POLICY DIALOGUE ON

RENEWABLE GENERATION AND REGIONAL POWER TRADE IN AFRICA

READING FOR SESSION #4

REGIONAL POWER TRADE AND BILATERAL CONTRACTS

AFRICAN SCHOOL OF REGULATION

AFRICAN SCHOOL OF REGULATION

Policy dialogue on

RENEWABLE GENERATION AND REGIONAL POWER TRADE IN AFRICA

Reading for Session #4

REGIONAL POWER TRADE AND BILATERAL CONTRACTS[1]

Table of contents

Introduction 1

1. Regional trade and power pools 2

   1.1. Regional governance 3

   1.2. The rules of regional trade and transmission cost allocation 3

2. Regional power trade, security of supply and contracts 3

3. Contract designs 4

4. Integrating bilateral contracts with efficient regional power trade 5

Introduction

Power trade at regional level can exist under market conditions or by bilateral agreements between parties without the need of an organised market. Power pools existed in the 1970s in several regions in the USA or in Spain (1985), for instance, allowing power to be traded among several vertically integrated utilities without the existence of wholesale markets, which only began to appear in Chile (1982) and later in the UK (1990). The common feature of those power pools was the least cost centralized dispatch of electricity production resources, i.e., that the most efficient available generation units were employed to meet the aggregated power pool demand at all times (subject to transmission constraints). The participants in some power pools also developed joint capacity expansion plans of transmission and sometimes also of generation.

Many cross-border regulatory arrangements are being employed throughout the African continent at bulk power system level, generally without competitive markets at national level. Some regions like Southern Africa and more recently West Africa have implemented regional markets at different levels of development. Given this diversity of situations, this document will avoid using the term "market" when referring to common general situations in Africa and will use the term "power system organisational structures" instead, as recommended by IRENA recently.[2]

---

[1] Prepared by Ignacio Pérez-Arriaga (African School of Regulation, ASR; IIT-Comillas and MIT), Mohamed A.Eltahir Elabbas and Luis Olmos (both with the Institute for Research in Technology, IIT, Comillas University).

[2] The term "power system organisational structures" can be used to refer to the systems, institutions, procedures and social relations through which electricity services are exchanged and rewarded. It encompasses all systems, from liberalised power systems (based primarily on market mechanisms) to vertically integrated

This technical note applies to all regional power system structures existing in Africa at bulk power system level, liberalised and regulated, because the main regional power trade challenges are common to all of them.

1. Regional trade and power pools

Large-scale integration or power resources can have a strong positive impact on the overall electrification process in the African continent, and in sub-Saharan Africa in particular. Superficially, regional trading of power seems to be a low-hanging fruit, since establishing an advanced power trading platform with sound rules and institutions does not require substantial expenses. It requires, though, the alignment of the involved governments and parliaments regarding giving up some sovereignty to the regional institutions – regional regulatory authority and regional operator – and the common acceptance of sound trading rules and sharing transmission utilization and cost. Development of these regulations requires specialized knowledge and their implications – although beneficial from the viewpoint of overall efficiency and facilitation of investment in generation and transmission – might enter into conflict with entrenched privileges of stakeholders in some of the countries.

Formally organized regional integration of power systems, i.e., regional power pools, can be an effective way to create economies of scale for mobilizing private-sector investments, leverage synergies related to demand and supply and advance economic integration. When properly designed and implemented, regional power pools can lower the cost of electricity supply and improve the quality of delivered electricity services, thereby driving socio-economic development. Power pools provide these benefits when they include regional-scale generation plants and adequate cross-border transmission infrastructure. These prerequisites can only be met under sound power pool rules and governance.

Regional power pools are particularly relevant in the specific context of sub-Saharan Africa, both because the size of the national power system in at least 20 countries in this region is presently below the efficient level of output for a single power plant and because some countries have sufficient renewable resources (e.g., hydro, geothermal, or solar) to not only meet domestic demand but to also export excess power. Five power pools have been established in SSA – West, East, Central and South, which have very different levels of development – as well as the organization coordinating the efforts to facilitate the trading of power among five North African countries (Comité Maghrébin de l'Électricité, COMELEC), also in collaboration with several Southern European countries.

The potential of these power pools remains largely untapped due to technical and political barriers. Effective power pools require a strong alignment of interests among participating countries and external partners, including private entities and financing institutions that are willing to invest in regional infrastructures under the right conditions. National-level political commitment is needed to give executive responsibilities and resources to regional institutions, identify barriers and vested interests that impede progress, and build the capacity to regulate and operate regional systems.

