ESMAP

Briefing Note 004/10

Regional Power Sector Integration

Lessons from Global Case Studies and a Literature Review

REGIONAL ENERGY INTEGRATION STRATEGIES PROGRAM

SOLVING ENERGY CHALLENGES THROUGH REGIONAL COOPERATION

Regional Power Sector Integration

Developing countries are increasingly pursuing—and benefitting from—regional power system integration (RPSI) as an important strategy to help provide reliable, affordable electricity to their economies and citizens. Increased electricity cooperation and trade between countries can enhance energy security, bring economies-of-scale in investments, facilitate financing, enable greater renewable energy penetration, and allow synergistic sharing of complementary resources.

At the same time, many RPSI efforts around the world are currently facing challenges that slow progress and mitigate the full benefits of greater integration. These challenges include: difficulty aligning national and regional investment decisions; differences in regulatory environments between countries; insufficient regional institutions; dearth of financing; changes in political frameworks; and national sovereignty and energy independence concerns.

This briefing note draws from the experiences of RPSI schemes around the world to present a set of findings to help address these challenges. It is based on case studies of 12 RPSI projects and how they are dealing with key aspects of RPSI, such as:

- Finding the right level of integration
- Optimizing investment on a regional basis
- Appropriate regional institutions
- Technical and regulatory harmonization
- Power sector reform and integration
- The role of donor agencies
- Reducing emissions through RPSI
- RPSI and renewable energy

By demonstrating what has and has not worked in different regions around the world, this report explores findings and develops guidelines in these key areas to help RSPI practitioners—politicians, utilities, governments, regulators, financiers, aid agencies, and others—identify strategic solutions to pursue. While there is a commonality of themes among different RPSI projects, all guidelines would need to be adapted to local conditions.

The findings demonstrate how persistence and constancy are often needed to deal with the nonlinear progress and lengthy timelines of RPSI. Many factors can impede progress but nothing in the RPSI schemes studied undermines the many essential benefits of RPSI that many countries are already receiving. The RPSI process requires—and warrants—both perseverance and flexibility of approach to succeed.

CASE STUDIES | An Overview[1]

The 12 case studies span a broad spectrum, from simple bilateral trade, through multi-country trading around a set of regional rules, to fully integrated competitive markets in industrialized countries (Figure 1). The case studies cover the technical, political, financial, regulatory, and contractual aspects of RPSI and comprise a mix of regional markets and of cross-border power projects:

Regional Markets

- Central American Electrical Interconnection System (SIEPAC)
- Greater Mekong Sub-region (GMS)
- Gulf Coast Countries (GCC)
- Nile Basin Initiative (NBI)
- Pennsylvania-New Jersey and Maryland Interconnection (PJM)
- South East Europe (SEE)
- Southern Africa Power Pool (SAPP)
- Union for the Coordination of the Transmissions of Electricity/ European Network of Transmission System Operators for Electricity (UCTE / ENTSO-E)

Cross-Border Projects

- Argentina-Brazil (Garabi Project)
- Cahora Bassa
- Manantali
- Nam Theun 2 (NT2)

Key characteristics of the schemes are shown in Table 1. The entries are chronological by when the scheme began, with some double entries signifying a subsequent fresh start (formalization of regional trading in the case of the Greater Mekong Subregion (GMS) and resumption of electricity transmission after a 20-year break due to sabotage of the transmission lines in the case of Cahora Bassa). The top part of the table summarizes the *transmission and trade schemes* studied, while the second portion gives data on three *generation* projects established specifically to serve regional markets (Cahora Bassa in Mozambique, Manantali in Mali, and Nam Theun 2 (NT2) in Laos). Data on the developed country case studies, which are also the longest established schemes, are given in the final portion.

The transmission and trade case studies are located in transitional and developing countries in South East Europe, Latin America, Africa, and Asia. They generally have small numbers of participants and have been developed relatively recently, gathering momentum in recent years. The MW and GWh in the table refer to maximum demand and energy consumed in the countries belonging to the regional scheme. As indicated in "Max Trade %" column, other than in PJM (which is self-contained), only a small proportion of the energy consumed in the countries participating in regional schemes originates in other countries. SEE has the highest net import figure (14%).

Most of the transmission and trade schemes involve some degree of private sector participation (PSP), the exceptions being SAPP, GCC, and NBI.

[1] The complete Case Studies can be accessed on the enclosed CD and at www.esmap.org.

Table 1: Key Characteristics of the Case Studies

SCHEME	YEAR	# PARTICIPANTS	MW	GWH PA	MAX TRADE %	PSP[1]	TRADE AGREEMENTS
TRANSMISSION & TRADE							
GMS	1971 (1995)	6	88,000	366,000	1%	✓	Bilateral
SAPP	1995	12 (9)	46.000	274,000	7%		STEM, now DAM
Argentina-Brazil	2000	2 (3)	125,000	480,000	13%	✓	Bilateral
SEE	2005	9	43,600	183,000	14%	✓	EU single market
SIEPAC	2010	6	9,700	32,000		✓	MER regional market
GCC	2010	6	73,000	290,000			Spinning reserve
NBI	2010	9	27,400	142,000			Bilateral
GENERATION							
Cahora Bassa	1977 (1997)	3	2,075	13,000			Bilateral
Manantali	2002	3	200	767			Bilateral
NT2	2009	2	1,070	5,636	100%	✓	Bilateral
DEVELOPED COUNTRIES					10%		
PJM	1927	14	163,500	700,000		✓	Multiple markets
UCTE/ENTSO-E	1951	24 (29)	672,000	2,300,000		✓	EU Single Market

[1] Private sector participation.

The Garabi project, interconnecting the 50 Hz Argentine system to the 60 Hz Brazilian network via two 1,000 MW transmission lines and inverter stations, is the only wholly private sector regional transmission interconnector amongst the case studies.

The developed country case studies—PJM and UCTE—have large numbers of participants and operate in sophisticated market-oriented environments. PJM is an independent regional transmission organization offering a variety of energy and transmission capacity markets to its utility members.

UCTE, now absorbed into a new organization called ENTSO-E, for nearly six decades was a technical organization managing the expanding synchronous system in Europe. In parallel with UCTE, other regional organizations developed market structures for the trading of electricity, these being framed with the European Union's (EU) commitment to establishing a single market for electricity in Europe.

In all of the case study schemes, there are some successful aspects, together with some more problematic features. Table 2 provides an illustrative summary of the persistent problems, even in the sophisticated OECD country systems. The positive and negative mix is also evident when performance is tracked over time, with unsustainable periods of successful operation. This is illustrated most dramatically by the Garabi scheme, but other cases also prove progress is by no means linear or guaranteed.

All of the schemes are seeking to address the problem areas. Additionally, each has a number of specific plans for the future Table 3. These plans include expanding the area of coverage and/or undertaking new generation and transmission investments. In a case like NBI, the completion of the interconnector 'backbone' is fundamental to the scheme becoming fully 'regional'.

In addition to investments, there are other issues the various schemes intend to address. These range from sectoral reform issues in SEE to the development and harmonization of rules and expansion of short-term trade in GMS, SAPP, and NBI. Specific timetables are rarely given for these actions, although in the case of GMS the second of the five phases laid out for regional power system integration (rules for cross-border trade) is due to be completed by 2012.

