei.pdf.

The focus of this paper is on the role of large hydropower facilities in sustainable development. It looks at the social, environmental, and economic impacts that result from the limitations of large hydro plants and provides recommendations for environmentally friendly, cost-efficient, and socially equitable development for projects of this nature.

Key words: Hydropower, environmental, economic, social

A1.6 Environmental aspects of RPSI

Public Service Commission of Wisconsin (1998): *Environmental Impacts of Electric Transmission Lines*. PSC Overview Series.

Available at http://psc.wi.gov/consumerinfo/brochures/electric/60/ob.pdf.

The Public Service Commission of Wisconsin provides background information on the environmental and social impacts of the construction of electricity transmission lines. The paper was designed to assist landowners, local officials, and other citizens who might be affected by the construction of such a line, and more generally to serve as a guide in helping to develop Wisconsin's long-term energy plans.

Key words: Environmental, social, transmission lines

Vallée, A., and G. Jean Doucet (1998): "Environmental Implications or International Connections: The New Arena." ***IEEE Power Engineering Review*****, August, and presented at the panel session on International High-Voltage Grids and Environmental Implications at the 1998 IEEE Power Engineering Society Winter Meeting, Tampa, FL**.

Available at http://www.geni.org/energy/library/technical_articles/transmission/IntlGridandEnvironment.html.

This report looks at the environmental impacts resulting from interregional power grid interconnections, focusing on case studies from North Africa, East Asia, Europe and North America, and at quality of life and renewable energy opportunities with long-distance transmission.

Key words: Asia, Africa, Europe, North America, environment, interregional power grid interconnections

Bocking, Stephen (1998): "Environmental, Social and Economic Impacts of Dams: Environmental Impacts." ***Dams and Development*****. International Development Studies Network.**

Available at http://www.idsnet.org/Resources/Dams/Development/impact-enviro.html.

This report looks at the major environmental impacts of dams, which it organizes into two categories. The first category is the impacts that arise from the existence of a dam and reservoir, such as loss of habitat, increased erosion, changes in downstream water quality, and reduction of biodiversity. The second category is the issues that arise due to the pattern of dam operation, such as changes to downstream hydrology, morphology and water quality, and also reduction in habitat diversity.

Key words: hydropower, environmental and social impact, dams

Beilfuss, Richard (1999): "Can this River Be Saved? Rethinking Cahora Bassa Could Make a Difference for Dam-Battered Zambezi." ***World Rivers Review*****, February 1999.**

Available at internationalrivers.org/files/990201cahorabassa.pdf

This paper argues that the neglect of downstream environmental issues in the building and operation of Cahora Bassa has had significant deleterious effects on natural habitats, wildlife, in-stream fishing, prawn fishing, grazing and flood recession agriculture. An appeal is made to artificially restore the natural flooding patterns of the river through prescribed releases from Cahora Bassa dam. An estimate of the cost in terms of foregone electricity production is given (10 to 15% reduction in hydropower output, valued at the time as $20 to $30 million per annum). The benefits that have been assessed of prescribed flooding in other African hydropower projects are cited: Tiga and Challawa Gorge Dams in Nigeria and Manantali Dam on the Senegal.

Key words: environment, hydropower, prescribed flooding

Bond, R. et al (2001): "Integrated Impact Assessment for Sustainable Development: A Case Study Approach." ***World Development*****, Vol. 29, No. 6, pp. 1011–1024**.

This paper explores approaches to assessing complex integrated projects, which should be evaluated by looking not only at the economic factors, but also social and environmental impacts. Three case studies—the Manantali hydropower project in West Africa, the ABGEP project in Sri Lanka, and the Acid Waters Project in Wales—are used to illustrate different approaches. The authors do not propose a single standardized methodology but recommend instead that the methodology chosen for a particular project should be one that is appropriate to the nature and scope of the project, the stage in the project cycle and the context (cultural, institutional and regulatory). Participation and consultation should be part of the approach.

Key words: environment and social assessment, methodology, Manantali, participation

Streets, David (2001): ***Environmental Aspects of Electricity Grid Interconnection in Northeast Asia.*** **Presented at the Workshop on Power Grid Interconnection in Northeast Asia, Beijing, China, 14-16 May.**

Available at: http://www.nautilus.org/archives/energy/grid/papers/streets.pdf

This document examines the environmental benefits of connecting the electric grid networks of the countries of Northeast Asia, including: Russia, Mongolia, China, Japan, the DPRK, and the Republic of Korea. The focus is on how the promotion of alternative sources of energy (namely hydro and to a lesser extent nuclear) to reduce the use of coal and the integration of the electricity networks of the different countries involved could significantly help to combat the air pollution of the region and provide more widespread and consistent electricity.

Key words: Asia, environmental, hydropower

Von Hippel, D. F., and J. H. Williams (2003): "Environmental Issues for Regional Power Systems in Northeast Asia." Presented at the Third Workshop on Power Grid Interconnections in Northeast Asia, Vladivostok, Russian Federation, 30 September – 3 October.

Available as:
http://nautilus.org/archives/energy/grid/2003Workshop/Env_Issues_DVH_JW_final_pdf.PDF

This report looks at the positive and negative environmental impacts of power grid interconnections in Northeast Asia. The main areas of focus of the report include air pollution, water pollution, solid and hazardous waste, land use, biodiversity and wildlife, and human health. The final sections of the paper evaluate the institutional issues related to the environmental impact of power grid interconnections.

Key words: Environment, interregional power grid interconnections

A1.7 Support of outside agencies for RPSI

International Development Association (2006): ***IDA 14 Mid-Term Review of the IDA Pilot Program for Regional Projects.***

Available at
http://web.worldbank.org/WBSITE/EXTERNAL/EXTABOUTUS/IDA/0,,contentMDK:21145534~menuPK:3211660~pagePK:51236175~piPK:437394~theSitePK:73154,00.html

This report takes stock of past projects of the IDA. One of the early conclusions is that IDA is increasingly being asked by African countries in particular to help solve problems on a regional basis. IDA finds itself well placed to work on regional integration projects because of close partnerships with many different donors, especially in Africa. In the authors' opinion, effective regional integration depends on countries harmonizing national policies to create a policy environment in which regional initiatives can succeed. This in turn necessitates regional policy alignment as well as private investments. The West African Power Pool (WAPP) is used as a case study.

Key words: regional development, donor coordination, WAPP

Asian Development Bank (2007): ***Cross-Border Infrastructure Tool Kit.*** **Asian Development Bank, Manila. Published with funding from the Public-Private Infrastructure Advisory Facility (PPIAF)**

Available at http://www.ppiaf.org/content/view/130/485/

This tool kit is organized around four main topics: Planning and Policy, Finance, Regulation and Accountability, and Private Sector Participation. Each has six to eight subtopics which are covered in detailed materials available on a CD-ROM. The overview documents are an introductory booklet, a list of source materials and links, a topics grid and a useful glossary of terms.

Key words: cross-border infrastructure, finance, private sector participation

****Independent Evaluation Group, World Bank (2007):** ***The Development Potential of Regional Programs—An Evaluation of World Bank Support of Multicountry Operations.*** **Washington, DC.**

Available at
http://siteresources.worldbank.org/EXTREGPROPART/Resources/reg_pgms_full.pdf

This report is an IEG evaluation of the World Bank's support to multicountry programs (defined as cooperation or integration among three or more neighbors) over the previous 10 years (1995–2005). The evaluation considers 19 regional programs and around 100 regional operations. The report notes three unique dimensions of regional programs that must be dealt with for projects to succeed. It finds that "Successful regional programs require consensus among participating countries on the distribution of program benefits and costs and strong country voice in governance arrangements." Five factors common to successful programs are identified from the surveyed integration experience.

Key words: World Bank projects, case studies, characteristics of regional integration, regional externalities, success factors

The World Bank (2008): ***International Development Association and International Bank for Reconstruction and Development Regional Integration Assistance Strategy for Sub-Saharan Africa.*** **Washington DC.**

Available at http://go.worldbank.org/SX8TA78YA0

This document outlines a general regional development strategy of which energy integration plays a key role. The report is divided into four sections discussing Africa in the regional context, outlining opportunities and challenges, taking stock of past bank support for regional integration, and proposing a regional integration assistance strategy. Ten appendices detail strategies and substrategies to integration in Africa, the institutional architecture, growth divergences between countries, regional implementation plans and results, a monitoring framework and a risk matrix. Power sector integration is addressed within this larger framework.

