Research Paper on

The South African Electricity Market

CAPACITIES FOR AN ENERGY TRANSITION

August 2022

Eskom

german cooperation
DEUTSCHE ZUSAMMENARBEIT

Implemented by: giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

SAGEN SOUTH AFRICAN-GERMAN ENERGY PROGRAMME

NORD POOL

Bredesen Consulting

Contents

Abbreviations

BRP	Balance responsible party
CPA	Central Purchasing Agency
DMRE	Department of Mineral Resources and Energy
ESI	Electricity Supply Industry
IPP	Independent power producer
NERSA	National Energy Regulator of South Africa
PPA	Power Purchase Agreements
SAPP	Southern African Power Pool
SMP	System marginal price
TSMO	Transmission System and Market Operator

1. Introduction

1.1 Background

The South African-German Energy Programme (SAGEN), funded by the German government and implemented by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), was approached by Eskom Transmission to provide further technical assistance and capacity building for the implementation of reforms in the power sector. This research paper has been developed under the project "Capacities for an Energy Transition" as an input to the power sector reform process. It serves as a high-level description of the market model and describes the various market segments and how the market is intended to work. The two other research papers created under this support project give further details on the role of the Central Purchasing Agency (CPA) within the South African market and the use of Contracts for Difference within the industry. It is beneficial for readers of this document to also read these papers as they are interlinked and provide insight into key aspects of how the future electricity market in South Africa could work. This report was prepared by Hans-Arild Bredesen from Bredesen Consulting acting as a sub-contractor to Nord Pool Consulting.

Contact

Questions and comments on this Report can be directed to:

Hans-Arild Bredesen

Team Leader

E: hans-arild.bredesen@bredesenconsulting.com

1.2 Content

This research paper presents the underlying concepts of the market model, more specifically as:

a) The South African electricity supply industry

b) Market concept and the key market features

c) Regulatory structures

d) International markets

The description is based on the existing presentations of the current model as well as the ongoing development of the future South African Market Code. This code (under development) shall become the regulation document for the South African market model.

Disclaimer: The development of the South African Market Code is a work in progress where the described market model, including the detailed rules, are being developed in parallel to this paper (and will continue to evolve over time). The final market model will also be influenced by the final changes to the Energy Regulation Amendment Bill (ERA) and potentially other governmental decisions.

2. The South African electricity supply industry

The South African government has outlined its intention to move to a competitive electricity market, eventually allowing all consumers choice of electricity supplier. The transition to a competitive market model will be based on a stepwise implementation of various market segments, as well as a phased introduction of participants to the South African power market. To understand the processes required within an electricity market, it is valuable to outline the relevant stakeholders and how they participate in the industry. Figure 1 shows a schematic of an electricity supply industry (ESI) with a competitive market.

Eskom is currently structured as a vertically integrated, state-owned enterprise but is in the process of unbundling into separate **generation, transmission and distribution** entities. The unbundling does not necessarily mean full legal separation but will at least incorporate functional unbundling. Approximately 95% of the electricity produced in South Africa is currently produced by Eskom Generation, primarily through coal-fired thermal power stations. Additional capacity produced by **independent power producers** (IPPs) is purchased by Eskom through contracts in the form of Power Purchase Agreements (PPAs), which specify the price at which electricity will be bought for a set number of years through a single buyer. The requirements for additional power are based on a ministerial determination by the Department of Mineral Resources and Energy (DMRE) in line with the Integrated Resource Plans of 2010 and 2019. In contrast to a centrally planned environment, a competitive environment will allow eligible IPPs to enter the market as they choose, with price signals determining when new capacity is created; if investors think that they will make a profit selling electricity they invest in new generation facilities.