Figure 1: 12 Case Studies of Regional Power Integration Schemes

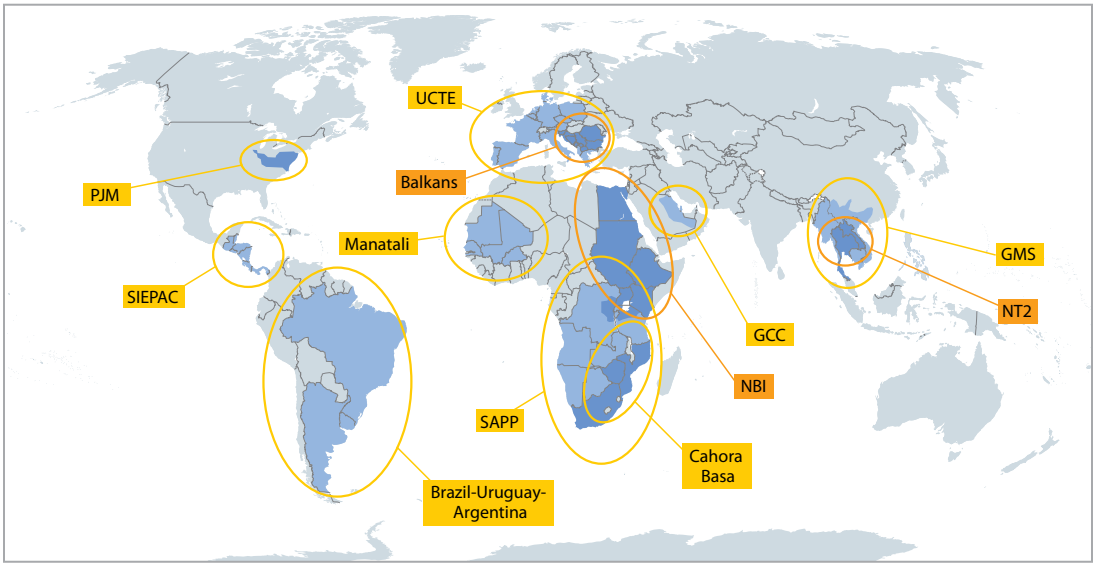

Table 2: Successes, Problems, and Future RSPI Plans

SCHEME	SUCCESSES	PROBLEMS AND INVESTMENTS	FUTURE EXPANSIONS	OTHER ISSUES
TRANSMISSION & TRADE				
GMS	Bilateral trade a proven model	Imposition of social and environmental problems on poor countries	Bilateral export schemes: about 60 projects are proposed.	Rules for cross-border power trading to be introduced by 2012 (Stage 2)—the start of market-driven power exchanges in GMS
SAPP	Regional interconnectors being developed/rehabilitated	Failure to implement Pool Plan; regional capacity shortfalls; failure to attract financing for regional generation projects	Implementation of 2009 Pool Plan, involving 57,000 MW of new generation by 2025 plus regional transmission, including interconnecting nonoperational members, if suitable financial resources can be mobilized	Make DAM fully operational; promote cross-border distribution projects to increase access to electricity; increase harmonization of rules, regulations, and codes
Argentina-Brazil	Regional transmission project promoted and owned by private sector	Banning of exports by Argentine government destroyed basis of Garabi project and set back market development in Southern Cone	Hydropower project at Garabi (2,800 MW) is under consideration	Southern Cone electricity trade is based on bilateral projects; regional market is still a long-term ambition
SEE	Progressive moves towards wholesale and retail competition	Next logical regional investment is in region with uncertain status (Kosovo)	Lignite plant in Kosovo under consideration; trade expansion through developing competitive cross-border trading, regional balancing capability, and congestion management	Completion of national obligations under EU Directives in market opening, transparency, and non-discriminatory pricing; coordinated transmission development planning is needed
SIEPAC	Creation of market institutions; creation of 7th (regional) market on top of 6 national ones that are at different stages of development	Long process (23 years from feasibility study)	Interconnectors to Mexico and Colombia under study would allow development of regional generation projects	Efficacy of MER will be proven once the SIEPAC transmission line is commissioned
GCC	Power Exchange Trading Agreement	World liquefied natural gas (LNG) market distorting regional trade in gas, resulting in imports of coal for electricity generation	Trade-off between gas and coal expansion of generation capacity (gas then going to LNG exports) to be resolved	Level of electricity trade uncertain will emerge once the GCC interconnections are complete and the reserve margin obligation system is in place
NBI	Investment projects underway	Lack of defined allocation of responsibilities between NBI and EAPP	Completion of NBI transmission backbone, linking the Eastern Nile to Egypt and to the Great Lakes region; hydropower to be developed in DRC, Ethiopia, and Sudan	Operational and market rules are to be developed to facilitate full use of physical infrastructure for electricity trade
GENERATION				
Cahora Bassa	Consistent supply since 1997	Reliability: 18 years out of service	Interconnector with Malawi; development of north bank power station at Cahora Bassa would add 850+ MW	HCB to become a full member of SAPP, providing greater access to regional market

Table 2, continued

SCHEME	SUCCESSES	PROBLEMS AND INVESTMENTS	FUTURE EXPANSIONS	OTHER ISSUES
GENERATION, continued				
Manantali	Operated satisfactorily since commissioning	Low tariffs and financial sustainability loans	Other schemes modeled on Manantali being developed e.g., Felou (60 MW), Gouina (140 MW)	Coordinating expansion under WAPP Masterplan
NT2	Export revenues for Laos; well planned environmental and social safeguards	Controversy over share of private participants	Similar hydropower export projects being planned in GMS region	Financing constraints on Government budget intended to ensure Laos revenues from NT2 are put to specified use
DEVELOPED COUNTRIES				
PJM	DAM and real time markets, transmission auctions	Locational marginal pricing does not give sufficient investment signals	Expand by cooperation with systems operators in New York and the Mid-West	Price differentials between regions remains to be addressed
UCTE/ ENTSO-E	Legally binding agreement after 2003 supply failure	Lack of coordinated regional planning and investment	Expansion of the UCTE synchronous area around the Mediterranean and the Former Soviet states	UCTE absorbed into ENTSO-E

Two further summary tables are provided below. Table 3 shows the ownership and financing of regional interconnectors developed in the different case studies. Table 4 shows the pricing arrangements adopted for interconnectors in the case studies. Given the uniqueness of each regional market, different solutions in each of these areas are likely to be appropriate in each RPSI initiative.

