The promotion of regional integration of electricity markets: Lessons for developing countries

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Abstract

This paper focuses on how to promote electricity regional cooperation. We begin by discussing the theory of international trade cooperation in electricity, with a view to discussing what preconditions might be important in facilitating wide area trading across national borders.

We then develop lessons based on the comparison of four case studies. These include three regional developing country power pools – the Southern African Power pool (SAPP), West African Power pool (WAPP) and the Central American Power Market (MER). We contrast these with Northern Europe's Nord Pool. These cases highlight both the potential and difficulty of having cross-jurisdictional power pools.

In the light of the theory and evidence we present, we draw key lessons for other regions – such as the South Asia Region (SAR) – in the areas of: preconditions for trading; necessary institutional arrangements; practicalities of timetabling; reasons to be hopeful about future prospects.

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The promotion of regional integration of electricity markets: Lessons for developing countries

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1. *Introduction*

The problem of how to promote wide-area trade in electricity is a well-known one *within* individual countries. National electricity markets in advanced countries developed over time as initially local, vertically integrated distribution companies found that there were substantial cost and quality of service advantages to horizontal integration and interconnection between service territories. While some countries developed near monopoly generation utilities which made use of a national transmission system (e.g. France), other countries did develop (limited, but in some cases substantial) trading between continuing regionally vertically integrated utilities (e.g. Japan and the United States). The creation of a national or wide area electricity transmission system which is centrally dispatched has been key to the promotion of trade in electricity[2]. Such a system physically allows energy from different power stations to be directed towards supplying given electrical loads from a common 'power pool'.

Clearly physical interconnection is necessary, because without it no electricity can flow across pre-existing electrical boundaries. Traditionally countries have been very reluctant to trade electricity across borders and hence have limited the construction of cross-border transmission lines. This is actually unusual in energy. For 2012, globally exports of electricity are around 3% of total production, in contrast to c.52% for oil (and Natural Gas Liquids), c.31% for gas and c.17% for coal

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[2] See for example Foreman-Peck and Waterson (1985) who document the emergence of a national integrated transmission system in the England and Wales.

(with the average for all goods and services being c.31%)[3], suggesting that there may be substantial scope for increased trade in electricity across the world.

This paper will focus on the institutional arrangements for facilitating electricity cooperation. We begin by discussing the theory of international trade cooperation in electricity, with a view to discussing what preconditions might be important in facilitating wide area trading across national borders. Next we will introduce four case studies. Arguably, the most successful international power market in the world is Nord Pool (which includes Norway, Sweden, Finland and Denmark). We compare this with three regional developing country power pools – the Southern African Power pool (SAPP), West African Power pool (WAPP) and the Central American Power Market (MER). We then go on to draw key general lessons on the promotion of electricity trade across borders based on the theory and experience for other regions such as the South Asia Region (SAR) – namely Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka.

2. The theory of cooperation and international trade applied to electricity

In thinking about the institutional arrangements that might facilitate increased cross border trade in electricity, it is useful to think about ideal electricity market design and institutions. Hogan (1995) suggests that a wholesale pool spot market and an independent system operator (ISO) should go together. This is because short term generator dispatch and short term transmission system operation are 'two sides of the same coin' (Hogan, 1995, p.26). This suggests that power trading should be associated with an institution which is also responsible for the operation of the transmission system in real time. Hogan (1998) suggests that nodal pricing of the transmission system access is also desirable unless the networks are relatively simple. Thus the US Standard Market Design - which incorporates these ideas - may be the most sophisticated market design for wide area trading, but it may not be necessary for international trade in electricity.

Other designs may work, but the institutional design of markets is undoubtedly important. Stoft (1996) correctly predicted (prior to the California electricity crisis of 2001) that the institutional conflict between the California ISO and the California Power Exchange might decrease system reliability and lead to inefficient dispatch! Efficient market design is also about the participation of the demand side in the wholesale electricity market. This is increasing in importance in many of the most sophisticated markets, such as PJM and New York (see Walawalkar et al., 2010). For many countries demand side response inside their own country might be much cheaper at the margin than expanding international imports of power.

A key point about market design is the need for sufficient transmission capacity. Fursch et al. (2013), in their examination of the European Union (EU), suggest that cost optimal trading within the EU would require 76% more transmission capacity. It is important to note that transmission capacity is not just required at the border to facilitate cross border trading. Loop flows in the electricity system mean that the ability to export/import electricity across one transmission link is dependent on the

[3] See IEA Electricity Information 2014, p.II.3-II.4; IEA Oil Information 2014, p. II.33-II.41; IEA Natural Gas Information 2014, p.II.21-II.27; IEA Coal Information 2014, p.II.4-II.10; and UNCTAD Statistics for world exports and world GDP.

absence of congestion on other transmission lines, which may be internal to one or other country. Without sufficient transmission capacity cross border trade is going to be limited.

The degree of sophistication in markets may be limited when moving to cross border markets. Brunekreeft et al. (2005) note that locational marginal prices (LMPs) as recommended by Hogan and practiced in the PJM area of the eastern US may be desirable in the EU, but they are unlikely to be politically viable. This may explain why the EU has promoted market coupling between national markets and allow some merchant interconnection, rather than LMPs. Perez-Arriaga and Olmos (2005) suggest that the problem that LMPs try to solve in the US with 200+ control areas is much less in the EU with 17 to 27 control areas. Clearly having congestion constraints (and their associated prices) imposed internationally is difficult to sell to national politicians.

International trade is always mutually beneficial under the assumption of costless adjustment of factors of production (and the other assumptions of the Heckscher-Ohlin model of international trade). However this assumption of costless adjustment is not clearly satisfied when it comes to the sectors affected by electricity trading. While one might assume that factors of production in the electricity sector can be moved to other sectors (the capital, labour and materials employed in fossil fuel based power production are reasonably fungible), it is not so obvious for electricity intensive industries. These industries, such as mining, glass, chemicals, may be dependent on cheap domestic power. If increased power exports leads to rising domestic electricity prices, this may undermine their comparative advantage, necessitating wider (costly) factor allocation adjustment within the economy.