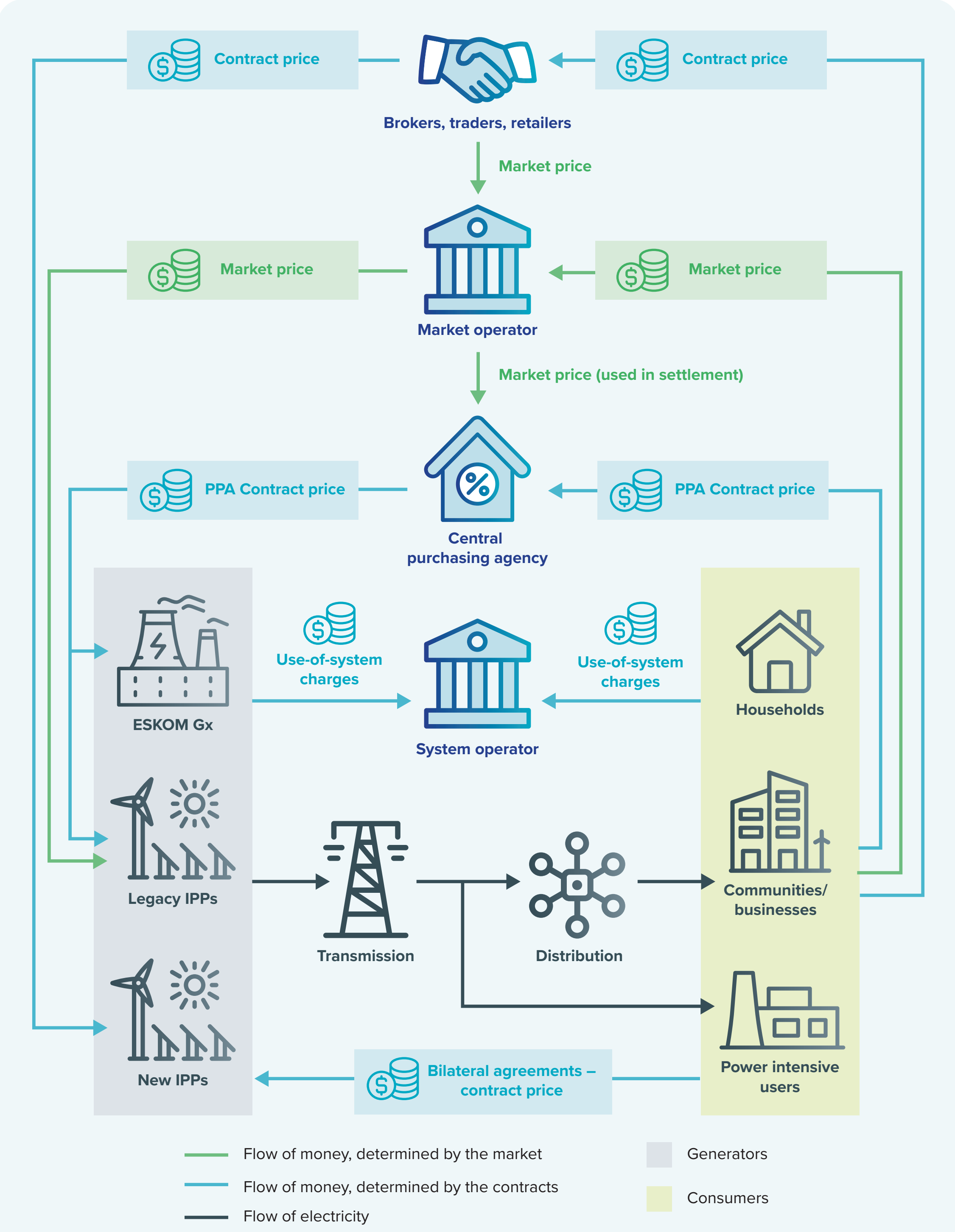

Figure 1. Participants in the South African electricity supply industry

Where these market mechanisms are deemed to be insufficient to ensure security of supply, contracts can be entered into with a special purpose vehicle called the **Central Purchasing Agency** (CPA), which performs a supporting role within the market (detailed in Section 5).