The main obstacles to achieving the benefits of power pools are well known: ineffective regional governance and flaws in the rules for regional trading and network cost allocation. Both discourage investments in transmission infrastructure and regional-scale generation plants, especially when combined with a lack of trust among states, a lack of willingness to liberalize markets, concerns over the preservation of national autonomy and sovereignty and a preference for bilateral contracts over regional agreements.

---

systems. For a liberalised power system, the term “power market” is equivalent to “power system organisational structure”. See IRENA (2022), “Re-organising power systems for the transition”, International Renewable Energy Agency, Abu Dhabi.

1.1. Regional governance

Securing the low-cost power needed to drive industrialization and economic growth is a priority for the governments of all countries. In SSA, while many countries struggle with insufficient or unreliable power, others are beginning to worry about excess capacity. It is becoming increasingly clear to them that a challenge on this scale requires a regional as well as a national approach, and that trading power is of the essence. Complex coordination both within and among countries is required in investment, regulations, and system operations and this will only be possible with political leadership.

Despite potential benefits, regional integration is frequently hampered by the absence of strong regional institutions and enabling regulations. Existing power pools generally lack executive powers and capacity in two key regional institutions: the system operator and the regulator. This undermines regional transmission planning and operation and results in poor regulatory harmonization.

1.2. The rules of regional trade and transmission cost allocation

The guiding principle in the design of a regional power pool is the "single system paradigm" – that is, the principle that a regional power pool must function as close as possible in its operation and planning decisions, transmission regulation and governance to a single country of the corresponding regional dimension. In practice, loss-of-sovereignty concerns and implementation issues severely limit the application of this principle.

When existing power pool rules fall short of this ideal, the efficiency and security of supply deteriorate. For instance, in the SSA power pools, current physical bilateral contracts distort the economic dispatch of generation and demand. The 2020-2023 WAPP Master Plan says[3]: "Indeed, up to now, contracts for the exchange of electricity between States are subject to bilateral agreements with a fixed rate for a long period and are monitored by a meter on the interconnection line. These contracts that proved their value in a radial market could be ineffective or sub-optimal in a large interconnected and meshed network in which all generation options should be able to compete."

Sound transmission regulation is critical to successful power pools. The absence of correct, commonly agreed-upon procedures to allocate transmission costs will deter potential investors as it increases the risk of not receiving sufficient economic compensation. Inadequate charges for cross-border transactions that use regional interconnections will stifle trade until sound transmission pricing rules are implemented. Moreover, power-pool-wide congestion management rules are needed to establish priorities in the efficient use of scarce network capacity.

This technical note focuses on the efficient operation of generation and demand resources at a regional scale in African power pools. A companion paper deals with the capabilities and performance of regional institutions, and another one with transmission cost allocation.

2. Regional power trade, security of supply and contracts

Regional power trade is governed by regulations that define the specific technical and economic operating rules that power transactions must comply with. Developing common standards is necessary to avoid technical failures, avoid economic distortions, and efficiently manage the regional network. Security of supply is a critical concern in national power systems. The vast majority of national systems that also belong now in regional markets were originally designed to be self-sufficient, and there was a strong belief among people working in the power sector that security of supply is a national issue. However, greater levels of coordination and communication are now needed to manage increasing levels of cross-border electricity flows, many times associated with regional generation projects of a regional scale, and there is a growing awareness that security of supply can no longer be viewed as a national issue for interconnected systems.

[3] http://www.ecowapp.org/en/documentation?keys=&field_type_doc_tid=All&field_date_news_value[value]&field_date_news_value_1[value]&page=1

In all kinds of power system organisational structures, concerns about security of supply have led governments and market participants to engage in firm long-term physical bilateral contracts in the initial stages of international power trade. These contracts seem particularly attractive when there are frequent supply shortages due to insufficient investment in new generation and transmission. Both consumers and producers engage in firm long-term bilateral contracts as a means of reducing supply and demand risk for themselves. In addition, these contracts have long been viewed as necessary in order to obtain financing for investments in new power plants or energy-intensive industries, and to hedge against price volatility.

In advanced regional power markets, these physical bilateral contracts have been replaced for the most part by financial contracts with multiple formats. In contrast, firm long-term physical bilateral contracts are prevalent today in cross-border power transactions in all African regional power pools despite the fact that, although these contracts can provide a high level of certainty regarding security of supply, they often result in losses of economic efficiency that could be avoided in most cases.[4] This is the topic addressed in this technical note.

3. Contract designs

Bilateral contracts between a buyer (a load with a prescribed consumption pattern for a period of time) and a seller (a generator that provides that pattern of power) typically agree on a price for that amount of energy, and therefore both are protected against changes in the price of energy during that period and for that amount of energy with that specific pattern.