Table 3: Ownership and Financing

Scheme	Ownership	Financing
TRANSMISSION & TRADE		
GMS	Interconnections owned by national transmission companies	National utilities, IFIs, international developers, commercial banks
SAPP	Interconnectors are publicly owned, some via SPVs; only private investor is Copperbelt Energy Corp (Zambia-DRC link)	IFIs, and development banks, national governments
Argentina-Brazil	Garabi interconnectors and frequency converter stations privately owned	IFIs, equity, commercial and development bank loans
SEE	Transmission assets are in public hands, growing number of IPPs in generation	National governments and utilities, development banks and IFIs
SIEPAC	SIEPAC transmission line owned by SPV (EPR), which is a public-private partnership	Equity, development bank loans
GCC	Public ownership of transmission assets, including interconnectors	National contributors (equity and debt) in proportion to net present value of estimated reserve capacity savings
NBI	Interconnectors owned by national utilities	National governments, development banks, and IFIs
GENERATION		
Cahora Bassa	Mozambique and Portuguese governments own SPV (HCB); Eskom owns assets located in South Africa	Portuguese and South African colonial governments, export credit agencies, commercial banks; EU banks financing Mozambique government purchase of HCB shares
Manantali	Public ownership by 3 countries via SPV (SOGEM)	IFIs, bilateral donors
NT2	Public private partnership via SPV (NTPC)	Equity (28%), IFIs, and international loans from developers, bilateral agencies, commercial banks (with guarantees), and export credit agencies
DEVELOPED COUNTRIES		
PJM	Investor-owned utilities dominate; large number of federal and cooperative-owned utilities have small market share	Investor and publically owned utilities raise equity and loan finance for investment projects
UCTE	Public ownership in various forms still dominant	Mixed financing

Table 4: Pricing of Traded Electricity

Scheme	Ownership	Comments
TRANSMISSION & TRADE		
GMS	Bilaterally negotiated prices in PPAs	Wheeling charges not an issue in Phase 1 of GMS regional market development
SAPP	Bilaterally negotiated prices in PPAs; some market trading	For DAM, nodal pricing mechanism is in place
Argentina-Brazil	Bilaterally negotiated contract prices	Tariffs for trade due to differential generation costs is at midpoint of marginal exporter generation & transmission costs and higher domestic generation cost
SEE	Cross-border compensation mechanism for transit of electricity	EU zonal pricing for wholesale electricity; progressive expansion of eligible customers at the retail level
SIEPAC	Cost recovery transmission use of service tariffs	Long-run locational signaling short-term market based on nodal pricing
GCC	Bilaterally negotiated prices in PPAs	Interconnection capacity rights may be auctioned
NBI	Subproject-specific bilaterally negotiated prices through PPAs pricing reflecting costs	Avoided costs in importing country also considered in the negotiation of prices
GENERATION		
Cahora Bassa	Bilaterally negotiated tariffs under PPA denominated in Rand	HCB negotiated more favorable tariffs with Zimbabwe Electricity Supply Authority and now sells in SAPP short-term markets
Manantali	Bilaterally negotiated tariff under PPAs indexing and tariff adjustment provisions	Amounts due are now always paid by national utilities; contingency fund has not been built up as envisaged
NT2	Bilaterally negotiated tariff under PPA	Tariffs include currency split and escalation formula; most of the energy is contracted on a take-or-pay basis
DEVELOPED COUNTRIES		
PJM	Wholesale prices and ancillary service prices are set by inter-regional competitive markets	Locational marginal pricing and the longer term Reliability Pricing Model is used in generation and transmission planning but in practice has not given sufficient reward to congestion-reducing investment
UCTE	Transmission tariffs (calculated in various ways) charged separately from energy tariffs	Energy is predominantly sold under bilateral contract (either as physical contract or using a financial instrument)

LITERATURE REVIEW | An Overview[3]

The purpose of the review is to assess the literature relevant to RPSI in the World Bank's client countries. The resulting document has an introductory discussion of cross-cutting themes, an annotated bibliography (with more than 80 entries), and extended bibliographic treatment of six documents of special significance to RPSI.

The themes discussed in the discursive part of the Literature Review are divided in three areas:

- ***Motivations*** and ***barriers*** to integration
  - Benefits of integration (the expected outcomes) and how these are to be shared
  - Barriers to integration (technical, political, economic)
- ***Outputs*** of regional integration
  - *Institutional infrastructure and market development* (agreements, rules, and institutions that make electricity trade possible)
  - *Physical infrastructure* (interconnectors, etc., that make trade in electricity physically possible)
- ***Facilitation*** of the regional integration process
  - *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

The papers in the annotated bibliography are divided into nine categories:

1. RPSI major overview papers
2. Economics of RPSI
3. RPSI institutions and markets
4. Technical aspects of RPSI
5. Hydropower
6. Environmental aspects of RPSI
7. Support of outside agencies for RPSI
8. Region-specific papers
9. Case studies from ESMAP projects

[3] The full Literature Review is available on the enclosed CD and at www.esmap.org.

FINDINGS | By Theme

The circumstances in which RPSI is being carried out varies enormously. Countries have diverse motivations for joining RPSI schemes; the electricity sectors are at different stages of reform and development; financial capabilities; and orientations to private sector involvement differ and social/environmental impacts vary. Against this background, an overarching finding is effective RPSI approaches must be tailored to the circumstances at hand. Political factors and historical evolution of the regional arrangements are equally as important as the 'objective' technical and economic factors (Box 1).

1. LEVELS OF REGIONAL POWER INTEGRATION

Regional power sector integration (RPSI) in its most integrated form involves robustly interconnected national electricity networks to enable trading of substantial power across countries; systems operation rules and control procedures that ensure high quality, reliable supplies originating in another country to be delivered to domestic consumers; and a market framework which encourages competitive international trading of capacity and energy. As system demand grows, generation and transmission expansion should be planned in-

BOX 1.

One Size Does Not Fit All in RPSI Schemes

The case studies differ in their immediate characteristics, such as size, stage of electricity sector reforms, ownership, resource usage, and environmental impact. They also differ in the framework conditions, such as the objectives of political leaders, the commitment to regional integration (in all sectors, not just the power sector), and the type of regional institutions alredy established or can be established as part of the RPSI process.

These differences point to the need for all aspects of RSPI strategies—ownership, financing, pricing, planning, and regulatory harmonization—to be tailored to local circumstances. Adapting to local circumstances should not just be a feature at the start of an RPSI initiative, but should result in reassessments and redesigns of the approach as the scheme develops over time. If it were possible to guarantee an orderly, predictable process of deepening of regional integration and concomitant growth in electricity trade, then it would just be a question of determining where to start. In practice, RPSI is almost always a more fractured process, with temporary reversals as well as periods of progress and consolidation.

The design, approach, and phasing of regional integration efforts must adapt to local realities, with considerable room for flexibility and adjustment as conditions and attitudes change. This means that there are no unique RPSI institutions or processes, and no hard-and-fast rules about issues, such as ownership, financing, and pricing, that will ensure the success of regional integration efforts. The best case would be one in which early regional integration provides tangible benefits, helping build consensus and momentum towards deeper forms of integration. Typically, though, the next stage may be far more difficult than the early success, and reversals may have to be weathered before further progress is sustained.

dependently of national boundaries, minimizing investment and operation costs for the region as a whole, while also contributing to regional environmental and social objectives.

In practice, only the regional power schemes in a few industrialized countries, after developing and maturing over many decades, approach 'full' RPSI. Schemes amongst developing countries are loosely described as RPSI, but are often at lower levels of integration.