International trade in electricity may however alter the risk profile around electricity prices. This is a version of the 'energy security' problem. In theory if two countries begin trading electricity this will normally provide some insurance against large shocks to electricity prices. This will be the case where their domestic supply/demand risks are either independent or negatively correlated. However clearly there will be some imported price volatility and the possibility of a large supply/demand shock in one country inducing a large price effect in the other country, which it could have avoided under a no-trade (autarky) in electricity situation.

Over time, there is the possibility that dependence on imports of electricity might develop and domestic production facilities might close. This could expose an importing country to a hold up problem if the other country refuses to export. However, in reality these would seem to be second order (and manageable) risks associated with increased trade dependence. It is worth pointing out that such energy security risk is two – sided, as the exporting country might become equally dependent on the export revenue from electricity sales.[4]

Trade theory has become increasingly concerned with considering departures from the assumptions of the basic Heckscher-Ohlin model. Markusen (1981) showed that if markets were initially monopolised a large country opening up to trade might suffer a loss of welfare due to the competition from another monopolist in the other country in a two country trade model. However Lahiri and Ono (1996) show that this result does not hold if new firms enter. Trade liberalisation becomes beneficial again. The general result of Dixit and Norman (1986) emphasises that trade can

[4] We discuss the dependence of Bhutan government revenue on electricity export income in the final section. This surely makes them a more reliable supplier of electricity than would otherwise be the case.

always be made beneficial as long as consumption and income taxes can be used to compensate losers within an economy.

An important question in international trade theory is whether trade worsens the natural environment. This might be a concern for electricity trading where exploiting low cost resources might involve burning more coal in a low generation cost country. Antweiller et al. (2001) find that trade is generally good for the environment. This is because trade effects can be divided into three: an increased scale of activity; a composition effect on industrial structure; and an effect in improving technology. For a sample of sites in 43 countries over the period 1971-96, they find the scale effect worsens pollution by 0.25-0.5% for each 1% increase in GDP due to trade, the structure effect is neutral and the technology effect reduces pollution by 1.25-1.5%. This gives an overall positive effect on the environment due to trade. If wide area trading makes emissions control and the spread of low emissions technology more likely, then it is likely to be good for the global environment. In electricity, these positive environmental effects are highly likely as trading often allows the exploitation of low cost renewable resources (e.g. hydro power in Norway) or the sharing of nuclear power (e.g. from France).

It is also important to be clear that electricity trade is not always beneficial where international trading is imposed on top of inefficient national arrangements. De Villemeur and Pineau (2012) model the integration of electricity markets in two jurisdictions, one selling at average cost, the other with a competitive market and prove that the overall welfare result is worse than under no interconnection. According to the theory of the second best we would expect that the price setting mechanism in each of the connecting national markets would need to be similar for trade not to worsen the initial distortions in the markets. Clearly if one jurisdiction was selling electricity at below cost and another at its true (higher) cost the result of the joining of the two markets would worsen the impact of the initial price distortion in the jurisdiction with prices below cost. This is likely to be a particular problem in some regions with a history of energy subsidies.

International power pools are a fairly typical example of the opening up to trade of a previously non-traded commodity. The initial situation in many developing countries is that there are monopoly electricity suppliers in each country each charging below cost in order to stimulate electricity intensive economic activity. If trade were to raise prices in one country but not in another that would affect the distribution of electricity intensive industry between the two countries. Of course this effect is tempered by the fact that commercial and industrial electricity consumers value the reliability of electricity supply as well as its price (Oseni and Pollitt, 2013) and hence if trade were to improve supply reliability and increase price at the same time in a particular country then it is possible that more electricity dependent industry would be attracted to that country.

As noted above, distributional effects are important in considering whether to open up to trade. This is particularly true for electricity. First, low electricity price jurisdictions worry that electricity trading will raise prices for final consumers, while increasing the profitability of electricity producers. If ownership of electricity production is concentrated while electricity consumption varies less than proportionally with income then electricity trading with higher price regions may be blocked (as is the case in some states of the US (by states with cheap coal) and between France (low price) and the UK (high price)). Similarly in jurisdictions with cheap electricity for large electricity intensive industries, there may be a reluctance to export electricity at the expense of the trade dislocation caused by a potential reduction in electricity intensive manufacturing exports (e.g. Norway). Finon and Romano (2009) suggest that this could be dealt with by a windfall tax on hydro and nuclear producers (in the context of European countries), which could then be distributed to domestic consumers if necessary. These effects explain why high price jurisdictions are naturally keener on electricity trading with lower price jurisdictions than the other way round (see Joskow, 1997, on the United States).

As discussed above, electricity trading is likely to cause a redistribution of factors of production within countries. Energy intensive companies and industries (and their workers) in exporting countries are likely to object to an expansion of exports which leds to higher domestic electricity prices. Examples of energy intensive companies in South Africa (part of SAPP) which might object to power export led price increase are AECI, Harmony Gold Mine Company, Kumba Iron Ore Ltd, Consol Glass (pty) Ltd, Glencore, among others. These energy intensive firms account for 44% of South African's total electricity use and contribute about one-fifth of the country's GDP. There is evidence that South Africa's Energy Intensive User's Group (EIUG) – an association of high energy consuming firms – disagreed with the 16% a year tariff increase proposed by Eskom in its five year multi-year price determination (MYPD3) covering period from April 2013 to 2018.[5] An example of heavy electricity user in the West African Power Pool (WAPP) is gold mining industry in Ghana. Mining activities contribute more than 6% and 40% to the country's GDP and export earning respectively, and the country's four major gold mining companies (Goldfields, Anglo Gold Ashanti, Golden Star and Newmont) account for 13% of the country's electricity use (Würtenberger and Hassan, 2011). This suggests that an export-led increase in electricity price in the country may lead to substantial economic restructuring (e.g., downsizing) and can possibly generate a protest. In the Central American Power Market (MER), chemical and metal industries in Guatemala are examples of heavy electricity users which might oppose a cross-border trade led price increase. It is interesting to note that opposition to electricity exports is not limited to developing countries. There is also evidence that trade union within Norwegian energy intensive industry were opposed to renewable electricity exports (Gullberg, 2013). Such internal opposition to increased exports is likely to be one of the reasons for the low level of global exports of electricity.