Key words: regional development, donors

African Development Bank (2008): ***Regional Integration of Power Systems: A Tool to Reduce Energy Poverty and to Accelerate Economic Growth.*** **Tunis.**

Available at
http://www.ofid.org/workshops/EnergyPoverty/Regional%20Integration%20of%20Power%20Systems%20June08.ppt

This short paper was delivered to a Workshop on Energy Poverty in Africa, held in Nigeria in June 2008. It provides a brief overview of the energy situation in Africa, and an overview of the African Development Bank's activities in promoting electricity integration in Africa: generation and transmission projects and capacity building at the utility, country and regional levels. The purpose of these projects is to foster the conditions for better availability, accessibility and affordability of modern energy. These include export-oriented projects that would enable the exploitation of local energy abundance for regional consumption on commercial terms.

Key words: Africa, regional power, affordability

A1.8 Predominantly region-specific papers

United Nations Economic and Social Commission for Western Asia (1997): ***Technical and Economic Aspects of the Establishment of a Regional Electricity Network.***

This report examines the technical and economic aspects of creating a regional electricity network in the ESCWA (Economic and Social Commission of Western Asia) countries of western Asia. It is broken down into five chapters: chapter I is an overview of the interregional electric interconnections in ESCWA with a focus on the economic, technical, and environmental benefits, as well as the power system constraints and techno-economic limitations of interconnection; chapter II is an overview of the power systems of the ESCWA members; chapter III examines the varying levels of electricity interconnections between the

countries of the ESCWA region; chapter IV focuses on the prospects for establishing a regional electric grid in Western Asia; and the conclusion, chapter V, looks at the technological and economic viability of creating and maintaining interconnected electricity networks in the ESCWA region.

Key words: Asia, interregional power grid interconnections, technical, economic, environmental

****UNDP/ESMAP (2001): *Regional Electricity Markets Interconnection Phase 1: Identification of Issues for the Development of Regional Power Markets in South America*.**

Available at http://www.esmap.org/regions/region.asp?id=1

This paper analyzes the restrictions to international power trade in 10 South American countries in 2001 as found by the Comisión de Integración de Eléctrica Regional (CIER) study No. 03. The focus of the paper is on institutional as well as technical issues. It examines the prerequisites for the development of electricity markets, incentives to promote regional interconnections, and the way in which investors were reacting at the time. Comprehensive recommendations are making investment in regional power projects more attractive.

Key words: markets, private sector, South America.

World Energy Council (2001): "Regional Electricity Trading: Issues and Challenges." Presented at the Workshop on Regional Power Trade, Kathmandu, Nepal, 19 March.

Available at http://64.224.32.197/Publications/shean.pdf.

In this paper, the South Asia Regional Initiative on Energy examines the benefits of regional electricity interconnection and trade among South Asian countries in light of the growing population and increasing demand for electricity in the region. The main benefits the paper focuses on are improved security of supply, better economic efficiency, and environmental enhancement and protection implications. The paper then addresses some of the major challenges, including: technical challenges, commercial issues, the effect of subsidies on prices, the inclusion of environmental considerations, market structure differences, governance and legal issues, financial issues, and national policy and security issues.

Key words: Asia, interregional power grid interconnections, regional cooperation challenges

Neuhoff, Karsten (2001): *Economic Considerations for International Electricity Interconnections in North-East Asia*. Presented at the Workshop on Power Grid Interconnection in Northeast Asia, Beijing, China, 14-16 May.

Available at http://www.nautilus.org/archives/energy/grid/papers/neuhoff.pdf.

Neuhoff looks at the economic aspects of grid interconnection between Russia, DPRK, and the Republic of Korea in relation to the experiences of other countries. His focus is strictly on the economic benefits to be obtained, and the paper stresses that political aspects of interconnection are intentionally left out of the analysis. The first section of the paper analyzes the economic benefits, while the second examines how the benefits would be attributed to the various parties involved. Neuhoff also looks at the financing options for

interconnection, and stresses that public/private partnerships, public ownership or ownership by the national transmission grids are preferable.

Key words: Asia, economic, interregional power grids, ownership, financing

Eynon, Robert T., Thomas J. Leckey, and Douglas R. Hale (2002): *The Electric Transmission Network: A Multi-region Analysis*. Washington, DC: The Energy Information Agency, United States Department of Energy.

Available at: http://www.eia.doe.gov/oiaf/analysispaper/transmiss.html.

This report looks at the expected increase in inter-regional power trading, and the pressure this will put on the existing electricity networks in four regions in the Northeastern United States as competitive electricity markets become more widespread. Potential negative impacts of increased inter-regional electricity trading/sharing are among the topics highlighted.

Key words: North America, interregional power grids, competitive electricity markets

Cherian, A. (2003, September): *Development and Operation of Trans-border Interconnections of Electric Power Grids in Africa.* New York: United Nations, DESA.

This UN-DESA paper gives a general overview of the current status of operational and planned regional interconnections in Africa, and some of the major constraints that need to be addressed. The constraints the paper examines fall into three categories: capacity, political and policy. The paper starts with a background section on electricity in Africa, then covers the constraints on interconnection as relevant to each region covered: Central Africa, East Africa, West Africa, North Africa, and Southern Africa.

Key words: Africa, interregional power grids, political, policy and capacity constraints

El-Sharkawi, Emad, and Michel Lokolo (2003): *The Potential for Regionally Integrated Energy Development in Africa: A Discussion Document*. The World Energy Council, London.

Available at: http://www.worldenergy.org/wecgeis/publications/reports/africa/foreword/foreword.asp or http://www.worldenergy.org/wec-geis/global/downloads/africa/AfricaInt03.pdf (this is the link to the PDF version).

This is a detailed report on the case for developing an integrated electric grid for the continent of Africa, to be used as a tool for development and poverty alleviation in the region. It outlines the benefits and costs of such a network and has a strong section on the factors that affect cooperation and integration of the continent's energy sources. The report also gives a thorough evaluation of the current state of the energy industry and of the varying levels of regional integration in Africa. There is a detailed and informative section on the geography of energy of the continent. Though the focus of the report is specifically on the African continent, it can be used for any developing country or region of the world looking to improve the consistency and distribution of its energy sources.

Key words: Africa, interregional power grids, regional integration, poverty

Verneyre, Francois (2004): *European Challenges, Overcoming Challenges*. Presented at the KEEI & IEA Joint Conference on Northeast Asia Energy Security and Regional 191 Cooperation, Seoul, South Korea, 16-17 March.

Available at
http://www.keei.re.kr/web_keei/en_news.nsf/0/4dfb5e1e76aa3c1349256e4800150eab/$FILE/Fra ncois%20Verneyre.pdf

This presentation looks at the various components, issues and challenges of the European electricity industry, and what East Asia can learn from it. The major issues to be examined include: fragmented markets, blackouts and their causes, and price spikes. The challenges looked at include: the security of supply and the realization of IEM (Internal Electricity Market), and associated challenges such regional integration and creating a balanced energy mix.

Key words: Europe, Asia, technical, interregional power grids, fragmented markets, price spikes, blackouts

IEEE (2004): *Panel Session: Status of International Connections and Electricity Deregulation in Africa.* Part of the IEEE 2004 General Meeting, Denver CO, 6-12 June. IEEE Power Engineering Society.

Available at http://www.ewh.ieee.org/cmte/ips/2004GM/2004GM_Africa.pdf.

This document is a very informative collection of essays written on various subjects related to regional electricity interconnections and electricity deregulation in Africa. In total there are 11 reports, most of which function as case studies representing a specific topic related to the issues outlined previously. For example, the reports cover such topics as the economic impact of interconnections for the Southern African Power Pool, and the potential positives and negatives resulting from large hydro projects through an evaluation of the Three Gorges Dam in China.

Key words: Africa, SAPP, China, interregional power grids, economic, hydropower

Vucetic, Vladislav (2004): *South Asia Regional Energy Trade: Opportunities and Challenges*. Washington, DC: The World Bank.

Available at
http://siteresources.worldbank.org/INTSOUTHASIA/Resources/Energy_a.pdf.

This paper gives a general overview of the current energy situation in South Asia, including installed capacity and production information for Bangladesh, Bhutan, Nepal, Pakistan, Afghanistan, Iran, India, and Sri Lanka. The paper also includes a brief section on interregional trade in comparison to the levels of trade in other regions of the world. A rationale for interregional energy trade in South Asia is given, including the benefits, costs, and obstacles.