Different schemes are at different stages of integration because of various driving motivations. The case studies illustrate that the variety of motivations, or objectives, impelling greater trade and interconnection can lead regions to achieve a variety of stages on the way towards full RPSI. As shown in Table 5,

Table 5: Diverse Motivations in the Regional Power Case Studies

Scheme	Motivations/Objectives	Comments
TRANSMISSION & TRADE		
GMS	Efficient, environmentally sound development of the power sector to aid economic growth; support to regional projects and electricity trade as means for these objectives	Planned stages: (1) bilateral export projects (well advanced); (2) trade between any pair of GMS countries; (3) interconnections expressly for trade, with third party access effective; (4)integrated, competitive regional power market (still conceptual)
SAPP	Development of a safe, efficient, reliable, and stable interconnected electrical system and of a regional power trading mechanism	Subsidiary objectives are harmonized standards and regulations (well advanced)
Argentina-Brazil	Reduce drought vulnerability of Brazil's hydropower-dominated system and expand Argentina's trading opportunities	In practice, following political and economic crisis in Argentina and suspension of electricity exports, power flows have been from Brazil to Argentina (and also to Uruguay), but the system is fulfilling its energy security purpose
SEE	Create a regionally integrated electricity market, forming part of the wider EU single market	Political commitment to join the EU provides motivation for aligning with EU energy directives; economies-of-scale and access to lower-cost regional resources also a consideration for generation and transmission investment
SIEPAC	Create an integrated regional electricity market in Central America	Regional market seen as means to improve efficiency, security of supply, lower costs, attract foreign investment, and contribute to economic development
GCC	Share reserve capacity, thereby reducing generation investment requirements	Shared reserves is effective; trade in electricity is still under development
NBI	Ensure coordinated power investment in Nile Basin to meet social and economic development objectives in the region	The power integration component is part of a broader scheme for the optimized management of water in the Nile Basin with irrigation as the main concern
GENERATION		
Cahora Bassa	Import of clean power for more reliable electricity supplies in South Africa	Objectives fall within those of SAPP, but the project was initially developed on a purely bilateral basis
Manantali	Contribute to meeting the power needs and increase the efficiency and reliability of power systems in Mali, Mauritania, and Senegal	Initially, the purpose of the project was the regulation of Senegal River for irrigation purposes; power generation was a secondary aspect
NT2	For Lao PDR, revenues from hydropower exports; for Thailand, access to cost competitive and diversified electricity supplies	One of a number of Lao PDR-Thailand hydropower projects in operation or under development

some schemes are specifically oriented to deep forms of RPSI (e.g., the regional market of SIEPAC) while others have more limited objectives (e.g., sharing spinning reserves by GCC).

The objectives also change over time, as do the consequent institutional arrangements. This is illustrated by UCTE, which in the first five decades was committed to technical and operational coordination of a synchronous system via a loose arrangement involving voluntary horizontal coordination with no hierarchical control or subordination. After a major shut-down of the synchronous system following a disturbance in Italy in 2003, UCTE required participating transmission system operators (TSOs) to sign a Multilateral Agreement legally enforceable in the European Court of Justice. Recently, a desire to broaden the approach to RPSI beyond the narrow confines of synchronous operations, led by EU legislation, has resulted in UCTE being incorporated with other RPSI schemes (including Nordel) into the new ENTSO-E thus creating a supra-national agency with statutory powers. Heterogeneous members of schemes can initially be coordinated in loose 'club' type arrangements, but deeper RPSI requires some form of subordinating arrangements.

The expectation in many cases is that regional schemes, which start with limited technical objectives, will eventually develop into competitive markets. Regional cooperation in the power sector generally commences with the building of transmission interconnectors and the negotiation of long-term bilateral power purchase agreements (PPAs). As interconnection increases, more countries join in trading. Short-term markets develop to take advantage of trading possibilities arising from noncoincident load profiles and different cost structures. As confidence grows, there may be progressive development of more comprehensive competitive markets for energy and capacity. Over time, countries develop common technical and economic rules, paving the way for regional electricity markets.

Table 6: Levels of Regional Power Sector Integration

Area of Regional Cooperation	Inter-connectivity	Trading Arrangements	Harmonization	Planning and Investment	Case Study Examples
Interconnection	Typically starts with two countries, later a wider interconnected grid	Long-term bilateral PPAs	Simple rules agreed for the operation of the interconnected system	National planning and investment	Cahora Bassa, Manantali, NT2, GMS, Argentina-Brazil, GCC
Integration—shallow	Interconnected grid involving a number of neighboring countries	Long-term PPAs supplemented with short-term markets	Harmonization of rules, grid codes, and transmission tariff	Some coordination of national investments with optimized regional investment plan	SAPP, *SIEPAC*
Integration—deep	Full synchronous operation of a multi-country interconnected system	Competition achieved through a range of markets (spot, day ahead, transmission capacity auctions, etc.)	Regional regulatory agencies, systems, and market operators	Regional integration body empowered to require investments in agreed regional plan to be implemented*	PJM, UCTE, *SEE*

Note: Schemes exhibiting some, but not all, deep integration characteristics are shown in *italics*.

* Full delegation of powers to enforce regional investment plans is yet to be made in any scheme.

This general sequence is not always followed. For instance, SIEPAC deliberately developed Mercado Eléctrico Regional (MER), the Central America regional electricity market, before building the interconnector to make trade physically possible. Amongst the other developing country schemes, SAPP is in some respects more advanced than GMS and NBI, which are still clearly at the interconnection stage, but all three have expressed the intention to move to deeper forms of regional integration, including competitive markets. Amongst the case studies, only GMS has a roadmap for this transformation:

- **Phase 1:** Bilateral export projects
- **Phase 2:** Trade between any pair of GMS countries
- **Phase 3:** Interconnectors built expressly for trade, with third party access assured
- **Phase 4:** Integrated, competitive regional power market

Findings

- There are many levels and types of RPSI. These range from simpler forms of interconnection, which may only include individual cross-border generation projects, to more advanced forms, which may include some combination of unified multinational power markets, technical and regulatory harmonization, a single power exchange, high interconnection levels, regional coordination of investment, and competition across borders with few impediments.
- Full integration of multiple national electricity systems into a regional electricity market offers the greatest benefits from RPSI. Few regions have achieved this as yet; Nordpool in Scandinavia is probably the closest.
- Substantial benefits can still be achieved at all levels of RPSI. Simple interconnections between national systems and one-off, cross-border electricity trade projects can offer substantial benefits, and countries may be content to stay at this or other intermediate levels of integration.
- Moving from no integration to full integration can take decades, but moving from intermediate to higher levels of integration can be relatively rapid. The rate at which progress is made towards full power sector integration depends on many factors, including the institutional capacity of participating countries.

2. OPTIMIZATION OF INVESTMENT ON A REGIONAL BASIS

The potential benefits of a regionally optimized generation and transmission expansion plans typically offer significant savings over the sum of the national power development plans designed to meet the same projected demand. Putting planning onto a regional basis is therefore a crucially important aspect of deepening RPSI. However, there are often problems following through with the actions identified in a regional least-cost plan, with investments reverting to the sequence specified in national power development plans.

The figures for the latest SAPP Pool Plan provide a good example of potential savings through a regional approach to investment (Box 2). The reality is regional power integration plans are seldom implemented, despite the consequent economic costs. In the Nile Basin area, for example, failure to ex-

ploit hydro-based regional power development potential has led to chronic shortages of capacity and the leasing of emergency diesel generators in several countries at costs well above what power from the regional plants could have provided. Shortfalls nonetheless persist: the Africa Infrastructure Country Dialogue report documents costs of outages in recent years of around two percent of the gross domestic product (GDP) in Kenya and four to five percent of GDP in Tanzania and Uganda.

An underlying reason for the 'national bias' that leads to failure to implement regional investment strategies is the unwillingness of countries to accept optimized regional investment plans. This applies as much to highly developed countries in UCTE as to developing countries in the regional schemes studies in Latin America, Africa, and Asia.