Neary (2007) predicts that trade liberalisation in a particular sector will also lead to low cost firms in the country with comparative advantage in a sector taking over the similar high cost firms in the other country. This is likely to raise welfare in aggregate, but it raises profitability for producers in the low cost country at the expense of consumers generally. Neary predicts merger waves resulting from trade liberalisation (subject to capital market liberalisation). Indeed this is clearly what has been seen in the electricity sector in Europe as a result of successive efforts on the part of the EU to create a 'single electricity market' (see Jamasb and Pollitt, 2005). This may not be a problem for the distribution of welfare internationally, as long as domestic shareholders can realise the benefit of the merger at the time of asset sale, however if there is capital market inefficiency this may not be the case.

International trading of wholesale power is more valuable when the price of power fluctuates seasonally or across the day at individual locations due to weather fluctuations (Bahar and Sauvage,

[5] See ESI Africa Magazine: SA's energy intensive users helping protect against blackouts, June 14, 2014. Available at http://www.esi-africa.com/sa-s-energy-intensive-users-helping-protect-against-blackouts/ Accessed 15 July, 2015.

2013). This means that trade will occur between countries even where their average pre-trade prices are the same. The rise of renewable energy in some countries adjacent to each other makes such trade more valuable. However it does put pressure on the physical characteristics of the system. Electricity is not a typical arbitraged product, because it has several dimensions of quality including voltage and frequency, in addition to energy (power). What is needed is a market operation regime which adequately accounts for the need to maintain power quality in the face of energy price fluctuations. A good example of how important this is was the incident which occurred on 4th November 2006 when a problem in Northern Germany (a ship hitting a power line) caused blackouts in southern Europe (and other places)[6]. Market integration meant that one of the German system operators created a power quality externality, which the Spanish grid operator failed to manage successfully.

Where there are multiple countries seeking to reach an international trading arrangement there may be additional negotiation issues. One of the parties may block the agreement in an attempt to increase its share of the benefits. If it does so excessively or in a way that may set a precedent for other international agreements between the parties this may lead to the agreement not being reached. There are obvious ways to handle this, such as using Shapley values which look at the value to the coalition of an additional member[7]. However there is a real problem where side payments between regions must be made. If these are politically difficult to enforce then this may prevent agreement.

Gately (1974) looks at the benefits from electricity cooperation between three Indian regions – Tamil Nadu, Andra Pradesh, Kerela-Mysore (KM). He finds that there are substantial benefits to all three regions cooperating in terms of reduced operation costs of their three power systems. However KM always has higher costs in any bilaterial or trilateral agreement. The rise in KM's costs are substantial (x3) as it exports its cheap hydro to other states, but costs in aggregate fall by 20%. Gatley shows that the order of joining the agreement may influence the value which an individual party can extract from agreement. He also notes that states may not just value the reduction in costs, but also care about the loss of jobs in the electricity sector as in state costs fall. The question for market arrangements put in place is therefore whether the market allows individual nations to capture a fair share – both in the national and overall sense – of the benefits to the cooperation. This may be a particular problem where a transit state which hosts a transmission line does not actually import or export much electricity from it. Compensating this state fairly for its participating in the international agreement may be subject to these sorts of issues.

Coordination of adjacent electricity systems under a single system operator could bring significant benefits in terms of congestion management. Kunz and Zerralin (2013) analyse congestion costs within Germany under the current regime of 4 separate transmission system operators (TSOs) versus a single German TSO. For a model calibrated to 2011, they find congestion costs of €30.36 m under full coordination versus €179.56 m under the current approach. They conclude that having four TSOs will become increasingly expensive relative to having a single TSO as the amount of intermittent generation increases.

[6] See UCTE (2007).
[7] See Hart (2008). Also, see Bigerna et al (2015) who discuss market power in regional markets.

Kogut (1988) makes a general point about joint ventures which is relevant to power markets. He notes that the pooling of resources in a joint venture (in this case a regional power market, where the participants are countries and their firms) may not be just about transaction cost savings or strategic advantages. It may be about the benefits of tacit knowledge transfer. Agreeing to participate in a wide area power pool is a good way to learn about other markets and to benchmark against best practice for any individual firm, beyond a simple cost benefit comparison against the current national arrangements.

Amundsen and Bergman (2007) discuss how prices across the Nord Pool area seem to be well integrated and vary according to underlying resource constraints. A particularly successful test of the Nord Pool system occurred in 2002-03 when a significant shortage of hydro capacity in Norway led to a severe price spike. Amundsen and Bergman (2006) note how the market coped well with this supply shock, maintaining political support. They suggest that the stakeholders involved understood that allowing market clearing prices to be high encouraged long term investment and that associated financial markets (which allowed hedging) also helped. This highlights how any international power pool needs to be able to withstand the inevitable stress tests that will come. In particular there needs to be confidence in the price determination process and a willingness to understand that a supply shock in one country will need to be supported by higher wholesale prices in connected markets. Thus temporarily high prices are an important price signal and represent a payment for mutual insurance.

The perception of the fairness of the regional market may be very important in extending international trade in electricity. Dickson and Kalipurakal (1994) suggest that the idea that competitive market determined electricity prices are always 'fair' is only one of several potential concepts of fairness in market transactions. Specifically, the idea that if there is scarcity, scarcity prices should be charged to everyone may be one that is difficult to accept (or to explain to a national electorate). Interestingly, Dickson and Kalipurakal find that the market traders in the US that they survey are generally happy with market determined prices (rather than the alternative of Dual Entitlement where prices go up if costs go up and do not go down if costs go down). This may not be true of electricity consumers (or their elected representatives) in general. CEER (2012, p.46) note that retail end user price controls continue in 16 out of 27 EU countries in spite of legislation aimed at creating a single electricity market with fully market determined wholesale and retail prices.