Key words: South Asia, interregional power grids

Pineau, Pierre-Olivier, Anil Hira and Karl Froschauer (2004): "Measuring International Electricity Integration: A Comparative Study of the Power Systems Under the Nordic

Council, MERCOSUR, and NAFTA." ***Energy Policy*****, Vol. 32, No. 13, September 2004, pp. 1457-1475.**

Available at doi:10.1016/S0301-4215(03)00111-3

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 toward developing integrated systems vary. In this article, three regions concerned with common market initiatives and at different stages of integration processes that involve infrastructural, regulatory, and commercial decisions are reviewed: 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.

Key words: Nordic Council, MERCOSUR, NAFTA, market integration, electricity trade

Alami, Randa (2005): ***Financial Aspects of Arab Power Development.*** **Oxford Institute for Energy Studies.**

Available at http://www.oxfordenergy.org/pdfs/F9.pdf.

This report looks at the financial aspects of the development of the electricity sector in the Middle East. The author examines the role of public and private partnerships and the strong regional cooperation occurring in the region today with regard to the financing of power sector projects. The report begins with an overview of the current trends for financing in this industry in the developing world, then more specifically the rest of the piece focuses on developments in the Arab world.

Key words: Middle East, economic/financial, financing, PPPs

Newbery, David (2005): ***Power Reform, Private Investment and Regional Co-operation.***

Available at http://www.eprg.group.cam.ac.uk/wp-content/uploads/2008/11/eprg0624.pdf

Modern infrastructure, particularly electricity, is critical to economic development. Deficits cause shortages that constrain total output, magnifying the return to their elimination. South Asia, faced with inefficient and bankrupt state-owned vertically integrated electricity supply industries, was under strong pressure to reform. An imperfect diagnosis encouraged private investment in generation to address shortages, with IPPs selling power under long-term contracts to the largely unreformed state electricity boards (SEBs). Buying IPP power at prices above retail tariffs when the SEBs could not even cover the cost of underpriced electricity from state-owned generators exacerbated financial distress and was a recipe for conflict.

Reforming the SEBs, through unbundling, full metering, effective accounting and management structures creating commercial discipline, under multiannual regulation insulated from clientelist political pressures, is an essential first step. Privatization of the distribution companies once they are properly "enterprised" should then follow to sustain

reform. Reducing losses, both nontechnical and technical, and increasing plant load factors yield far higher returns than generation investment, where India and Pakistan already appear above predicted levels of electric intensity, perhaps because of low effective prices, and could eliminate most shortages. The Indian Electricity Act of 2003, requiring metering, multiannual regulation and regulated third-party access to the national transmission grid, is a useful start.

Private investors will require assurances that the contracts needed for IPPs are honored, that legal disputes are efficiently and fairly resolved, subject to fallback international arbitration, and that their purchasers are creditworthy. This is easier with cheap gas, which is available to Bangladesh, but scarce in India. Regional energy trade would therefore do much to improve the investment climate, and a South Asia Energy Charter could underwrite increased energy trade. The European Energy Charter has helped integrate the transition countries of Central Europe and stimulated FDI in the power sector, and might have similarly stimulative effects in South Asia, quite apart from creating profitable trade opportunities and increasing regional security of supply and greater resilience against external oil shocks.

Key words: South Asia, electricity boards, sector reform, private sector participation

Economic Consulting Associates (2006): *Study of Electricity Trade Potential in the Black Sea Region.* Prepared for the World Bank, Washington, DC.

This study covers seven countries in the Black Sea region. It examines several scenarios and estimates the benefits of regional power system integration. A number of issues are discussed in detail: transmission and transfer, security, environment, economic costs, energy market reforms, financing and pricing of electricity trade.

Key words: Black Sea, transmission pricing, environment, energy market reforms

Gnansounoua, Edgard, Herman Bayema, Denis Bednyagina, and Jun Dong (2007): "Strategies for Regional Integration of Electricity Supply in West Africa." *Energy Policy*, Vol. 35, No. 8, August 2007, pp. 4142-4153.

Available at doi:10.1016/j.enpol.2007.02.023

To improve peoples' living conditions in West African countries, national governments have to considerably reinforce the electricity supply infrastructures. Rehabilitation of the existing installations and construction of new power generation facilities and transmission lines require substantial resources which are tremendously difficult to raise due to the region's specific economic and political conditions. This paper examines the long-term prospects for integrated development of the regional electricity industry and evaluates its advantages by using PLANELEC-Pro, a "bottom-up" electricity system expansion planning optimization model.

The evolution of the regional electricity market is analyzed on the basis of two strategies. The "autarkical" strategy consists in adequate expansion of national power generation systems and the exchanges of electricity between the countries in subzones. Another approach, referred to as "integration" strategy, is recommended in this article. It leads to fast retirement of the obsolete power plants and the integration of new investment projects at the level of the whole West African subregion. The main finding is that the regional integration

strategy is capable of bringing about additional benefits in terms of reduced capital expenditures, lower electricity supply cost, and the enhanced systems reliability compared to the autarkical strategy.

Key words: West Africa, electricity markets, regional integration

Amundsen, Eirik S., and Lars Bergman (2007): "Integration of Multiple National Markets for Electricity: The Case of Norway and Sweden." ***Energy Policy*****, Vol. 35, No. 6, June 2007, pp. 3383-3394.**

Available at doi:10.1016/j.enpol.2006.12.014

During the second part of the 1990s, the Nordic countries (Denmark, Finland, Norway and Sweden) created a unique multinational market for electricity. This paper aims to analyze the degree of integration of the different national markets that constitute the Nordic electricity market. In particular, the Norwegian and Swedish wholesale and retail electricity markets are analyzed. The results suggest that the wholesale markets are well integrated. Thus prices differ significantly only during periods with unusually high or low supply of hydropower. However, the retail markets are not integrated to the same degree. Thus retail prices and trade margins differ significantly. Differences in the national electricity market legislation seem to be a key factor behind these differences.

Key words: Market integration, wholesale and retail competition

Foster, Vivien, and Cecilia Briceño-Garmendia (Eds.) (2010): "Africa's Infrastructure - A Time for Transformation." A copublication of the Agence Française de Développement and the World Bank, Washington DC.

Available at http://go.worldbank.org/NGTDDHDDB0

This report is a synthesis of the results of the Africa Infrastructure Country Dialogue (AICD) studies which have been conducted so far in 24 countries, plus around 17 background papers. The report documents enormous, crippling deficits in infrastructure in sub-Saharan Africa, with what is described as the "largest infrastructure challenge by far" being in the power sector. Electricity consumption per capita is only 10% of levels elsewhere in the developing world and in recent years has been falling. As many as 30 countries experience power shortages and interruptions in service on a regular basis from public utilities.

Sub-Saharan Africa has present installed capacity of about 70,500 MW, of which AICD estimates that some 44,300 MW needs to be refurbished, with an additional 7,000 MW of new capacity needing to be built each year to meet suppressed demand, accommodate economic growth, and allow for the rollout of electrification. Over the period 1990 to 2005, generation increased by only 1,000 MW per annum. The targeted expansion will require an estimated US$26.6 billion of capital expenditure per annum. Taking account also of operation and maintenance requirements, AICD estimates on the basis of the current financing into the sub-Saharan power sector that the electricity financing shortfall is US$29 billion per annum, but that this could be reduced to US$23 billion through efficiency measures and higher tariff recovery.

The AICD report identifies regional integration as a vital component of the strategy to overcome the power deficit and put the continent onto a path of rapid economic growth and

socioeconomic development. The report states that 21 countries have national power systems below the minimum efficient scale of a single plant. By sharing large-scale, cost-effective energy resources across countries, it is claimed that regional trade could reduce electricity costs by US$2 billion a year. The report acknowledges, however, that achieving regional gains is not easy, given the "challenges" of mobilizing political will, developing effective regional institutions, setting priorities soundly, harmonizing regulatory procedures, and facilitating project preparation and finance.

Key words: Africa, regional integration, financing gaps

A1.9 Case studies from this project

The case studies from this project are listed in this section, with brief bibliographical entries highlighting unusual aspects or particularly salient lessons.

The case studies should all be attributed to Economic Consulting Associates, London, 2009, with the by-line of having been prepared for the ESMAP project on the Potential of Regional Power Sector Integration.

Generation Case Studies

Nam Theun 2

The Nam Theun 2 project (NT2) is developing part of the hydroelectric potential of Laos for export to Thailand. NT2 involves the construction of a 1,070 MW hydroelectric storage project with the capacity to deliver an annual average of 5,636 GWh of electricity to Thailand via a 138 km double circuit 500 kV transmission line. A 115 kV line will also be built to supply a small portion of production to customers in Laos. The project was expected to commence commercial operations early in 2010.