It is common for there to be uncertainty and skepticism about regional arrangements and little feeling of ownership of regional plans. Part of the reason for this is so-called 'optimal' plans are not robust, but depend on the particular set of assumptions adopted for the final run of the scenarios. If changes in assumptions can radically alter the sequencing of projects for a particular country, it is understandable that decisionmakers retreat to the comfort of a national investment plan.

Concerns over energy supply security are often cited as a reason for favoring national over regional investment strategies, despite the lower costs of the latter. In some cases, notably SEE, countries rely on other countries for their supplies, especially countries with whom they have recently been at war or are unrecognized by other countries in the region. For example, there is general acceptance that the lowest-cost new baseload generation would be located in

BOX 2.

Failure to Realize Regional Power Investment Gains—The Case of SAPP

The Southern African Power Pool (SAPP) has nine interconnected operating members (Botswana, Democratic Republic of the Congo, Lesotho, Mozambique, Namibia, South Africa, Swaziland, Zambia, and Zimbabwe) and three nonoperating members (Angola, Malawi, and Tanzania). SAPP's latest 2025 Pool Plan requires an investment of US$89 billion to construct 57,000 MW of new generation capacity, plus additional funding for the associated transmission lines. The cost is US$48 billion less than the sum of the national power development plans to meet the same projected level of demand. A capital cost saving of 45% should be sufficient to galvanize SAPP members to implement the regional investment strategy, but past experience is not encouraging.

The previous regionally optimized Pool Plan, announced in 2001, was ignored because there was surplus capacity in the region at the time. By 2007-08, the surplus capacity had been exhausted and even South Africa suffered blackouts and load shedding. President Mbeki apologized publicly, admitting the politicians failed to listen to the utilities and SAPP. However, the same fate could lie ahead for the new Pool Plan. With the regional shortages, countries are now investing in electricity but are keener than ever to pursue their own national investment strategies. The lack of adequate reserves in the region is predicted to last at least until 2013. Special regional cooperative arrangements have been made in SAPP to ensure the lights will be on in the stadiums during the 2010 World Cup matches.

Kosovo to take advantage of its lignite resources. However, countries, such as Serbia, would prefer to develop their own resources rather than rely on a region they still recognize as part of their national territory but outside their direct control.

An example of RSPI between countries with a long history of good co-operation is Argentina and Brazil. Originally planned during the 1990s, the Garabi Interconnector was to export electricity from Argentina to Brazil. The 2002 economic and political crisis in Argentina led to a collapse in energy sector investment and, by 2004, in response to growing energy deficits, the Argentinean government banned exports of electricity. The interconnector's owners have since recovered from this financial shock with the interconnector now being used for exports from Brazil to Argentina. Still, this example shows the political risk associated with regional projects where governments are not necessarily committed to their implementation.

The SEE market also shows the potentially adverse consequences for national system operations of regional investment plans. Many countries were left with unbalanced generation mixes following the breakup of Yugoslavia and its integrated grid. For example, Kosovo's generating capacity is almost entirely comprised of inflexible baseload lignite generators making load-following very difficult, while Albania's capacity is largely comprised of hydropower plants with large seasonal differences in output.

Another common barrier to regional planning is the desire of countries to either maximize their exports of energy or to minimize domestic supply costs by retaining the benefits of lower cost domestic energy resources for themselves. Countries need to be convinced that they will all benefit from any regional plan. Within GMS, for example, the large numbers of proposed cross-border generation projects reflects the combination of lower income countries, such as Lao PDR and Myanmar, which have large low-cost hydropower resources, and higher income countries, such as Thailand and Vietnam, which want to increase electricity supplies at least cost. The small size of the domestic electricity markets and national economies in Lao PDR and Myanmar means that their hydropower resources would not be exploited, unless for the regional market. There is no conflict between developing these for regional export or for domestic supply. In other regions, this conflict may be less easy to resolve.

The 'brittleness' of regional power planning is a reality RPSI participants need to confront. Once there is consensus on the scenario that is to become the regional plan, there must be a firm commitment to adhere to that plan. Countries otherwise forfeit the enormous collective gain of the regional approach to investment. Having Heads of State (or other high-level political figures) formally endorse and sign regional power investment plans, as is done in the West African Power Pool (WAPP), can ensure visible political buy-in and increase chances of following through with regional planning investments.

Findings

- The optimization of generation and transmission investment on a regional rather than a national basis can offer substantial cost reductions.
- These cost reductions often go unrealized when countries follow national priorities, including domestic energy supply security, economic nationalism, and sovereignty concerns.

- Recognizing as legitimate and appropriately addressing these and other important national priorities is essential to achieving regional investment optimization and the full benefits of RPSI. Approaches for achieving this will differ depending on local circumstances and the combinations of planning and market forces that drive investment decisions.
- With the exception of PJM, none of the regions studied implement mandatory regional planning although several encourage the use of indicative regional plans with buy-in from politicians to ensure commitment to delivering these.
- Explicit mechanisms to share benefits, such as allocating shares in cross-border projects, may help overcome reluctance to implement regional plans.

3. REGIONAL INSTITUTIONS

RPSI schemes are often initiated through some political initiative, giving them initial momentum. To sustain the schemes, it is necessary to establish regional institutions. These typically are of two main forms:

- Special purpose vehicles (SPVs): a corporate structure established to execute and operate a specific regional project (such as a large export-oriented hydropower plant).
- Regional bodies: groups charged with deepening RPSI through working with governments, regulators, and utilities from member countries on an on-going basis. Examples would include power pools and their secretariats, regional regulators (or regional associations of national regulators), and regional transmission/system/market operators.

SPVs are a feature of five case studies—Argentina-Brazil, SIEPAC, Cahora Bassa, Manantali, and NT2. For the implementation of individual projects, SPVs have a number of advantages, including a transparent and workable framework for the ownership of shared assets and the employment of well-qualified personnel (Box 3). The alternative of national ownership of components of a regional system is best avoided because it makes political interference much more likely, including national demands for priority use of the assets during shortages.

The other case studies provide examples of schemes with different kinds of regional bodies and RPSI mandates. The kind of regional power institution established is strongly related to the existing overall regional integration framework. SAPP, for example, falls under the Southern African Development Community (SADC), which is one of the eight regional economic communities (RECs) recognized by the African Union. SADC has a strong regional integration agenda across the whole spectrum of socioeconomic development of its 15 member states. The power sector is just one aspect of SADC's integration ambitions. SAPP's strength is that is has always been a utility-driven institution that also benefits from the political guidance of SADC.

Similar to SADC, NBI is a broad regional integration institution, but it does not have the same political mandate and cohesiveness of a REC. The member countries of NBI belong to at least one, but typically several overlapping RECs (notably COMESA, East African Community, and Intergovernmental Authority on Development). The GMS regional market forms one part of the overall GMS integration initiative promoted by member countries and external bodies, such as the Asian Development Bank (ADB). However, GMS's cohesion is somewhat reduced by the multiplicity of other regional initiatives and institutions active in the same geographical area and sector, particularly the Association of South-East Asian Nations (ASEAN).

BOX 3.