Bilateral contracts can be designed to include physical or financial obligations. Physical obligations require the physical use of designated infrastructure (i.e., the generation plant for a prescribed output, the demand for the same pattern of consumption, and the capacity of transmission infrastructure to transfer that amount of power from the former to the latter) to fulfil the contract. This format puts the greatest constraint on the operation of the system but also guarantees that power will be delivered as promised if the contracted physical facilities are available. For instance, if there is a shortage of generation in country A but a demand D_A located in this country has a firm physical bilateral contract with a generator G_B located in a neighbouring country B, the supply to D_A will be guaranteed if the generator G_B is available to produce and the capacity of the transmission infrastructure to carry power from country B to country A has also been committed and it is also available. And this power transfer must take place even if, at the same time, there is a shortage of power in country B or in the entire region. This is what the term “firm” means in the definition of the contract.[5]

Financial contracts, by contrast, only require exchanges of money and do not influence the physical operation of the system, i.e., the buyer does not care about which unit is producing the energy that it consumes, and the seller does not care about which load consumes the energy that it produces. Purely financial contracts do not have any impact on power system operation, i.e., they are ignored when the regional system operator decides which power plants must be scheduled to produce at any given time (more on this later).[6] The economic transaction for the agreed pattern of demand is settled

[4] Firm physical bilateral contracts sometimes obey to other reasons beyond the provision of extra security of supply. For instance, a coal-fired generation power plant may have a fixed annual quota of coal that must purchase from a nearby coal mine. Or a gas-fired power plant may have a multi-year take-or-pay gas contract that has been signed back-to-back with an export power contract. These cases are more complex to address, but the basic principles that are exposed here still apply.

[5] This requires the prior agreement of country B, perhaps specified in a broader regional agreement among countries that integrate a power pool that countries A and B are part of.

[6] Here it is assumed that the regional system operator is in charge of managing the security and operational aspects and also of determining the least cost operation of the generation and consumption resources. In some regional power systems these two functions are performed by different entities, i.e., the regional system operator and the regional market operator.

privately among the two parties of the contract. Financial contracts do not provide any security of supply guarantee, i.e., the generator that signed the contract might be scheduled by the regional system operator to produce or to be idle and, if there is a shortage of power, the demand that signed the contract may be curtailed as any other demand.

A financial contract can be established in the simple terms described above, which totally ignore the features of the specific regional power system organisational structure. However, financial contracts can be adapted to different power system organisations. For instance, let's assume a regional power system organisation that is able to produce hourly prices of energy whose value can depend on the location within the region– for instance, each country may have a single price, which can be different for each one, or a system of nodal prices is adopted, so that each transmission node has its price –. For the sake of simplicity, it is assumed here a single price per country. These hourly prices would be the outcome of a regional power market with a day ahead market with hourly prices, but they could also be the outcome of a computation of the marginal supply cost at each location by a regional system operator on the basis of the variable costs of generation duly audited by a regional regulatory authority.

If both the buyer and seller are located in the same country or in two countries where the hourly energy price is expected to be always the same, the most adequate format of the financial contract is a "contract for differences or CfD". In a CfD the buyer pays the seller the difference between the agreed contract price PC and the actual hourly market price PM at this hour and for the amount of energy ECh scheduled for that hour in the contract, i.e. (PC-PM) x ECh. Therefore, although the generator is being paid in the market only PM x ECh, the contract compensates for the difference so that the final net revenue of the generator is PC x ECh.

Analogously, in a CfD the seller pays the buyer the difference between the actual hourly market price PM at this hour and the agreed contract price PC for the amount of energy ECh scheduled for that hour in the contract, i.e. (PM-PC) x ECh. Therefore, although the load has to pay in the market PM x ECh, the contract compensates for the difference so that the final net payment of the load is PC x ECh.

The beauty of the CfD contract is that – although both buyer and seller are hedged against low energy prices (the seller) and high energy prices (the buyer) – they are also exposed all the time to the actual prices and they are free to deviate with respect to the contracted energy pattern if this is convenient for them. In other words, the parties that have signed a CfD contract should behave in the short term as if the contract did not exist. For instance, if the energy price is lower than the variable cost of production of the generator, the rational behaviour of the generator will be to shut down, as it would do normally, ignoring the economic outcome of the CfD, which cannot be modified by the generator's short-term operational decision. Similarly, if the buyer in the CfD is a manufacturing facility that sees a very high price of energy so that the product that it produces (e.g., steel rods) would become too expensive to be competitive, the wise decision of the factory will be to stop production that day to avoid incurring losses, since the factory's short-term operational decision cannot change the economic outcome of the CfD contract.