Nam Theun 2 is an enclave project in which output from a new build generation facility is almost entirely devoted to export via a dedicated transmission line. Most of the contracted output is on a take-or-pay basis at prices agreed to in a power purchase agreement. The major partners in the trade project are the single Thai customer (EGAT), a special-purpose entity created to build, own and manage the facility and its public and private-sector shareholders, the Government of Laos, the state-owned Lao utility, international aid and development institutions, and international commercial banks.

Concerns have been raised about whether the repayment conditions imposed by the financers may prove to be too onerous for the Government of Laos, which is already under pressure from the IFIs to tighten macroeconomic management. The IFI financing and involvement is conditional on the implementation of financial management capacity building programs within the Government of Laos. The conditions also specify priority spending areas for the use of NT2 funds with associated reporting requirements.

Cahora Bassa

Cahora Bassa is a 2075 MW hydropower project on the Zambezi River in Mozambique established to supply power to South Africa via 1,400 km of high-voltage direct current (HVDC) transmission lines, with a small component set aside for supplies to Mozambique.

The project was conceived during Portuguese colonial rule, and the dam was being completed just as Mozambique achieved independence in 1975. During the civil war, the HVDC power lines were put out of operation, and a rehabilitation project was needed before flows of power could resume to South Africa. In the meantime, Zimbabwe negotiated a share of the Cahora Bassa output and built an HVAC transmission line which was commissioned in 1997, one year before flows of power to South Africa finally resumed via the HVDC interconnection.

The Cahora Bassa project is operated by a company set up for this purpose, Hidroeléctrica de Cahora Bassa (HCB). This was initially majority owned by the Government of Portugal, but the Mozambique government became the majority shareholder in 2007. The payment to the Government of Portugal for 67% of HCB shares was US$950 million (US$250 million of which was from HCB funds). This was after what is said to be a 90% write-down of the outstanding debt to the Government of Portugal. Annual energy output is on the order of 13,000 GWh.

The large accumulated debt was due not just to the 18-year inoperability of the scheme, but to the very low tariffs consistently negotiated by the South African utility, Eskom. With the general shortage of power that has emerged in Southern Africa, the negotiating power balance has shifted in HCB's favour. Through its involvement in the Southern African Power Pool (SAPP), HCB has been able to diversify its customers beyond South Africa, Zimbabwe and Mozambique. To bring Malawi into the SAPP grid, a 220 kV interconnector is being built between HCB and Malawi. Future plans include the construction of a new 1,300 MW power station on the north bank of the Cahora Bassa dam.

Manantali

The Manantali dam and hydropower project, which is jointly owned by Mali, Senegal and Mauritania, is located on the Senegal River in Mali. The installed generation capacity is 200 MW and the average energy output over the period 2003-2006 was 767 GWh per annum. In terms of an agreement on how the energy is to be shared, Mali receives 52% of the energy generated, Senegal 33%, and Mauritania 15%.

The project was originally sponsored by a river basin organization, the Organisation pour la Mise en Valeur du fleuve Sénégal (OMVS). The Manantali dam was completed in 1987, but construction of the hydroelectric power plant and associated transmission lines only began 10 years later and was completed in 2002. The second phase of the project also included a component to address adverse social and environmental issues, and to broaden the representativeness and responsiveness of OMVS to the needs of diverse water users. A special-purpose company, Société de Gestion du Barrage de Manantali (SOGEM), was created by OMVS to be the asset holder and operator of the Manantali infrastructure. SOGEM in turn contracted Eskom Energie Manantali (EEM), a subsidiary of Eskom, the government-owned South African electricity utility, to manage the hydropower station and the associated infrastructure.

The Manantali project has been successful in delivering energy to the three participating countries. The payments due according to an agreed Tariff Protocol have not always been forthcoming, however, giving rise to payments arrears on project loans. After the first phase of the project, donors wrote off loans and provided fresh financing for the hydropower project, and this may have created a moral hazard precedent for the second phase. With the growing influence of the West African Power Pool (WAPP), future plans include the

development of a number of hydropower projects similar to Manantali on the Senegal River and the Gambia River. The existing OMVS interconnected network is to be extended and eventually linked into a subregional West African grid.

Transmission and trading case studies

Greater Mekong Subregion (GMS)

The six countries of the Greater Mekong Subregion (GMS) are Cambodia, China, Lao PDR, Myanmar, Thailand, Vietnam. Regional power trade in the GMS began in 1971 with exports from the Nam Ngum hydropower plant in Laos to Thailand. Subsequently, a number of other cross-border trades have developed—in each case on a bilateral and one-way basis. These include the Theun Hinboun and Houay Ho hydropower plants in Laos, exporting to Thailand, along with the soon-to-commission Nam Theun 2 project (which is the subject of a separate case study). A large number of other hydro power plants are under development or planned in Laos and Myanmar for export to China, Thailand and Vietnam, together with high-voltage interconnectors. It is intended that these will form the nucleus for future Cambodian and Lao national grids and for trade between GMS countries.

The GMS regional power market is one part of the GMS Economic Cooperation Program. The Asian Development Bank has been a major driving force behind the program, although other donors also provide support. An Electric Power Forum was formally inaugurated in 1995. Subsequently, a 2002 Inter-Governmental Agreement established a Regional Power Trade Coordinating Committee. Two memoranda of understanding, signed in 2005 and 2008, set out a phased approach to expanding regional power trade beginning with country-to-country trade on the basis of bilateral power purchase agreements, but subsequently expanding to encompass multilateral power trading.

The GMS regional market is of particular interest because of the motivations underlying its development. It is intended to facilitate and build on the development of major power projects in the region's poorer economies which are being developed for export of electricity to the wealthier but resource-constrained economies. This is similar to, for example, the motivations of the hydro-rich countries in SAPP seeking to export to South Africa, but different from some of the other regional power markets studied (such as SIEPAC), which represent integration among countries at rather similar levels of development and with similar resource endowments.

Gulf Cooperation Council (GCC) Interconnection

The Gulf Cooperation Council (GCC) electricity interconnection scheme was originally conceived in 1981 but took off in earnest in 2001 when the GCC Interconnection Authority (GCCIA) was established and, subsequently in 2004, when the national governments of the six member states—Kuwait, Saudi Arabia, Bahrain, Qatar, United Arab Emirates (UAE) and Oman—agreed to finance the interconnections and a control center. The physical infrastructure is being implemented in three phases, the last of which, to connect the northern countries (Kuwait, Saudi Arabia, Bahrain and Qatar) with the southern states (UAE and Oman), is expected to be completed in 2010.

All six countries participating in the GCC are well endowed with oil and/or natural gas resources. Instead of being a tool to foster greater economic efficiency through regional dispatch of plants, the GCC electricity scheme was envisaged primarily to allow

participating countries to share reserve capacity to minimize overall investment in peaking plant. The legal framework for trade is centered on the proposed Power Exchange Trading Agreement which will be signed by participating entities—primarily the transmission entities in member countries. This agreement relates chiefly to the obligations of participating entities, including an obligation to maintain a minimum (standing) reserve margin of capacity relative to system peak demand and operating reserves, and arrangements by which members may use reserves from other countries to satisfy those obligations. Any surplus interconnector capacity available once these primary roles are satisfied may be used to trade energy. How much electricity is actually traded will only become evident when the trading arrangements have been finalized and the physical infrastructure completed.

Southern African Power Pool

The Southern African Power Pool (SAPP) is an initiative of the utilities of the region to coordinate investments and foster trade in electricity. SAPP was formed in 1995 and currently has 12 members, of which 9 are the interconnected "operating members," these being the national utilities of Botswana, DR Congo, Lesotho, Mozambique, Namibia, South Africa, Swaziland, Zambia and Zimbabwe. The non-operating members are the national utilities of Angola, Malawi and Tanzania. From 2009, electricity companies which are not national utilities have also been admitted as members, the first of these being the transmission company MOTRACO. In due course, HCB is also expected to become a member.

SAPP established a Secretariat in 2000 and in 2001 began operating a Short-Term Energy Market (STEM). This operated successfully until the regional capacity shortage which emerged around 2006. It was being replaced in 2009 by a Day-Ahead Market, which is a more sophisticated, "closed loop" system designed to optimize system operations and charge for transmission in losses in a much more accurate way than was the case with STEM.