Nam Theun 2 Power Company

The Nam Theun 2 project (NT2) involves the construction of a 1,070 MW hydroelectric storage project in Lao PDR with the capacity to deliver 5,600 GWh annually to Thailand via a dedicated interconnector. A small portion of production is supplied to customers in Laos. NT2 is an enclave project in which output from a new-build generation facility is almost entirely devoted to export. Most of the contracted output is on a take-or-pay basis at prices agreed upon in a power purchase agreement.

A special purpose vehicle, the Nam Theun 2 Power Company (NTPC), was created to build, own, and manage the facility. NTPC is incorporated in Laos under Lao law as a foreign investment company. It is a joint venture between: Electricité de France International (35%), Lao Holding State Enterprise (25%), Italian-Thai Development Public Company, Ltd. (15%), and Electricity Generating Public Company (EGCO) of Thailand (25%). NTPC brings together the project developers, representatives of the host governments ,and (indirectly) the power purchasers. (EGCO is partially-owned by the Electricity Generating Authority of Thailand—the power purchaser.)

The type of REC or other overall regional arrangement is an important determinant of the institutions that have emerged to promote RSPI:

- ***Loose cooperation:*** GMS is yet to establish a full-time secretariat for regional power. Instead, various working groups bring together representatives of national utilities and regulatory agencies and act as secretariat rotating between members. This is reflective of both the wider GMS initiative and other regional institutions, such as those under ASEAN.
- ***Harmonized, uniform approach:*** In SEE, countries are either already members (Bulgaria and Romania) or aspire to be members of the EU and in pursuit of that overall political objective, are willing to fulfill the necessary requirements of the stringent EU Directives in the power sector. This requires extensive subordination of national interests to regional requirements. A regional Energy Community Secretariat exists to oversee and manage the integration process and has power to rule on disputes relating to the regional market. Members are also required to conform to relevant EU legislation on electricity and gas markets, state aid, and competition.

The institutions promoting power sector integration are crucial, but, as the above discussion illustrates, it is difficult to derive general rules about institutional design where the history and political framework are different and changing over time. Ideally, institutions need to evolve to encompass the wider cooperation between countries and reflect the established approach to such cooperation. Creating new institutions with no basis in existing cooperative arrangements are unlikely to succeed, as is trying to force a level of permanence and control exceeding that in other existing arrangements.

Table 7: Regional Power Institutional Forms

Scheme	Motivations/Objectives	Comments
TRANSMISSION & TRADE		
GMS	Working Groups under the GMS Economic Cooperation Programme (Secretariat ADB); no permanent secretariat	National regulatory agencies (in Lao PDR and Myanmar, Ministries of Energy)
SAPP	SAPP is part of the Southern African Development Community (SADC); main organs—Executive Management Committees, 5 technical sub-committees; permanent secretariat in Harare, Zimbabwe	National regulatory agencies exist in most countries. Eight are members of Regional Electricity Regulators Association of Southern Africa (RERA)
Argentina-Brazil	Privately owned SPV: Companhia de Interconexo Energetica, registered in Brazil	National regulatory agencies—El Ente Nacional Regulador de la Electricidad (Argentina); Agencia Nacional de Energia Electrica (Brazil)
SEE	Energy Community of South East Europe; permanent Secretariat is located outside region (Vienna, Austria)	National regulatory agencies, coordination through the South East Europe Electricity Regulation Forum
SIEPAC	Project initiated by the Central American Electrification Council and formulated under Marco Treaty and Mesoamerican Project Regional transmission line SPV is public-private partnership, La Empresa Propietaria de la Red (EPR)	The 7th Market Regional Institutions are superimposed over existing national ones; regional regulator is Comisión Regional de Interconexión Eléctrica; Marco treaty also created regional system and market operator—Ente Operador Regional
GCC	Gulf Cooperation Council Interconnection Authority—Planning and Operating Committees, Secretariat in Saudi Arabia	Regulatory Advisory Committee is to be set up to deal with regional regulatory issues
NBI	NBI institutions have secretariats in Entebbe, Kigali and Addis Ababa; East Africa Power Pool (EAPP) Secretariat is located in Addis Ababa; NBI countries belong to COMESA and/or various other regional economic communities	All NBI countries except DRC have separate regulatory agencies. Some belong to Regional Association of Electricity Regulators for East and Southern Africa
GENERATION		
Cahora Bassa	SPV is Hidroelétrica de Cahora Bassa, registered as a company in Mozambique	Mozambique, South Africa, and Zimbabwe have regulatory agencies and these belong to RERA
Manantali	SPV is Société de Gestion du Barrage de Manantali (SOGEM); hydropower complex operated under management contract with Eskom Energie Manantali	Mali, Mauritania, and Senegal have national regulatory agencies; Economic Community of West African States Regional Regulatory Authority set up in 2008 has jurisdiction over cross-border electricity exchanges
NT2	SPV is NTPC, incorporated in Laos, with majority private ownership structure	Enclave project regulated via provisions of the PPA; national regulators have oversight role
DEVELOPED COUNTRIES		
PJM	PJM is a limited liability company: members are utilities, customers and suppliers	Federal Energy Regulatory Commission for interstate matters and State regulators
UCTE	UCTE absorbed into ENTSO-E: members are transmission systems operators (TSOs)	National regulators and their associations—Agency for the Cooperation of Energy Regulators (replacing European Regulators' Group for Electricity and Gas and the Council of European Energy Regulators); competition regulation overseen by European Commission

Findings

- Regional institutions are vital for RPSI but there is no single institutional form that is appropriate for all regional power integration schemes.
- The strongest institutions are those that grow organically from local initiatives rather than imposed from outside. Opportunities to build on existing arrangements should be explored before creating new institutions.
- SPVs provide a good model for projects serving multiple country markets.

4. TECHNICAL AND REGULATORY HARMONIZATION

Harmonization is not a precondition for regional power integration, but is often the next step after simple coordination. Harmonization refers to establishing common norms and rules in technical, economic, and legal matters pertaining to RPSI:

- ***Technical***—rules and procedures assuring access to and stable operation of interconnected transmission systems
- ***Economic***—rules for the operation of markets or for the adjustment of tariffs where prices are regulated
- ***Legal***—agreed common procedures and mechanisms for the resolution of disputes

Harmonization is particularly important when there is an intention to attract the private sector into investing. Private investors will not invest without a high degree of certainty about transmission line access, revenue flows, and regulatory predictability. Public utilities should have the same concerns: whether they are purchasers or sellers, they benefit from greater transparency, consistency, and predictability. Harmonization is of general importance in improving conditions for initiating RPSI.

Drawing on the experience of industrialized country power pools, such as PJM, UCTE, and NORDEL, the benefits of greater harmonization have also been recognized in many developing country schemes. SAPP, GMS, and NBI have harmonization projects underway. SIEPAC is the only developing country scheme that has fully harmonized technical rules and common approaches to regulation in the regional market, although these coexist with different national market rules and procedures in the six participating member countries. Although motivated by the desire to follow the requirements of becoming EU members rather than by power system integration considerations alone, SEE provides an interesting example of a regional organization with a strong drive for harmonization (Box 4).