When it comes to the benefits of wide area markets there is a lot of concern about the exercise of market power, particularly if competition policy enforcement is weaker internationally than it is domestically. In the European Union, which has pan-European competition policy and enforcement, this is not a big issue. However in other regions, such as SAR, if the market design gave rise to the exercise of market power this would be an issue. Market monitoring within wide area markets is an important activity to ensure that the market is behaving as intended.[8]

Von der Fehr and Harbord (1998) look at different types of markets which may deviate from the perfectly competitive outcome: capacity constrained markets with Bertrand competition; collusive oligopolies in repeated games; supply function equilibria; and auction approaches. Clearly there is a worry about gaming, especially between countries within regions. Changing the nature of

[8] See Goldman et al. (2004) who discuss five case studies where market monitoring was important.

competition, by extending the market, may change the current behaviour of players within existing markets. Similarly, Neuhoff and Newbery (2005) discuss how the move to integrated markets could initially lead to higher prices until enough competition emerges to definitely lower prices.[9]

There is a question of whether existing independent power producers (IPPs) will individually participate in a power market or form a coalition (or merge) to get a higher price. Jia and Yokoyama, (2003) use Shapley values to investigate whether an IPP would be better off participating individually in a power market or via a coalition. Ferrero et al. (1997) however show theoretically that if power pools are big enough selling into them at marginal cost (and participating in a 'grand coalition') may be better than deviating and not participating in the power market. This modelling suggests that if the international power pool is big enough the gains for an individual country from participating may become bigger than refusing to participate (the EU Single Electricity Market project, may be a good example of this).

Market power is not necessarily limited to incumbent generators in an international power market. National system operators may also exercise market power. System operators manage congestion on their networks and the transmission constraints behind them represent significant barriers to electricity trading (Kumar et al., 2005), as mentioned above. However they are under national incentive schemes to minimise internal congestion within their control areas. Under international trading they may have incentives to shift transmission constraints to international interconnectors to reduce constraints within their own country, reducing the benefits of international competition. The Swedish transmission system operator was recently subject to anti-trust action by the European Commission for doing this within Nord Pool.[10]

While power markets are good for short term competition and efficiency there is an issue with whether they induce optimal long term planning. Kagiannas et al. (2004), note that generation expansion planning is evaluated differently if done by several competing firms (or countries), than if done by one monopoly firm. They note that the scope for mistakes to be made in aggregate may be increased by increasing the number of firms in the market.

Hobbs et al. (2005) estimates the benefits of Netherlands - Belgium market coupling to the Belgian market using a transmission-constrained Cournot model. The study projects social surplus improvements on the order of 200m €/year, assuming market coupling does not encourage the largest producer in the region to switch from a price-taking strategy in Belgium to the Cournot strategy due to a perceived diminished threat of regulatory intervention. However benefits would be higher if transmission capacity was increased to allow the competitive baseline to be achieved.

In the context of the EU the impact of reducing market power, through more effective competition, is potentially very significant. Lise et al. (2006) show that for a simulation of 8 EU countries in 2000 moving from a situation of strategic competition to perfect competition would reduce profits substantially. In their analysis the profits of EdF and Electrabel (the incumbent generators in France and Belgium) would fall by one third. This implies the importance of having enough transmission capacity to promote competition and of the monitoring of the competitive behaviour of market

[9] This was the initial experience within the England and Wales power pool where competition took 8-10 years to fully mature (see Newbery, 2005).
[10] See http://ec.europa.eu/competition/elojade/isef/case_details.cfm?proc_code=1_39351, Accessed 15 July 2015.

players. In the case of developing countries, international trade requires adequate transmission capacity and mutually beneficial pricing arrangements, even if neither are fully optimal.

3. *Case studies of cross jurisdictional electricity trading*

In what follows we contrast three developing country power pools (Southern African Power Pool – SAPP; West African Power Pool – WAPP; and the Central American Power Market - MER) against Nord Pool. The developing country power pools are chosen because they represent serious international attempts to allow groups of countries to benefit from potentially beneficial trade. Nord Pool represents a global benchmark for international trading and has been used with the EU as an exemplar of how to create a single electricity market.

In Table 1 we outline the development history and the institutional features of each. We compare what happened to facilitate trade; the nature of the trading platform; what institutions were set up to support it; the governance of these institutions; the practical steps to implementation; and the concrete evidence on the benefits of trade. The case studies are not all successful and some took many years (more than might be thought necessary) to reach fruition.

[Insert Table 1 here]

In Table 2 we report some statistics which illustrate the extent of the cross border trading associated with each of our case study power pools in 2012. Year 2012 represents a typical year because trading performance of the pools this year does not vary significantly from those of other years (see Appendix 1). The table shows the proportion of cross-border electricity trades to interconnector capacity (transmission capacity) and total electricity consumption in some selected countries across various Power Pools. Data on annual electricity consumption and trade were converted from kWh to MW for them to be in the same units as interconnector capacity. Conversion was done by dividing the annual data on each variable in kWh by 1000*24*365. The results as reported in the table indicate that a lot more trade takes place in Nord Pool and in SAPP than in the other power pools. For instance, while the interconnection capacity utilisation are respectively 39% and 50% for Nord Pool and SAPP, WAPP and MER record just approximately 9% and 4% respectively. Similarly, the proportions of cross-border trade to consumption are 28% and 21% for Nord Pool and SAPP respectively, whereas in WAPP and MER trade is only 5% and 2% of their consumption. It is worth noticing that while SAPP appeared to have utilised its transmission capacity (50%) more than the Nord Pool (39%), Nord Pool has traded more of its consumption (28%) than the SAPP (21%). This is likely to be because transmission capacity is less optimally sized in SAPP than in Nord Pool preventing the sort of profitable peak trading that is possible in heavily interconnected markets.

The performance of SAPP does stand out relative to other developing countries' power pools. The reason for SAPP's success might be because of the (excess) existing generation capacity in South Africa which makes trading possible. Unlike the WAPP whose installed capacity stood at only 9,705MW as at the time it was formally created, Southern African Power Pool (SAPP) installed capacity at inception in 1995 was 48,461 MW, with about 38,000 MW in South Africa alone. Similarly, SAPP was created many years before other pools in developing countries - e.g. WAPP was established in 2000/2001. Those extra years of existence were used to develop the power pool –by developing and upgrading international transmission links - in order to promote trading within the pool.

[Insert Table 2 here]

4. *Key policy lessons from the case studies*

This section highlights the lessons learned from the various trading arrangements discussed in this paper. We organise these under a number of key headings.

Pre-conditions for international electricity trade

Both expanded bilateral power trading and more formal power pools require a broader pre-commitment to free trade to be successful.