SAPP's achievement in moving toward competitive markets for trading electricity are overshadowed by the lack of implementation of the 2001 SAPP Pool Plan, which was the plan for coordinated regional investments in generation and transmission. SAPP does not have the mandate to be directly involved in the investment projects, its role being limited to advising the utilities and governments in the region. The supply-demand imbalance that emerged in 2006 with its resultant load shedding has resulted in an acceleration of investment projects as well as the intensification of demand management strategies. This includes greater commitment by SAPP countries to raise electricity tariffs to long-run marginal cost levels and to have tariffs set in the future by independent, professional regulators.

Nile Basin Initiative

The Nile Basin Initiative (NBI) is a body formed in 1999 to "develop the river in a cooperative manner, share substantial socioeconomic benefits, and promote regional peace and security." There are nine member countries (Egypt, Sudan, Ethiopia, Uganda, Kenya, Rwanda, Burundi, DR Congo and Tanzania). The NBI has a broad development and natural resource management agenda, one important component of which is cooperative development of the power sector. At present, there is limited electricity trade within the Nile

Equatorial Lakes (NEL) region, but not within the Eastern Nile area where the countries involved have separate electricity grids (Ethiopia, Sudan and Egypt).

NBI and the East African Power Pool are carrying out planning studies on future regional power sector integration. The main current projects are the building of a transmission line between Ethiopia and Sudan, an interconnection project in the NEL region and a hydropower development at Rusumo Falls, shared between Burundi, Rwanda and Tanzania. The medium- and long-term electricity requirements of the region are expected to be met though development of the hydropower resources of the DR Congo, Ethiopia and Sudan. Further development of the institutional structure and the interconnection backbone will be needed.

Argentina-Brazil

The main focus of this case study is on the Garabi interconnector between Argentina and Brazil, which was commissioned in the year 2000. This consists of two sets of 500 kV transmission lines, together with two 1000 MW 50Hz/60Hz frequency converter stations. The Garabi project was planned during the 1990s, when the Southern Cone countries were liberalizing their economies, reforming their electricity sectors, and moving toward power system integration, through developing a unified regional electricity market.

The international economic crisis which started at the end of the decade precipitated a political crisis in Argentina in 2002, resulting subsequently in a sharp reversal of approach in economic and energy policies. The abrogation of Argentina's export commitments in 2004 has meant that the usage of the Garabi interconnector has been very different from what had earlier been planned, but more broadly has set back the earlier vision for the rapid development of a regional electricity market in the Southern Cone.

SIEPAC

The Central American Electrical Interconnection System (SIEPAC) project is an initiative to create an integrated regional electricity market among six Central American countries: Guatemala, El Salvador, Honduras, Costa Rica, Nicaragua and Panama. It consists of two components, the first being a regional electricity market (MER), which is based on a standard set of trading rules at the regional (supranational) level. Part of the MER initiative is the creation of a regional institutional structure, including regional regulator and a regional transmission operator.

Only when MER and the regional institutions were in place has the second component been advanced: the development and completion of a new 1,800 km international transmission line, running from Panama in the south to Guatemala in the north, that will increase transfer capacity at all borders to 300 MW. The line is due to be commissioned in 2010, and it remains to be seen to what extent usage will occur once the physical transfer capacity is in place. An important test of the success of the integration project will be whether large generation projects are undertaken specifically to serve the regional market using the SIEPAC institutional and physical infrastructure.

South East Europe

This case study examines the regional electricity strategies of the nine countries which were signatories of the treaty establishing the Energy Community in 2005: Albania, Bosnia &

Herzegovina, Bulgaria, Croatia, Kosovo, Macedonia, Montenegro, Romania and Serbia. Significant drivers toward integration have been the need for reconstruction following a period of conflict and the small size of some of the countries, which necessitates cross-border trading if some of the generation investment projects are to be feasible. In line with the aspirations of these countries to join the European Union (which Bulgaria and Romania have subsequently done), the treaty seeks to further the implementation of the European Union *Acquis Communautaire,* which in the electricity sector requires:

- evolution of competition in wholesale and retail supply fostered by a common regulatory framework with independent national regulators, functionally and financially unbundled transmission system operators, (TSOs) and unbundling of integrated utilities;
- establishment of a regionally integrated network linked into the wider EU market, including common rules for generation, transmission and distribution;
- coordination of regional planning and facilitation of competitive investment. The treaty does not, however, mandate any investments.

The achievements to date include establishment of operating institutions and working groups (such as ETSO), resynchronization of the transmission networks with the European UCTE network, establishment of a cross-border transmission compensation mechanism, and development of independent regulation and TSOs in several countries and progress toward independent distribution network operators in some countries. The current stage of development has emphasized the harmonization of national market rules. Countries are following parallel paths, but each is adopting the EU Directives and establishing market rules that permit competition. The broader integration into a single market (for wholesale trading and for capacity) is currently at the experimental testing stage.

UCTE

This case study examines the role of the Union for the Coordination of Transmission of Electricity (UCTE) in the development of electricity integration in Europe. When it was formed in 1951, UCTE was an organization that represented national integrated electricity utilities, including generation; hence it had the acronym UCPTE (P for production). With the unbundling and privatization of generation in many of the countries, in 1999 the organization became the UCTE, concentrating on the technical issues of operating a large, synchronous system spanning national boundaries. Responsibility for market-related interconnection issues was passed to the Association of the European Transmission System Operators (ETSO), which was formed in 1999.

By the time this UCTE case study was being finalized, UCTE, ETSO and other similar organizations outside of the synchronous area had been subsumed into a new institution called the Association of the European Network of Transmission System Operators for Electricity (ENTSO-E). This is a very recent development: the main thrust of the case study is on UCTE as it was prior to this development. The members of UCTE were the transmission systems operators (TSOs) within its synchronous zone. The original UCTPE had seven members; as of early 2009, UCTE had 29 TSO members, representing 24 countries.

UCTPE and UCTE concentrated on developing coordination and common rules to facilitate cross-border transfers of energy and transmission services. This provided practical means of

sharing the burdens of security of supply and system stability as the electricity systems of Europe expanded and became progressively more integrated.

UCTE sought practical solutions to technical issues and promoted common standards. Due to a major supply failure incident in 2003, UCTE changed its processes from a voluntary set of operating guidelines into a defined set of rules, enforced through a legally binding agreement.

UCTE limited its role to transmission system operation and was not therefore directly involved in the development of regional electricity markets in Europe. Its role was rather one of continued accommodation of trade initiatives both from the EU and from trading participants.

The new organization, ENTSO-E, takes over roles in network code coordination, interconnector charging and inter-TSO compensation, and completion of retail competition—all needed for the development of the European Union single competitive market in electricity—as well as coordinated planning, flexible operation to accommodate wind generation, and continued geographic expansion of the former UCTE synchronous areas.

PJM

PJM was created in 1927 when utilities in Pennsylvania, New Jersey and Maryland decided to share their generating resources, forming the world's first cross-utility power pool. Over time, the membership, role, structure and geographical sphere of influence of PJM has changed. Under the electricity sector reforms of the late 1990s, PJM opened its first bid-based energy market in 1997, and the Federal Energy Regulatory Commission (FERC) approved it as the nation's first fully functioning independent system operator (ISO). In 2001 it became the nation's first fully functioning independent regional transmission organization (RTO).

Today, PJM Interconnection is a not-for-profit, member-driven integrated power pool responsible for wholesale electricity in all or parts of 14 states (Delaware, Illinois, Indiana, Kentucky, Maryland, Michigan, New Jersey, North Carolina, Ohio, Pennsylvania, Tennessee, Virginia, West Virginia and the District of Columbia). PJM Interconnection operates the world's largest competitive wholesale electricity market. The main markets offered by PJM Interconnection to its members are:

- Day-Ahead Energy Market
- Real-Time Energy Market
- Auction for Forward Commitments to build generation or transmission capacity to meet the requirements calculated by the Reliability Pricing Model, which works in conjunction with PJM's Regional Transmission Expansion Planning process
- Financial Transmission Rights auctions
- Transmission Services

Use of the locational pricing in transmission planning does not give sufficient reward to transmission investment that relieves congestion. As a result, despite the existence of a market which has many competitive dimensions, significant price differentials between regions persist.

A2 Detailed annotated bibliography for selected references

Charpentier, J.P., and K. Schenk (1995): *International Power Interconnections*. Viewpoint Note No. 42, The World Bank.

The note endeavors to provide some answers to the question: "*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*?"