Things get more complicated when buyers and seller are located in different locations of the regional market and prices are not expected to be the same in both locations. In this case, an additional hedging mechanism (e.g., another CfD) can handle the risk introduced by that uncertain difference in prices. There are different approaches to deal with this problem and to provide financial hedging to both parties in the contract.

4. Integrating bilateral contracts with efficient regional power trade

The most important objective to be accomplished by the regional organisation structure is to dispatch the generation resources in the region to meet all the regional demand in the most economic way at any moment in time. This is what is called an optimal economic dispatch or an optimal load flow, which must obviously account for the capacity of the regional transmission network, the coupling among

time periods due to the technical requirements of ramps in the output of the plants, the required times to start up and shut down generators, the need for operation reserves, and the management of hydro reservoirs. Efficient operation of power systems is a complex but very well-studied field for which a variety of computer tools are widely available. As indicated above, this least cost operation could be based on audited variable (i.e., short-term) production costs of the generation plants or on competitive bids offered by the plants. This depends on the power system organisational structure that has been adopted for power trade in the region under consideration.

The presence of firm physical bilateral contracts can distort the efficient operation of a regional organisational structure, because these contracts require to preschedule generation plants, regardless of whether the least cost dispatch would have scheduled them or not. In other words, a physical bilateral contract mandates the concerned generation unit to produce, even if there is a plant with a less expensive variable production cost that is idle and could be dispatched instead; the result is an obvious economic loss.[7]

Is there some way to provide financial risk hedging against price volatility and also physical firmness of supply with a bilateral contract – either internal to a country or cross-border – without interfering with the economic operation of the regional organisational structure?

The answer is yes.[8] The two parties can sign a long-term contract (let's call it a "priority financial bilateral contract") for any desired energy pattern at a privately negotiated contract price, under specific conditions that provide financial hedging to both parties for the contracted energy pattern, as well as security of supply for the buyer and security of production for the seller if – and only if – the generator is available, the demand is able to consume and there is enough transmission capacity to hold the transaction that is either free to use or has been previously committed to the considered transaction. This can be achieved by combining the best features of the two basic types of contracts.

The financial component consists of a CfD exactly how it has been previously described. A standard CfD if the generator and the load are located in places where they are subject to the same price, which must be supplemented by another CfD to hedge the difference between the prices in the two locations in the more general case. If the generator and the load are not subject to any obligation to sell or to purchase at any externally given price a CfD is not needed, and they just have to agree on the energy price.

The priority financial bilateral contract will be ignored by the regional system operator except when the least cost regional dispatch of generation fails to meet all the demand in the country where the demand (i.e., the buyer in the contract) is located and therefore all the negative aspects of bilateral contracts will be avoided. When the regional dispatch cannot guarantee that the supply in the country where the buyer is located is enough to meet all demand, the "priority feature" of the contract will be activated and – if the generator and the committed transfer transmission capacity are available – the supply of electricity to the buyer for the contracted demand pattern will be guaranteed.

The "priority financial bilateral contract" may contain clauses penalising the generator if it fails to be available when the "priority feature" needs to be activated.[9]

In summary, for the parties in a "priority financial bilateral contract":

Under "normal" conditions, i.e., when the supply of electricity to the buyer is not threatened:

---

[7] For the sake of simplicity, it has been assumed that the demand is rigid, i.e., inelastic to price. In reality, given adequate conditions, some loads can react to prices and shortages in a similar way to generators being scheduled or not depending on prices.

[8] Amy Rose, "Improving the performance of regional electricity markets in developing countries: The case of the Southern African Power Pool", MIT PhD thesis, June 2017, http://hdl.handle.net/1721.1/112622

[9] Analogously (this may be considered unusual) the contract may have clauses penalising the demand at another emergency time when the energy prices at the generator's location are above a predetermined very high level and the generator is idle because the contracted load is not consuming at that time.

- contract holders are fully hedged to consume/produce the contracted quantity at the contract price,
- the power system operates efficiently as if the contract did not exist,
- and nothing impedes the contract holders to respond to short-term prices efficiently.

Under “emergency” conditions, i.e., when the supply to the buyer is at risk:

- contract holders are guaranteed the same level of security of supply, and income (generator) or payment (load), as they would receive if contracts were physical; and
- a penalty is assigned to the generator in case it fails to be available when required. The dual situation – i.e., the buyer not being able to consume – would result in a penalty for the buyer, if this is what has been agreed in the contract.