Electricity is just one commodity that could be freely traded across borders. It is not clear that it can be traded easily without a prior commitment to the creation of a free trade area. The existence of a regional trade agreement can aid regional electricity trading in several ways: the existence of a regional trade regime reduces/removes possible trade barriers to regional power market and reduces planning time as most of the rules and regulations necessary for regional trading would have been established. However there is still a need for specific trade agreements to support electricity trade. This is partly because WTO rules do not adequately address trade in electricity, because it combines goods (production) and services (transmission), and involves other policy objectives to do with the environment and energy security.[11]

Free trade arrangements between countries lead to the establishment of the trust required to promote the development of a regional power pool. SAPP, WAP and MER are clearly being promoted within a wider trade development context. Thus, SAPP is an offshoot of the Southern Africa Development Community (SADC) while WAPP is a subsidiary of the Economic Community of West African States (ECOWAS). The existence of regional trade might be the reason why bilateral power trades can thrive even before an advanced power pool is achieved.

Our case studies are consistent with the hypothesis that greater trade openness leads to more cross-border trade in electricity, even keeping the potential gains from trade constant.

The existence of a common currency is *not* a pre-condition for an effective functioning electricity market. Although a common monetary unit does help facilitate trade because it signals deep trade integration, this is not necessary and fully functioning cross border electricity markets can exist in the presence of multiple currencies (as is the case in all four of our case studies).

[11] For a discussion see: http://www.wto.org/english/res_e/publications_e/wtr10_forum_e/wtr10_7may10_e.htm Accessed 15 July 2015.

Similarly, it should be pointed out that institutions of competition policy enforcement across a free trade area are not necessary for power pools to develop and function effectively (they don't exist for the SAPP or MER countries). However, such institutions are a sign of deep trade integration – such as in the EU – and do act as regulators of mergers and market power in cross jurisdictional power pools (such as across Nord Pool).

It almost goes without saying that for trade to occur, there must be a price differential between the potential parties to the trade. This implies that there must be a relatively low electricity price country, where the unit value of electricity exports to the relatively high price country is greater than the willingness to pay for a unit electricity consumption within the low price country. In many countries of WAPP this is not the case, in the sense that the price an importing country (e.g. Ghana) would be willing to pay for a kWh is less than the willingness to pay of demand for a kWh within the potential exporting country (e.g. Nigeria). In theory this country should be exporting only after satisfying its latent domestic demand. This fact may explain the slowness of the development of international interconnection from countries with favourable export potential.

Adequate transmission capacity is essential for power trading to occur. Thus, agreements for expanding transmission capacity are integral to the development of an international power pool.

A generalised commitment to free trade is not enough to promote the development of a fully functioning cross-jurisdictional power pool, with a single market price. The development of WAPP beyond bilateral trading has been prevented by a lack of transmission capacity. Lack of transmission capacity has not prevented the emergence of spot markets in MER or SAPP but has severely limited their significance and explains the prolonged dominance of bilateral trading. By contrast in developed regional power pools such as Nord Pool there has been a significant amount of transmission capacity which has supported the development and operation of more effective power pools. While our case studies suggest power markets can come before the development of interconnection (e.g. in the case of MER), they can only be significant in the presence of sufficient interconnection.

However 'cross border' investments in transmission capacity did occur to a limited extent historically where there were sufficiently large bilateral gains relative to the cost of transmission expansion (i.e. large price differentials which can be arbitraged by relatively short distance wires). This explains the existence of some transmission capacity between jurisdictions within all of our case studies, prior to the formation of the power pools we discussed. The expansion of this initial transmission capacity - to the extent that it has occurred – has been supported by feasibility studies which have attracted multilateral agency finance. MER, WAPP, SAPP have all been financed by international development agencies (IADB, World Bank and AfDB).

Good Institutional Arrangements

The role of strong, efficient and independent institutions in ensuring an effective functioning integrated power market cannot be over-emphasised.

An integrated power pool needs an efficient operator who can oversee and sanction the activities of market participants in order to prevent predatory pricing, non-disclosure of capacity, and other forms of unruly behaviour. Cross-border institutional arrangements are essential, but can take a variety of forms. WAPP and SAPP are international arrangements for electricity exchanges which lack overarching regulation, and SAPP has been successful. While the strength of the institutional arrangements governing cross-border trading is undoubtedly limited if it is cross border, it clearly is possible to build strong cross-border power markets (as recently demonstrated by MER).

Getting the appropriate combination of regulation and market design for power pools is important.

While a new cross border regulatory agency is not necessary, some regulatory oversight is beneficial. SAPP could have benefited from some regulation of Eskom's potentially predatory pricing behaviour. Nord Pool and MER are subject to some form of external regulatory oversight. Cross-border electricity markets within the EU are subject to the jurisdiction of the European Commission, which regulates EU wide competition. Market design may be important for reducing the need for cross-border regulatory enforcement action. For instance, price based (rather than cost based) bidding might involve large distributional transfers and potentially significant welfare losses. The price determination process should both be based on underlying economic cost and take account of the potential for market power and the existing pricing inefficiencies within the trade partners. Clearly disputes about price determination are potentially more difficult to resolve in a cross-border market than in a national market and hence should be avoided.

Countries may have rational reasons to wish to mitigate the price risks associated with electricity market integration. Small countries faced with increasing their exposure to foreign sources of electricity price volatility may be unwilling to have much exposure to short term international market prices and prefer most trades to occur under long term contracts at fixed prices. This may explain the lack of trading in the short term day-ahead market (DAM) of SAPP and the preference for bilateral contracting in both SAPP and MER. Clearly as long as the price determination process for long term contracts is reasonably efficient then this may not be a problem and the market participants should decide the mix of contract terms under which electricity is exchanged.

The use of day-ahead markets and/or real time markets facilitates more trade and greater market efficiency.

Day-Ahead/real time trading leads to more competition than in bilateral arrangements and therefore results in more efficient utilisation of resources. The bidding mechanism in day ahead/real time market tends to make suppliers more efficient in order to keep their marginal costs as low as possible since they can be bid out of trade/market if they bid too high price. A day ahead/real time market is more flexible and does more to facilitate trade than bilateral arrangements alone. This seems to be in line with the experience of MER (where most trade is bilateral) vs Nord Pool (where there are effective real time markets). Efficient short term prices should act to guide the more efficient determination of long-term contract prices.