According to the authors, three major incentives exist for regional interconnections:

- Emergency support
- Cost savings due to different load profiles across regions
- Savings in investment and operational costs

Regarding the third point, the paper argues that these savings are often exaggerated because in reality utilities strive for some degree of self-sufficiency in their territory as opposed to relying on available capacity surpluses elsewhere.

Five different types of exchanges are outlined:

- Firm energy sales
- Backup exchanges for emergency support
- Marginal exchanges of spinning reserves
- Exchanges based on surplus capacity without guarantees
- Compensation exchanges in which losses arising from lags between supply and payment are compensated for

The fact that electricity cannot be stored is cited as the reason why self-sufficiency has traditionally been seen as a reason for governments to create state-controlled energy companies. However, increased global competition has forced utilities to cut costs and deregulate some of the markets.

In terms of institutional arrangements, a general framework is outlined.

1) Harmonize the national power sector structures. The unilateral restructuring of Norway as part of NORDEL is cited as a reason for why exchanges temporarily dropped between NORDEL countries.

2) A cooperative structure and pooling arrangements are deemed necessary to provide stability to the system.

3) Open access and free transit are also seen as essential.

Furthermore, the transmission system should be regulated to ensure correct pricing signals. Wheeling rights are to be legally defined, and environmental issues that prevent electricity transporters from acquiring permissions need to be handled.

In terms of pricing issues, the authors believe that a competitive framework cannot be based on marginal cost and profit-sharing, as competitors will not be inclined to declare their pricing information. A bid-based pricing system is suggested.

Regional Electricity Cooperation and Integration (RECI) (2000): *e7 Guidelines for the pooling of resources and interconnection of electric power systems*. Montreal, Canada

Available at http://www.e8.org/index.jsp?numPage=127

The e7 is a group of major utilities from OECD countries which have committed themselves to playing an "active role in addressing global electricity issues and to promote sustainable development worldwide." The group was formed at the Rio Earth Summit in 1992: e7 has subsequently become e8 (Russian electricity utility joined in June 2006).
http://www.e8.org/

The RECI Guidelines are the output of an e7/ESMAP working group which was set up in 1998. The guidelines consist of a short introductory volume plus eight modules.

The tone is largely one of instruction, with liberal insertions of useful pieces of information and checklists of various kinds. Some of the underlying themes are:

- regional electricity cooperation and integration offers large benefits to developed countries and is "crucial" for the development of the electricity supply industry in developing countries;
- "the main barriers are political ones" but the hope is expressed that "the economic surplus resulting from cooperation is generally so considerable that political barriers should be overcome";
- besides measurable economic benefits, the contributions of RECI to environmental and social objectives are also highlighted in the guidelines;
- reform of electricity sectors in developing countries is favored in order to facilitate private investment, without which the investment levels necessary to meet projected demand growth will not be reached.

The modules are subdivided into three sections. Each module consists of a number of chapters which appear as sub-bullets, as follows:

Section I: Strategic planning of interconnected systems (long-term)

- **Module 1: RECI Feasibility**
  - Integration of national power systems (technical and economic benefits, political and institutional factors)

- Overview of the electric power sector in developing countries
- Organizing and implementing RECI (regional generation and transmission development plan; generation, transmission and systems operation criteria and rules; progressive development of regional market structure; evaluation and implementation of regional projects; institutional structure to implement RECI)
- RECI in different regions (with thumbnail sketches of CIER, GMS, OMVS, SAPP and Mediterranean Ring schemes)

- **Module 2: Market Analysis**

(Chapter includes further detailed specification of range of possible benefits of RECI.)

- Pooling generation resources (evaluation of cost reductions and other benefits in relation to investment costs)
- Access to new markets (different approaches to energy demand modelling—econometric, techno-economic and general equilibrium; scenarios and uncertainty analysis)
- Ability to pay and tariff setting

- **Module 3: Resource Development**

(Chapter aims at generation, transmision and load management plan for a region to give reliability, cost competitiveness and environmental soundness, plus flexibility to cope with uncertain environment. Assumption is vertical integration—competitive situation is considered in Module 7.)

- Generation and interconnected systems planning
- Process for developing a generation resource plan
- Planning for uncertainty
- Annex on commercially available models for system planning

- **Module 4: Integrated Operational Planning; Optimal Conditions**

(Identifying optimal conditions for the success of a joint project—how to design the project and divide the surplus so all participants are satisfied with the regional approach)

- Costs and benefits of joint planning
- Distribution of surpluses (game theory concepts and worked examples; design of transfer payments and role of regulator)
- Trust (iterative processes; trust and reciprocity; conflicts and compliance)

Section II: Project implementation (medium-term)

- **Module 5: Pooling Resources: Technical Conditions**

  (Benefits of interconnection can be negated by additional vulnerability of interconnected power system—close attention to technical requirements is needed.)

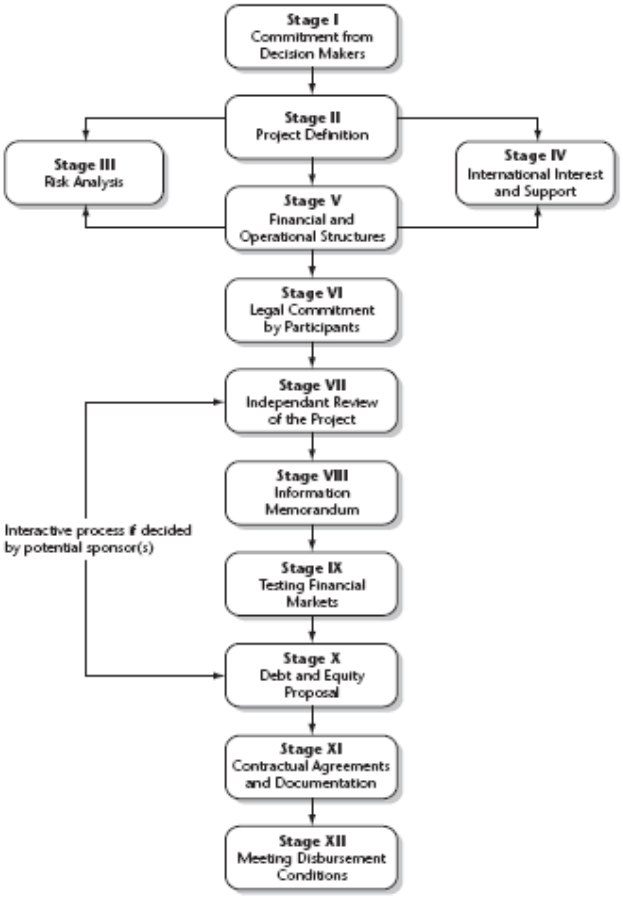
  - Basic technical conditions (power supply reliability; system planning criteria; AC/DC technologies and frequency control methods)
  - Technical studies required (system adequacy—reserve requirements and LOLP; system security; transmission capacity enhancement; metering; system simulation and analysis—power flow, fault current, voltage stability)
  - Advanced interconnection technologies (HVDC; improvement of AC system stability)
  - Overview of interconnected power systems around the world (Japan, North America, Nordel, UCTE, Southeast Asia)

- **Module 6: Financing Interconnection Facilities**

  (Corporate financing difficult when utilities are weak; project financing which relies on strength of project's cash flows more likely; careful distinctions are made between participants in the project, sponsors and the various groups of advisors.)

  - 14 chapters, the first 13 of which are captured in the diagram below (apply to both corporate and project financing)
  - Objective, Results and Tips/Recommendations are given for each
  - Final chapter is "Special Considerations"

Table 1: Project financing process



Section III: Operational planning (short term)

- **Module 7: Market Operational Structures**

  (Covers variety of market models, from the vertically integrated utility, pools of VIUs and competitive market model. Restructuring to foster competition requires a reliable and secure interconnected transmission system that provides nondiscriminatory access to all participants. This chapter provides a framework for the rules and institutions needed to achieve this.

  The US Regional Transmission Operator (RTO) model is central to the discussion. RTO can be an independent systems operator (ISO) or a transmission company (Transco) or some combination of the two.

  - Market operational issues (governance, capacity, energy, ancillary services, transmission access, congestion management, interregional trade)

  - Assumptions and market principles (RTO minimum characteristics [independence, operational authority, etc.] and functions [transmission

tariffs, congestion management, parallel path flow, ancillary services, real-time information, market management, planning and expansion, interregional coordination])

- Market model description (assumption that control areas participating in the RECI organization will utilize an RTO approach for interregional trade transactions).
- Participant obligations and responsibilities (regulator, RTO and licensed participants)
- Market operation (market rules, dispatch process, prices, bilateral contracts, ancillary services, suspensions, transmission services, settlements and billing)
- Interregional coordination

- **Module 8: Operating conditions for a RECI organization**

  (Module gives details of international agreements that are required. These must cover both technical requirements to ensure secure and reliable system and nondiscriminatory treatment /open access for all participants. Examples from UCTE and NERC are given.