Other than in SIEPAC, the regional regulatory bodies in developing countries are associations for the exchange of information and experience. Deepening of RPSI would follow empowerment of regional regulatory bodies with discretionary powers to override national regulators. In Southern Africa, the regional regulatory association—Electricity Regulators of Southern Africa (RERA)—is trying to navigate around this restriction. Although, a reasonably conducive environment has enabled the development of the short-term markets (STEM) and day-ahead markets (DAM) in the SAPP region, RERA has recognized that

BOX 4.

Regional Power Harmonization in South East Europe

The South East Europe (SEE) case study examines the regional electricity strategies of the nine contracting parties, which were signatories in 2005 of the Energy Community Treaty: Albania, Bosnia & Herzegovina, Bulgaria, Croatia, Kosovo, Macedonia, Montenegro, Romania, and Serbia. Significant drivers towards integration in the SEE region 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 large generation investment projects are to be feasible. In line with the aspirations of these countries to join the European Union (EU; which Bulgaria and Romania have joined), the Treaty seeks to further the implementation of the EU Acquis Communautaire.

As a result of these drivers, important features of the process of regional power integration in the SEE region are:

- 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 to the wider EU market, including common rules for generation, transmission, and distribution
- Coordination of regional planning and facilitation of competitive investment, although the Energy Community Treaty does not, of itself, mandate any investments

a tighter regime is needed to expand electricity trade further and to attract private investors. It recently completed a project with ESMAP support—*Guidelines for Regulating Cross-border Power Trading in Southern Africa*—to provide clear guidelines for regulating cross-border power trading in Southern Africa. The guidelines will be administered by the national regulators but on a harmonized basis—premised on the idea that the same objectives can be pursued in the region via *de facto* rather than *de jure* regional regulation.

Findings

- Harmonization of technical standards is needed to avoid endangering or loading excessive costs onto neighboring systems.
- Harmonization of relevant economic regulations among participating countries is not a prerequisite for initial levels of RPSI, but is increasingly required as cross-border competitive power trade develops.
- Deepening RPSI will require a gradual move towards uniform approaches by national regulators, creating a common regulatory framework for regional markets or possibly some form of 'regional regulator' with discretionary powers in the regional market.

5. POWER SECTOR REFORM

There is a clear theoretical connection between the introduction of markets in national electricity sectors and RPSI. The greater competition engendered by market-based reform is aided by the introduction of more (supply and demand) players through a regional rather than domestic market. The resulting international electricity trade, in turn, justifies the interconnections and the enabling rules and regulations. In this way, the two processes can complement one another. After unbundling previously vertically integrated national utilities, transmission operators would be the focal points for regional schemes.

In practice, such synergistic momentum has not often developed, but a number of RPSI schemes have forged ahead. Indeed, it is possible for market reforms at the national level to create barriers to RPSI. Utilities with substantial domestic market power may seek to block increased competition from imports. Competitive markets can make long-term contracting and financing of regional projects more challenging. And there may be strong opposition to opening up domestic power markets to imports from countries that retain monopoly markets given the resulting perceived "unfairness" in competition between utilities in the two countries (although here the solution is to speed up power sector reforms in other countries).

Linking RPSI to power sector reforms runs the risk that delays in reforms endanger the progress of RPSI. Africa provides a stark example of stalled electricity sector reform. Widespread market-oriented reforms were expected, but today reforms are evident in only a few of the 24 countries covered by the case studies. In Latin America, the experience is mixed. Promising reforms in the Southern Cone are in sharp reverse while in Central America SIEPAC shows that RPSI can proceed even when countries are at very different stages of reform (Box 5). In other case studies (such as SAPP, SIEPAC, and NBI), partial national electricity sector reforms have made some contribution to the momentum for the deepening of RPSI.

Findings

- Competitive power markets are not a prerequisite for initial RPSI. Different levels of power sector reform amongst participating countries can be accommodated by careful design of regional integration schemes.
- Deeper levels of integration will require national power markets be at similar stages of reform in order to address concerns that the benefits of integration are captured by countries where power monopolies persist.
- Competitive power markets can facilitate and complement RPSI, but also can create barriers to electricity trade due to its potential to reduce the market power of incumbents and the added difficulty of financing cross-border projects as long-term contracting becomes more challenging.

6. ROLE OF DONOR AGENCIES

Multilateral and bilateral donor agencies have played significant roles in regional power integration in the developing world. The most prominent aspect has been in helping to finance regional projects, but donor agencies have also been involved in shaping or even creating regional institutions. Experience teaches that donors need to be cautious about imposing ambitious integration agendas. Instead, they should support gradualist approaches in line with local realities and the objectives of RPSI participants.

The ambitions for the 44,000 MW Grand Inga project on the Congo River exemplifies this point: donors have committed large volumes of resources to a project that has failed to progress. Lower profile interconnection schemes in Central Africa and countries involved in the proposed Western Power Corridor (WESTCOR) interconnector to Inga (Angola, Namibia, Botswana, and South Africa) could have been implemented to deliver regional benefits in much shorter time frames.

BOX 5.

SIEPAC: Regional Integration without Coordinated Power Sector Reforms

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, which is based on a standard set of trading rules at the regional (supranational) level; and institutional structures, which includes a regional regulator and a regional transmission operator. These institutions have supranational legal status, granting them independence from any of the six national legal systems. The second component, developed subsequently, is a new 1,800 km international transmission line, running from Panama to Guatemala, to increase transfer capacity at all borders to 300 MW.

In SIEPAC, the diverse range of institutional development and capacity in the national electricity sectors is recognized as an important element affecting the design of the regional market. To accommodate these differences, the Mercado Eléctrico Régional (MER) has been designed as a seventh market that connects the six national markets while remaining separate from them. The design deliberately allows the individual countries to develop their sectors at their own pace while enabling trade within the region. The focus on gradualism is explicitly required in the Marco Treaty, which is the intergovernment founding legal agreement for the regional power scheme.

In several cases of already implemented projects, the World Bank and regional multilateral banks have played key roles in the financing of projects, including NBI (World Bank and African Development Bank), NT2 (World Bank and Asian Development Bank), and SIEPAC (Inter-American Development Bank). In the Manantali project, the World Bank worked closely with bilateral agencies, notably Agence Française de Développement and Kreditanstalt für Wiederaufbau.

Large-scale donor financing can also have undesirable outcomes, particularly in less developed countries where financing has a significant concessional element. This may allow electricity tariffs to be set at subeconomic levels for long periods, making eventual adjustments more painful. To pre-empt this, donors may be tempted to add conditionalities but these can introduce other kinds of problems (Box 6).

While the financing of regional projects can be problematic, donor agencies can play an important role by providing technical assistance and advisory support to RPSI institutions. As well as bringing the benefits of technical expertise, donors can offer a 'neutral' and independent voice, fostering common understanding and encouraging consensus. For example, the SEE energy community makes extensive use of donor-funded consultants to provide analyses of further development of and remaining national barriers to regional energy markets. The reports from these independent consultants are likely to carry more credibility and be more widely accepted than if they were produced by regional institutions alone.

BOX 6.

IFI Financing—Manantali and Nam Theun 2

The 200 MW Manantali hydropower project in Senegal was originally sponsored by a river basin organization, the Organisation pour la Mise en Valeur du fleuve Sénégal. The Manantali Dam was completed in 1987, with the expectation that the loans for the dam would be paid through electricity tariffs. Construction of the hydroelectric power plant and transmission lines began 10 years later and was completed in 2002.