<u>How to ensure timely development</u>

There can and should be a timetable for reform and development.

Developing and keeping to a timetable are essential for the rapid development of an integrated power market. It is necessary that agreeing parties design a timetable with clear objectives and details of the procedures or processes required. This would allow them to keep track of their progress as well as having a definite focus. In each of our jurisdictions a timeline of development can be identified. The setting of a clear timetable, for each stage of market development, seems to have been instrumental in the development of Nord Pool.

There can be an important role for international organisations to facilitate the creation of power pools.

The creation of a regional power pool requires substantial investments in building and updating generation capacity, transmission networks, and human development. All four of the international power markets we look at have received significant external development support and financing (e.g. from the AfDB, IADB and the EU). The support levels are significant (50+% of the funding for the SIEPAC project within the MER came from the IADB)[12]. Thus, the evidence is that the sustained support of international organisations or foreign capital (as bilateral aid or development finance) is required.

In SAPP there is a significant gap between bids for electricity to be traded and actual traded volumes in DAM (only around 25% of bids were actually traded in September 2013)[13]. This gap is due to transmission constraints. Similarly, the slow development of trading in the WAPP was partly caused by lack of adequate funding required to embark on massive infrastructural developments necessary for effective trading arrangements, although they do receive foreign support. WAPP might have developed more quickly if an international organisation had fully taken charge of the creation and development of the WAPP for a possible hand-over to the member countries at a later date.

Clearly sovereign countries *may* be reluctant to cede control of the project to an international agency, but the fact is that the MER countries have been willing to do this.

The viability (or otherwise) of an international power pool should be assessed in advance by a careful cost-benefit analysis.

Clearly any major policy change should be subject to an impact assessment. This is particularly true of electricity markets which lend themselves to modelling. This assessment can provide a quantification of likely benefits and identify the need for any side payments to countries who facilitate trade but do not directly benefit (this was a particular issue in the SIEPAC case). Also, fuel costs may be reflected more quickly in power prices in an international power market, than in a managed national market. This can expose wholesale electricity price dependent customers to significant variability in prices. Modelling would expose whether such volatility is likely to be higher or lower with an integrated market.

Power pools can (and should) start with a small number of countries and grow over time.

The EU experience also suggests that regional power markets – involving just 2 or 3 parties- might be a good place to start on the road to full market integration. Nord Pool became an international power market by expanding from Norway to include Sweden in 1996 (it now covers trades between 9 countries). Indeed, the most integrated markets are those that have grown organically rather than

[12] See http://www.iadb.org/en/news/webstories/2013-06-25/energy-integration-in-central-america,10494.html Accessed 15 July 2015.

[13] See SAPP (2013).

those that deliberately started with a large number of jurisdictions. The slow growth of WAPP may be a function of the large number of participating countries – 14 - at the beginning. Starting small means that large gains from trading can be demonstrated and that new parties willingly opt in to an existing working arrangement. This would seem to offer more chance of steady deep progress, rather than prolonged initial development periods and thin trading.

Reasons to be hopeful about the prospects for international power trading in other regions, such as SAR

Trust building around electricity trading is possible even between countries with a history of conflict.

Our three developing country case studies are drawn from troubled regions. The nature of the trouble was not necessarily at the border but sometimes internal conflict (with SAPP and MER). This did represent a potential source of supply risk for international partners. However in the case of SAPP there have been actual cross-border conflicts in the past. Often electricity trading - by reinforcing mutual interdependence - can be a significant positive outcome for the conflict resolution process.[14]

The potential gains within the South Asian Region (SAR) from cross-border electricity trade are large.

ESMAP (2008) discusses the nature of the gains from increased energy trading in the South Asia Region (SAR). The SAR countries are part of a free trade area – SAFTA (South Asian Free Trade Area, formed in 2006) – and currently have very little cross-border trade in electricity but exhibit significant potential for beneficial trade. This report discusses the bilateral (and multilateral) electricity trades that might be mutually beneficial within the region. Of these, six are relevant to our initial list of eight SAR countries: Pakistan-India and Pakistan-Afghanistan; Bhutan-India; Nepal-India; Bangladesh-India; India-Sri Lanka; and Bangladesh, Bhutan, Nepal and India multilateral trade.

The ESMAP report discusses the absence of electricity interconnection between Pakistan and India and the difficulties of interconnecting Pakistan with Afghanistan, suggesting that the gains from trade are modest. Bhutan-India is the one electricity trade success story in the region, with Bhutan deriving significant government revenue from the export of hydro based electricity to India. In 2010 Bhutan exported 5.4 TWh (or 75% of its production) to India. Nepal-India has the biggest unexploited trade potential. Nepal has 43 GW of identified economic hydro capacity, and an installed capacity of just 721 MW in 2010[15]. Much of any hydro capacity could be exported to India, but Nepal net *imports* of 0.8 TWh (with production of just 3.6 TWh) in 2012[16]. Bangladesh-India electricity trade is also at a very low level in spite of good prospects for the export of gas based generation from Bangladesh to India (0 TWh of reported exports, out of production of 49 TWh in 2012)[17]. In spite of considerable under-utilised hydro resources in Sri Lanka and a mere 30 km of sea to India, there remains no interconnection between the two countries.

[14] We discuss positive electricity developments on the island of Ireland and in South East Europe in Oseni and Pollitt (2014).

[15] Source of recent electricity production, import and export figures: CIA The World Factbook. Available at https://www.cia.gov/library/publications/the-world-factbook/index.html.

[16] IEA Electricity Information 2014, p.III.6.

[17] IEA Electricity Information 2014, p.III.6.

In terms of a regional electricity market, there would seem to be a lot of potential for a joint Bangladesh, Bhutan, Nepal and India market, aimed at exploiting the considerable hydro potential of Bhutan and Nepal. Studies carried out by USAID under its SARI-E program[18] identified relative low cost transmission investments ($9m to $52m at the time) which would significantly increase cross border transmission capacity in the north east border region of India and its three neighbours.

Chattopadhyay (2013) quantitatively examines the high benefit to cost ratios across three potential cross border links within the SAR: India-Sri Lanka, India-Bhutan and India-Nepal. The major sources of benefit are avoiding unserved energy, operational cost benefits and capacity benefits, when measured using an investment planning and optimisation model. These benefits are $1.8bn p.a., against one-off transmission line costs of $700m. Chattopadhyay does not discuss the distributional impacts and why the links are not already built if they are really so beneficial.