  Agreements for all participants are often called grid codes: these are the rules that all participants in a deregulated market must obey for reliable operations).

  - Items considered in Agreements
  - Adequacy of generation (operating reserve, generation controls)
  - Adequacy of transmission (transmission system criteria and transfer capability, voltage controls)
  - Operation planning
  - Recommendation

The combined document is voluminous. Module 1 alone is 124 pages. As an example of the disaggregated structure, Chapter 1 of Module 1 consists of the following subsections:

- technical and economic benefits (Sec. 1.1)
- progressive steps in cooperation and integration (Sec. 1.2)
- political and institutional issues (Sec. 1.3)
- experience of e7 utilities (Sec. 1.4)
- other leverage: CDM and regional organizations (Sec. 1.5)

The modules are quite varied in tone and level of detail. Those in Sections II and III constitute some useful reference material, for example:

- Module 5 (technical) provides useful source material for economists on the hardcore electrical engineering aspects.
- Module 6 (financial) provides useful source material (for economists as well as engineers) on the steps to methodically follow in order to secure financial closure for a project.

Modules 7 and 8 provide the concepts and useful checklists for establishing the institutions, grid codes and other agreements needed to make RECI happen. (See, in particular, the series of questions in Module 7, chapter 1).

UNDP/ESMAP (2001): ***Regional Electricity Markets Interconnection Phase 1: Identification of Issues for the Development of Regional Power Markets in South America*.**

Available at http://www.esmap.org/regions/region.asp?id=1

This paper analyzes the restrictions to international power trade in 10 South American countries in 2001 as found by the Comisión de Integración de Eléctrica Regional (CIER) study No. 03. The focus of the paper is on institutional as well as technical issues.

The executive summary gives a short overview of the issues:

- *Requisites for the Development of Electricity Markets*: sound market rules as well as legal and regulatory framework in order to attract private-sector investment
- *Incentives to promote international interconnections*: cost-reflective prices of energy, capacity, transmission services and ancillary services on both sides of the interconnection. Furthermore, as long as there are differences in LRMC, they might lead investors to seek bilateral contracts, and the study recommends avoiding regulatory restrictions in order to encourage expansion of these contracts, whichwill result in a common market.
- *Signals received by potential investors in the countries studied*: The report outlines the most commonly observed shortcomings of the market structures currently in place. These include lack of remuneration for the transmission system (Argentina), lacking of rules for capacity payments (Brazil), and lack of reliability standards (Chile).

The remainder of the report is divided into eight subsections including an introduction and a conclusion section. Each of the remaining sections are addressing recommendations on one aspect of international power trade in South America. Finally, five annexes provide additional information on some of the discussed topics.

The introduction sets out the major impediments for regional energy trade at the time. These include long distances between countries, a weak power grid in some countries, and an energy strategy that is focused on self-sufficiency. Furthermore, some countries had not yet introduced regulatory changes to the energy sector and continued to be centrally planned.

Section II summarizes the conclusions of the previous, CIER 02 study:

- Interconnections would result in substantial increases of operational efficiency.
- Operations savings could come from hydroelectric complementarity among countries and complementarity of peaking demand.
- Cost reductions would exceed the costs of building the transmission facilities.
- The benefits could only be realized if energy sources are shared. Any restrictions would lead to a reduction of overall benefits.

Section III discusses the impact of the potential interconnections in terms of prices. Short-term benefits are expected to come from differences in marginal costs. For importers, the benefits will be the lower costs for the users less the losses local generators incurred. In the exporting system, marginal cost will increase due to an increase in demand, and the domestic users will lose while generators will benefit from the increase in marginal cost. Long-term effects would include a reduction in LRMC and an increase in efficiency and the use of investments. Given that spot price volatility in systems that in the past have relied on hydro is high, an interconnection may increase the volatility in other countries as well. Long-term agreements and appropriate regulations could decrease the effect.

Section IV discusses the requisites for attracting private investors. Minimum requisites are:

- Nondiscrimination and reciprocity
- Due execution of contracts
- Compliance with reliability standards
- Open access to transmission
- Open access to information
- Compliance with legal framework
- Ancillary services should allow for the use of equipment in the different countries
- Secure export payment collection
- Dispatch simulation should be predictable
- Finally, reliability standards and rates of transactions need to be agreed on

Section V discusses the incentives for private investors to build international interconnections. Several models regarding the building, leasing, operating and transferring of assets are discussed. The costs of interconnections are to be assessed independently of profitability and can be assimilated to a capacity payment through bilateral firm power sales agreements.

Of importance is the political framework an interconnection is inserted into. In an integrated market, a high degree of integration is needed. This means that supply and demand must be treated under the same terms, and exchanges must be considered a long-term commitment. In partial trade agreements, countries base their exchanges on specific agreements and reap the benefits that accrue from the differences in marginal cost. There is not one overarching framework governing all exchanges to which countries must adhere.

Section VI discusses regional signals to investors. Potential benefits for investors can come from:

- Firm contracts
- Opportunity exchanges
- Emergency exchanges
- Ancillary services trade
- Quality transactions
- Power transit toll regulations
- Reliability

Past problems in the region included:

- Ancillary services not being shared
- Economic signals not set in such a way as to encourage efficiency
- Spot transfers restricted
- Quality standards not certified
- Asymmetries between thermal and hydro that introduce inefficiencies into the system
- Lack of reciprocity between countries for import–export transaction

Section VI discusses an implementation plan that will improve the shortcomings of the current system with regard to creating international interconnections. The benefits would be a more efficient supply of energy, the possibility of larger-scale projects, increased competition, reduced supply risks, and reduced environmental impact.

Power efficiency and reliability should be improved by ensuring that energy is dispatched on an economic basis, disregarding the origin of the power source. In the meantime, system reliability must be kept at a technically feasible and economically sustainable level.

The regional market would have a set of rules allowing for transmission and rules for transactions that would strengthen national markets and as a result would respect investments made in those markets. There would have to be reliable market management,

and the structure of the energy sector would foster competition and transmission independence, and there would be an unbundling of the segments in the sector. Finally there would be a way to maintain reliability, and deviation from the standards would be discouraged by imposing costs.

Section VIII, the conclusion and recommendations section, briefly sets out the next steps for the South American markets which revolve around creating regulatory principles, an implementation plan and guidelines for the various services such as firm, opportunity and ancillary.

United Nations, Department of Economic and Social Affairs, New York (2005): ***Multi-Dimensional Issues in International Electric Power Grid Interconnections.***

This report is arranged into seven main sections with an executive summary, introduction and conclusions, and recommendations. The report's sensible premise is that international electricity interconnection projects are diverse initiatives composed of multidimensional issues, costs and benefits. These almost always include: technical, economic and financial, legal, political, social and environmental. Accordingly, these issues provide the framework for analyzing international interconnection initiatives, and the major sections of the report are dedicated to the analysis of each of these aspects. An additional section considers international grid interconnections and energy security.

Energy security is identified as a major factor affected by and affecting electricity integration. The paper also places a particular focus on fair, inclusive and transparent processes to ensure that all groups and stakeholders are represented in the process of developing the integration project. This will help to ensure all parties take ownership of the final arrangement, thereby minimizing the potential for conflict.

Technical

Identifies key factors influencing design, such as synchronicity of the interconnecting systems, size of the project and location (including terrain to be traversed), constraints on transmission capacity (thermal limits, voltage regulation). These issues may be exacerbated for liberalized markets where the incentives are to operate the systems closer to their constraints.

The report emphasizes the importance of technical simulation in the design process (which requires quality data to be available), as well as integration with other aspects (economic, legal, political).

Economic and financial

These include both direct and indirect costs and benefits. Direct benefits include revenues from sales and the avoided cost of displaced energy sources. Indirect benefits include stimulation to local economies in the construction phases, and the benefits to the economy from captured efficiencies. Integration may also spur the development of country-level electricity markets where integration allows sufficient scale to support increased competitive participation. The extent of competitive market development that can be supported will depend on the level of market power.

The report suggests that the economic and financial structures should be in place before the physical interconnections proceed.