After the first phase of the project, the multilateral and bilateral development agency financiers of the dam wrote off loans and provided new financing for the hydropower project. This may have created a moral hazard precedent for the second phase in that payments based on the Tariff Protocol have not always been forthcoming. Loan payments have been made in arrears and significant debt is carried by the special purpose company, Société de Gestion du Barrage de Manantali (SOGEM), which was created to be the asset holder and operator of the Manantali infrastructure.

Moral hazard type problems with soft budget constraints could be avoided with carefully designed financing conditionalities. These conditionalities can also produce unintended consequences. In the case of the Nam Theun 2 (NT2) project, for example, concerns have been raised about whether the repayment conditions imposed by the financiers are too onerous for the Government of Laos. The involvement of international financial institutions (IFIs) was 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.

The response of countries, such as Laos, to such conditionalities may be to avoid approaching IFIs and bilateral development institutions for financing, resulting in projects with lower levels of social and environmental safeguards.

Findings

- Donors can play an important role in developing RPSI, through financing, providing technical expertise, and acting as 'neutral' advisors.
- In some cases, the involvement of donors can help RPSI participants recognize and mitigate the environmental and social impacts of RPSI.
- Donors must avoid imposing an overly ambitious RPSI agenda and allow RPSI to evolve at a pace determined by the participants.

7. CARBON EMISSION SAVINGS FROM RPSI

Participants in many RPSI schemes aspire to use increased electricity trade to reduce overall greenhouse gas (GHG) emissions by making possible more dispatch from less emitting plants. In the past, regional carbon emission reductions have been associated with large hydropower schemes that often outsize the host country's electricity needs but provide a regional supply to meet the demand of national power markets. Despite some offsetting methane emissions from decay of submerged vegetation behind hydropower dams, the net GHG emission reductions from hydropower generation effectively displace high carbon emissions from the relatively small national fossil fuel power stations.

Estimates indicate that the savings in carbon emissions from the RPSI schemes studied here are likely to be relatively small. For the GMS, the Asian Development Bank has estimated that GHG emissions over the period to 2025 would be around 36 $MtCO_2e$ lower with a fully integrated regional energy market. This represents a saving of three percent in emissions compared to the base case. This analysis suggests that integration alone is unlikely to deliver large reductions in emissions. Major efforts to promote energy efficiency at national levels and expand the use of renewable energy technologies will also be needed.

None of the regional power schemes studied have yet obtained Clean Development Mechanism (CDM) certification. The first submission made by SIEPAC was rejected and a new submission awaits adjudication. One of the GMS projects, a 220 kV Vietnam-Cambodia interconnector, applied in 2008 and also awaits a decision. If successful, several other GMS projects will make applications for CDM funding in the near future.

Findings

- Carbon savings from international power trade have been modest and mostly result from increased imports of hydropower.
- Several RPSI schemes are pursuing the use of the CDM as a means of monetizing emissions reduction due to increased regional trade, but none yet have been successful.

8. RPSI AND RENEWABLES

Many forms of renewable power—like solar and wind—offer intermittent electricity generation following natural cycles.[4] High shares of these nondispatchable generators can create challenges for system reliability and require back-up capacity that adds to total system cost. Deeper levels of RPSI can help address these issues through shared reserves and a larger, more diverse generating portfolio, which utilities can tap to meet their demand. Interconnections and resulting power trade can also spur renewable energy expansion by providing markets willing to pay premium prices for "green power" that is exported from one country to another. Trade can also bring economies-of-scale needed for large hydropower plants. In these ways, RPSI can act as an enabler for increased renewable deployment.

In a number of cases, enhanced RPSI has been an essential driver for hydropower plant development. Development and operation of NT2, Cahora Bassa, and Manantali, for example, all rest on successful interconnection and sales of power internationally. These relatively large hydropower schemes would have been too large to develop for their home country electricity markets alone. Both the host country of the plant and the importing country benefit from this arrangement.

However, the case studies do not give many examples of how enhanced RPSI has enabled the widespread deployment of other renewable energies. Perhaps, the case studies selected have not dealt with this issue so far. Or

[4] Hydropower can be a stable source of fully dispatchable electricity generation depending on hydrological regimes and water storage facilities.

there are other, more pressing barriers to widespread renewable deployment that can be addressed by enhanced integration. Nondispatchable renewable energy generation must reach a certain minimum percentage of the national generation mix before it poses any challenges to system reliability that could be alleviated by stronger and more robust interconnection and trade. Not too many developing countries have reached that level and may have to overcome other challenges (e.g., high cost, need for new regulations, insufficient local expertise) before greater integration can play an enabling role for renewables.

In the meantime, there are RPSI schemes on wind power integration in developed countries. PJM and UCTE are both actively researching problems integrating wind power. The experience gained from these sophisticated regional systems will help expand the use of new renewables in developing country regional schemes.

Findings

- With the notable exception of large hydropower projects, the case studies have not demonstrated RPSI to be a substantial enabler of renewable energy.
- Lessons for future RPSI design can be gleaned from managing the expansion of cross-border renewable energy flows in more closely integrated regional markets (notably UCTE/ENTSO-E).

ABBREVIATIONS AND ACRONYMS

ADB	Asian Development Bank
ASEAN	Association of South-East Asian Nations
CDM	Clean Development Mechanism
CO2e	Carbon dioxide equivalent
COMESA	Common Market for East and Southern Africa
DAM	Day-ahead market
DRC	Democratic Republic of the Congo
EAPP	East African Power Pool
EGCO	Electricity Generating Public Company (Thailand)
ENTSO-E	European Network of Transmission System Operators for Electricity
EPR	LaEmpresa Propietaria de la Red
Eskom	(South African electric company)
ESMAP	Energy Sector Management Assistance Program
EU	European Union
GCC	Gulf Cooperation Council
GDP	Gross domestic product
GHG	Greenhouse gas
GMS	Greater Mekong Subregion
GWh	Gigawatt hour
HCB	Hidroeléctrica de Cahora Bassa (Mozambique)
Hz	Hertz
IFI	International Financial Institution
km	Kilometer
kV	Kilo volt
LNG	Liquefied natural gas
MER	Mercado Eléctrico Régional
Mt	Megatonne
MW	Megawatt
NBI	Nile Basin Initiative
NT2	Nam Theun 2 (Laos)
NTPC	Nam Theum 2 Power Company
OECD	Organisation for Economic Co-operation and Development
PJM	PJM Interconnect, originally Pennsylvania, New Jersey, Maryland
PPA	Power purchase agreement
PSP	Private sector participation
REC	Regional Economic Community
RERA	Electricity Regulators of Southern Africa
RPSI	Regional power sector integration
SADC	Southern African Development Community
SAPP	Southern African Power Pool
SEE	South East Europe
SIEPAC	Central American Electrical Interconnection System
SOGEM	Société de Gestion du Barrage de Manantali (Mali)
SPV	Special purpose vehicle
STEM	Short-Term Energy Market (SAPP)
t	Tonne
TSO	Transmission system operator
UCTE	Union for the Coordination of the Transmissions of Electricity
US$	United States dollar
WAPP	West African Power Pool
WESTCOR	Western Power Corridor
WAPP	West African Power Pool

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Energy Sector Management Assistance Program
The World Bank
1818 H Street, NW
Washington, DC 20433 USA
email: esmap@worldbank.org
web: www.esmap.org