Clearly if such large potential gains from electricity trade exist it would be worth understanding what barriers stand in the way of electricity trade across regions, such as the SAR, and how they can be overcome. However the lessons from our four case studies offer clear guidance on developing the right pre-conditions, setting up appropriate institutional arrangements and how to organise the process of building a successful international power pool.

[18] See: http://www.sari-energy.org/

Table 1: A Comparison of Nord Pool, SAPP, WAPP and MER

	Nord Pool	SAPP	WAPP	MER
Countries currently involved	Austria, Belgium, Czech Republic Denmark, Estonia, Finland, France, Germany, Italy, Latvia, Lithuania, Luxembourg, Netherlands, Norway, Poland, Russia, Spain, Sweden, UK	Angola, Botswana, Democratic Republic of Congo, Lesotho, Malawi, Mozambique, Namibia, Swaziland, South Africa, Tanzania, Zambia and Zimbabwe	Benin, Côte d'Ivoire, Burkina Faso, Ghana, Gambia, Guinea, Guinea Bissau, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leone and Togo	Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua and Panama
Date of Formation	1993	1995	2000	1998
Notable milestone dates	1991: Norwegian market deregulated. 1993: Nord Pool established by Norwegian TSO. 1996: Sweden joins. 1998: Finland joins. 2000: fully integrated as Denmark joins. 2001: Market surveillance established. 2000: Nord Spot market established. 2005: Day-a-head and Intra-day markets opened in Germany. 2009: Market coupling of 11 European countries launched. 2010: Bidding area in Estonia. 2011: Intraday market in Belgium and the Netherlands.	1980: Regional integration, Southern African Coordination Conference (SADCC) created. 1992: Southern African Development Community (SADC) established. 1995: Inter-governmental memorandum of understanding signed and SAPP introduced. 2000: Permanent secretariat established in Zimbabwe capital city, Harare. 2001: Short-Term Energy Market (STEM) introduced. 2002: Post-STEM (Balancing Market) introduced. 2006: Revised Inter-governmental	1975: Regional Economic Integration, Economic Community of West African States (ECOWAS), created. 1999: Article of agreements signed. 2000: Creation of WAPP. 2006: Article of agreements revised. 2012: Commissioned Mercados Energy Market International to design and develop the market models and rules for power exchanges.	1976: First Interconnection line built between Honduras and Nicaragua. 1979: Governments agreed to create Central American Electrification Council (CEAC). 1987: Initial feasibility study on the creation of the Central American Electrical Interconnection System (SIEPAC). 1989: CEAC established. 1996: Marco Treaty of the Electrical Market of Central America signed. 1998: Marco Treaty ratified. Economic-technical study of SIEPAC carried out. 1999: Regional

	2012: Bidding area in Lithuania. 2013: Bidding area opened in Latvia. Intraday introduced in Latvia & Lithuania.	memorandum of understanding (IGMOU). 2009: Day-Ahead Market (DAM). 2010: Energy Imbalance Settlement. 2013: Ancillary Services Charges.		transmission line company (EPR) incorporated. 2000: Regional electricity market regulator (CRIE) established 2001: Regional electricity system and market operator (EOR) established. 2002: New tie-line between Guatemala and El Salvador completes interconnection of all six countries. 2002: MER begins operation after Transitional Regulations for the Regional Electricity Market (MER) was finalized by CRIE and signed by the governments. 2005: Central American Free Trade Agreement (CAFTA) signed into US law. 2006: Construction of the SIEPAC transmission line begins. 2008: Initially planned completion date for SIEPAC line missed. 2013: SIEPAC transmission line completed.
Institutional Oversight	- Board of directors - Management	- SADC Directorate of Infrastructure &	- The General Assembly. - The Executive	- The Regional Regulator (CRIE). -The Regional

	team: CEO, business development, markets & operations, finance, legal & market surveillance, IT, communications.	Services. - Executive Committee - Management Committee: Environmental, market, operating & planning sub-Committees, &Coordination Centre Board.	Board (EB). - The Organisational Committees: Engineering and Operation, Strategic Planning, Finance, Human Resources.	System Operator. - Government Steering Committees: The Group director, technical consultant, Programming and Evaluation (CPE), Advisory panel.
Markets (with dates)	2000: Spot market established. 2005: Day-a-head & Intraday introduced. 2009:Market coupling launched. 2010-2013: More bidding areas & intraday markets introduced.	Pre-2001: Bilateral trading. 2001: Short-Term Energy Market (STEM) introduced. 2002: Post-STEM (Balancing Market) introduced. 2009: Day-Ahead Market (DAM). 2010: Energy Imbalance Settlement. 2013: Post-Day Ahead Market (PDAM). 2013/14: Ancillary Services Charges.	Yet to resume market operation at pool level. Current power exchanges are based on bilateral contracts not guided by WAPP.	Pre-2002: Bilateral trading 2002: Spot market introduced.
Key features	Extensive physical and financial integration of power markets, within context of EU single electricity market.	Extensive integration driven by surplus power from South Africa's Eskom to its neighbours.	Slow development of regional power trading since its formation, due to lack of transmission links and shortage of generation.	Eventual building 1200km SIEPAC transmission line with 300 MW capacity after many years of planning.
Overall trade agreement	European Union / European Free Trade Area	Southern African Development Community (SADC) region	ECOWAS Free Trade Area	Members plus Mexico and Colombia
International sponsors	EU	Donation from The Government of Norway (NORAD), Sida (Sweden), World	African Development Bank (AfDB), European Investment Bank	Inter-American Development Bank (IDB), the Spanish government,

		Bank, African Development Bank (AfDB), USAID, DFID (UK), and others.	(EIB), NEPAD-IPPF, USAID, Nordic Fund, Danida and Danish Mixed Credit, and others.	Central American Bank for Economic Integration (CBEI).

Sources:

NordPool Spot History: http://www.nordpoolspot.com/About-us/History/

SAPP: Beta (2013) – Overview of SAPP, http://www.usea.org/sites/default/files/event-/SAPP%20Overview.pdf

WAPP: http://www.ecowapp.org/; http://www.ecowapp.org/?page_id=366

MER: See Zarnikau et al. (2013).