Legal

The legal issues are complex. Binding agreements should be transparent and enforceable. This requires legal capacity in the participating countries, including existing legal framework and legal human capacity among other factors. The required legal agreements include PPAs, liability for supply failure, environmental responsibility, physical security of the line, and agreement on the operation of the line.

The process of creating legal structures to support electricity integration can have the side benefits of strengthening the legal capacity and experience in the participating countries and establishing a precedent for trade in other energy forms or products.

Political

Political agreements underlie the legal agreements. They must stipulate how benefits and costs are to be shared, how information is to be shared, how the interconnection will be operated, and how firms will be selected and paid.

The report argues that electricity interconnections can bring political benefits, including incentives to avoid conflict with neighbors, increased internal political stability (by raising living standards and fostering economic inclusions for communities previously unserved by an electricity connection), and even result in increased democratization (through demonstrating the benefits of participatory decision making). The process of developing the complex arrangements necessary to support electricity trade can have spillover benefits for broader international cooperation.

Interconnections can also bring political costs, such as providing an excuse for internal political oppression along the route of the line, providing political power to one country over another, involving countries in each others' internal affairs (for example, by creating exposure to instability in a neighbor), create opportunities for corruption (which can in turn affect the political balance of power within the country), create political costs in protecting the line (where the line presents a hostage to be used in extortion by local groups), and create political costs of tariff rationalization.

A critical attribute needed to support an integration project is political will. Political attributes favoring integration include cultures of regional cooperation and long-term planning, and common memberships of strong regional organizations.

Barriers to political integration include longstanding national rivalries and distrust, internal disunity, substantially different political systems, political strength of internal groups with interests in limiting competition from trade, and corruption.

The report suggests approaches to overcoming these barriers, including transparency, inclusiveness both between and within nations, information sharing, fairly distributing the benefits and costs, and using international agencies to assist.

Social

Benefits are closely aligned with the economic benefits (including access to electricity). Costs include exposure to social disruption during construction. Benefits and costs can vary between countries and between groups within countries.

Environmental

Benefits arise through more efficient use of resources, avoided air and water pollution, including displacing biomass (which is often associated with deforestation). Environmental impacts may also result. The location of benefits and impacts may be different, necessitating a careful overall assessment.

Energy security

The report offers an expanded definition of energy security. This includes six dimensions: energy supply, economic, technological, environmental, social and cultural, and military/security. Electricity interconnections will tend to have associated benefits and costs within these six dimensions.

Strategies for reaching interconnection agreements

The suggested strategies include:

- Ensure fair distribution of economic, social and other benefits and costs among stakeholders (nations and groups within nations).
- Ensure direct and indirect costs are specified accurately, preferably within long-term system planning. Continue studies after implementation.
- Emphasize transparency, and provide access to material.
- Include affected parties in early stages and continue consultations.
- Establish protocols for collecting and distributing quantitative data.
- Establish clear legal and administrative authorities.
- Work with international and regional institutions to help achieve political agreement and to provide participatory capacity to stakeholders.
- Use existing transmission and transport corridors.

Related to this list, the report suggests areas where agencies such as the United Nations can provide support to interconnection projects:

- Training, including in technical analysis, policy development, negotiation, legal issues
- Information gathering

- Sponsoring analysis, particularly in areas where individual countries or private groups have limited capacity (e.g., large-scale studies such as integration simulations, market designs)
- Supporting meetings and engagement among counterparts and stakeholders

The recommendations from a World Bank presentation on how to advance the development of international electricity interconnections are quoted in the conclusion to provide an alternative summary of the report's conclusions.[6] These are:

- Bottom-up approach: increase bilateral trade
- Top-down approach: improve the broad framework to support longer-term trade
- Strengthen the physical infrastructure, gradually constructing a regional network starting from bilateral trades
- Using regional forums for multi-country discussions and coordination

Annotated bibliography

The report includes an annotated bibliography. Selected entries have been updated and integrated into Annex 1, as noted elsewhere in this Literature Review.

Independent Evaluation Group, World Bank (2007): *The Development Potential of Regional Programs—An Evaluation of World Bank Support of Multicountry Operations*. Washington DC.

Available at
http://siteresources.worldbank.org/EXTREGPROPART/Resources/reg_pgms_full.pdf

IEG evaluation of the World Bank's support for multicountry programs (defined as cooperation or integration among three or more neighbors) over the previous 10 years (1995-2005). The evaluation considers 19 regional programs and around 100 regional operations.[7] The relevance of a regional program is determined by the existence of a regional externality (positive or negative) or efficiency opportunity.

The report finds that "Successful regional programs require consensus among participating countries on the distribution of program benefits and costs and strong country voice in governance arrangements." (Executive summary, page xv)

[6] Vladislav Vucetic, World Bank South Asia Energy Program: Presentation to USAID/SARI Energy semi-annual meeting, New Delhi, 2004 (http://sari-energy.org/DynamicPPTShow/ PPTDownloads/PPT103OCT04.zip) – see Annex 1.8.

[7] The Management Response to the IEG report noted the small sample size and short analysis period. Many of the regional initiatives studied only began near the end of the IEG's evaluation period.

Successful programs require compatible rather than conflicting interests among countries. Three unique dimensions are noted about regional programs:

- They involve objectives on two levels, regional and national, that have to be agreed on and linked and sequenced.
- Design and implementation must account for relations between countries and political economy within countries.
- Division of labor between regional and national institutions must be agreed on and structured.

Unsuccessful initiatives have failed to deal with one or more of these issues. Following from this, five factors are found among successful programs (see chapter 5):

- **Strong country commitment to regional cooperation**—helps achieve country commitment and buy-in. Requires:
  - Evaluation of the costs, benefits and risks (winners and losers at the country and within-country level) and recognition of how benefits and costs will be shared,
  - A regional platform for negotiation and conflict resolution, and for helping to build mutual trust where there is a preexisting history of distrust at the political level,
  - Sequencing program interventions (preparatory analysis, institutional design, physical infrastructure build, etc.).
- The incentive to free-ridership requires monitoring performance against commitments to enhance trust among the participating countries.
- **Scope of objectives matched to national and regional capacities**—ambitions at the regional level must be realistic within the policy and institutional capacity at the country level.
- **Clear delineation and coordination of the roles of national and regional institutions**—successful initiatives have used national institutions for implementation at the country level, and regional institutions for coordination and support services (such as data collection and sharing and dispute resolution). Country-level roles must be clearly defined and understood. Regional institutions should not be too dominant or too limited. The institutions at different levels should be adequately linked, but this takes time to establish.
- **Accountable governance arrangements**—found to take time, but a necessary investment to achieve country ownership and support. Require significant country voice to encourage stakeholder participation, appropriate level of representation given the project goals (e.g., ministerial representation for high-level integration), and effective coordination where there are multiple donors.

- **Planning for the long-term sustainability of program outcomes** following the end of external support. This includes the source of ongoing financial support, and addressing the national policy environment in support of the regional initiative.

Together these argue for a more strategic approach by the bank and development partners.

The paper notes that integration initiatives have been undermined by poor coordination among donor agencies. It also finds that regional partnerships have had less success than regional projects. Partnerships tended to be driven by donors and to have poor links to national institutions. Incentives within the bank, which are aligned with individual country assistance, are found to be poorly suited to motivating successful regional initiatives.

World Bank (2008): ***Building Regional Power Pools: A Tool Kit*****. Washington, DC.**

Available at http://siteresources.worldbank.org/EXTENERGY2/Resources/toolkit_book_final.pdf

This document has three main sections: a Roadmap, a Nordel Case Study, and Modules on establishing cross-border transmission facilities and upgrading SCADA/EMS systems. The third section in fact only has a couple of paragraphs on each of these topics, and the Modules themselves are separate documents available elsewhere.

The **Roadmap** has an introduction on the benefits of regional power pools and then discussion of three requirements.

- **Benefits**
  - Reduced or postponed costs
  - Improved supply conditions
- **Requirements**
  - Legal and regulatory framework
  - Systems planning and operational framework
  - Commercial framework for energy exchanges

Boxes provide some additional details. One of the most useful is Box 3, which gives a detailed list of possible beneficial forms of tradable energy services and/or pooling arrangements:

- Reserve capacity supply services (emergency supplies, scheduled outages and spinning reserve)
- Economy energy (SRMC based)
- Firm energy (LRMC based)
- Energy banking and interchange

- Wheeling (charges for connection and for losses)
- Multilateral cooperative exchanges (cooperative pool)
- Multilateral competitive exchanges (competitive pool—needs much more elaborate software with real-time capabilities)