Table 2: Share (%) of Trade in Electricity Consumption and Transmission Capacity in Selected Countries by Pool (2012 Data)

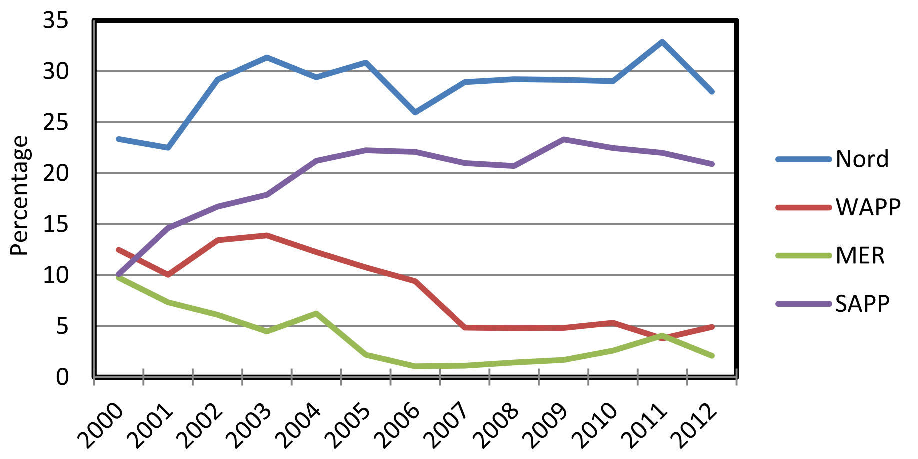
Selected Country	International Transmission cap. (MW)	Installed National cap. (MW)	National Electricity consump (MW)	Exports (MW)	Imports (MW)	Total Cross border trade (MW)	Trade as % of transmission cap.	Trade as % of consump
	(1)	(2)	(3)	(4)	(5)	(6)=(4)+(5)	(7)=(6)/(1)	(8)=(6)/(3)
Nord Pool								
Norway	5395	30180	14703.2	1,974	390	2,363	43.8	16.1
Sweden	11825	36510	15353.9	1,679	1,455	3,135	26.5	20.4
Finland	3310	16680	9960.0	381	1,839	2,220	67.1	22.3
Denmark	6405	13710	3915.5	1,297	1,463	2,760	43.1	70.5
Estonia	1941	2751	877.4	264	156	420	21.6	47.9
Latvia	2084	2166	778.8	242	530	772	37.1	99.2
Lithuania	2714	3820	1097.3	754	645	1,399	51.5	127.5
Total	**33674**	**105817**	**46686.1**	**6,591**	**6,479**	**13,070**	**38.8**	**28.0**
West African Power Pool (WAPP)								
Ghana	627	1985	650.9	28.4	49.7	78.1	12.5	12.0
Nigeria	855	5900	2192.9	0.0	0.0	0.0	0.0	0.0
Senegal	100	638	158.0	0.0	0.0	0.0	0.0	0.0
Cote d'Ivoire	327	1222	368.8	88.1	0.0	88.1	27.0	23.9
Total	**1909**	**9745**	**3370.7**	**116.6**	**49.7**	**166.2**	**8.7**	**4.9**
Central American Power Market (MER)								
Guatemala	300	2745	812.2	15.1	0.9	16.0	5.3	2.0
El Salvador	300	1491	533.8	0.8	4.3	5.1	1.7	1.0
Honduras	300	1701	536.1	0.0	1.3	1.3	0.4	0.3
Nicaragua	300	1108	293.3	0.0	7.3	7.3	2.4	2.5
Costa Rica	300	2800	920.5	8.8	23.2	32.0	10.7	3.5
Panama	300	1976	590.2	14.3	1.0	15.3	5.1	2.6
Total	**1800**	**11821**	**3686.1**	**38.9**	**38.1**	**77.0**	**4.3**	**2.1**
Southern African Power Pool (SAPP)								
DRC	260	2437	684.6	218.7	0.7	219.4	84.4	32.0
Zambia	1400	1679	1008.9	30.6	25.3	55.9	4.0	5.5
Mozambique	5800	2428	1159.8	1,349.3	945.0	2,294.3	39.6	197.8
Botswana	1450	132	302.3	0.0	249.0	249.0	17.2	82.4
South Africa	2050	44260	24554.8	1,616.4	1,206.6	2,823.1	137.7	11.5
Lesotho	230	76	35.1	0.0	28.2	28.2	12.3	80.5
Namibia	750	508	415.0	10.4	287.6	298.0	39.7	71.8
Total	**11940**	**51520**	**28160.4**	**3,225.5**	**2,742.4**	**5,967.8**	**50.0**	**21.2**

Data Sources: CIA: The World Fact Book https://www.cia.gov/library/publications/the-world-factbook/index.html
International Renewable Energy Agency, IRENA (2013) WEST AFRICAN POWER POOL: Planning and Prospects for Renewable Energy.
http://www.irena.org/DocumentDownloads/Publications/WAPP.pdf
International Renewable Energy Agency, IRENA (2013) SOUTHERN AFRICAN POWER POOL: Planning and Prospects for Renewable Energy.
http://www.irena.org/DocumentDownloads/Publications/SAPP.pdf

Appendix 1: Annual shares of Trade in Electricity Consumption by Power Pool (based on Table 2)

Figure A1 shows the share (%) of trade (imports + exports) in electricity consumption from 2000 to 2012. The Figure shows less variation in the proportion of cross-border trade in consumption for most of the years. The exceptions are WAPP and MER whose shares of trade in consumption shrunk considerably between 2000 and 2008 and between 2005 and 2009, respectively. The reason for this might be connected with the inability of member countries to satisfy their rising domestic energy demand which posted serious challenges to cross-border exchanges. For instance, Nigeria recorded some electricity exports between 2000 and 2004 but became a non-exporting country afterwards. Similarly, Cote d'Ivoire's electricity exports fell by approximately 54% between 2006 and 2010. The period between 2005 and 2009 experienced drops in exports by all the MER countries, reflecting the impacts of rising domestic needs in the face of constrained generation.

Figure A1: Share (%) of Trade in Electricity Consumption by Pool - selected countries



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