While competition will be allowed between **generators**, the **transmission** and **distribution** networks must be operated and regulated as monopolies independent of the market. This is because access to these networks is required by all participants and therefore non-discriminatory third-party access must be ensured as a prerequisite to competition. To cover the costs of owning, operating and expanding the network, an unbundled **use-of-system** tariff (sometimes referred to as a **wheeling** tariff) is applied to all electricity transferred on the network. This charge is paid to the **System Operator**, who is responsible for the metering of all market participants, the real-time balancing of supply and demand on the integrated power system and the iswsuing of dispatch instructions. In a competitive market environment, the System Operator will use trades reported from the **Market Operator** to manage the real-time processes required for the physical balance of the power system. The **consumers** (often represented by **traders**, **brokers and/or resellers**) will buy electricity from a chosen supplier that will utilise the various trading opportunities through the markets to buy the required electricity to meet the requirements from the consumers. The **Market Operator** is the body responsible for managing the markets created to facilitate this choice and for ensuring that financial settlements between buyers and sellers are settled in a transparent manner.

3. Market concepts

In a perfectly balanced system, the amount of electricity produced equates to the amount of electricity consumed at any given time. The benefit of a market is not only that it allows consumers to choose products that best suit them but that in doing so, this system balance occurs at a price that is acceptable to everyone (defined as **market clearing**).

Given the coordination required to achieve this balance, different market mechanisms are used to facilitate it. These include market platforms in which:

a) predicted supply and demand are traded by participants ahead of time, to allow for system planning and coordination = short-term physical markets such as the **Day Ahead markets** and in the future, **intraday markets**

b) any imbalances created due to the difference between real and predicted supply and demand are reconciled to ensure system security = **balance responsibility, reserve markets** and **ancillary services.**

c) contracts can be entered into to provide capacity for longer term supply security = **capacity remuneration schemes**

d) the market model allows for **longer-term bilateral trades (both physical and financial)** to be traded directly between a buyer and seller outside the short-term physical markets to allow for hedging against price risk**.**

The **short-term physical energy market**, where electricity is paid for as consumed, consists of a commitment to the delivery and consumption of power. A future **financial energy market** allows for trading to occur on contracts, with an underlying reference to the short-term market. This market can be used for derivative trading, to support risk management strategies by participants. (For more details on these contracts please see the Eskom Transmission research paper entitled "Contracts for Difference").

Eskom has already established the Eskom Dynamic Energy Market (EDEM), which can form the basis of the required platforms for a competitive electricity market. These platforms, operated by the Transmission Market Operator are illustrated in Figure 2.

Figure 2. Overview of Eskom's Dynamic Energy Market (EDEM) model

Eligible buyers and sellers are also able to conclude physical and financial bilateral contracts outside this market. The physical contracts, incorporating the commitment for delivery and consumption of power, will result in declarations to the Market Operator by the end of each day's trading on the Day Ahead market (gate closure). Intraday variations will be permitted as approved by the System Operator (after accounting for network constraints).

3.1 Day Ahead and intraday markets

A **Day Ahead market** is normally where most energy is traded. As the name suggests, the Day Ahead market is run one day ahead of real time and attempts to establish a provisional hour-by-hour balance between electricity supply and consumption. Generators submit a bid to the Market Operator for each of their power producing units, declaring their capacity, availability and price for each hour of the following day. These unit-based bids are referred to as complex orders, as they include technical parameters (start-up or shut-down times, how fast a unit can change its output, minimum generation) and the prices associated with production as a capacity-dependent curve. Retailers, brokers and traders representing the consumers (households, businesses and power-intensive industries) submit their predicted consumption levels per hour as demand orders to the Market Operator. Once generators have offered their capacity, expressed with different volumes at different prices, and consumers have indicated their willingness to pay for energy at a set of given prices, the Market Operator matches generators and consumers on an hour-by-hour basis. Matching generators and consumers in this way results in a provisional balance point, as indicated in Figure 3, at which electricity is sold at a **system marginal price (SMP)** for all parties. The power generation units are activated in an ascending order of their respective offer price, and as a result, the most economically efficient production units will be chosen first (**energy optimisation**).

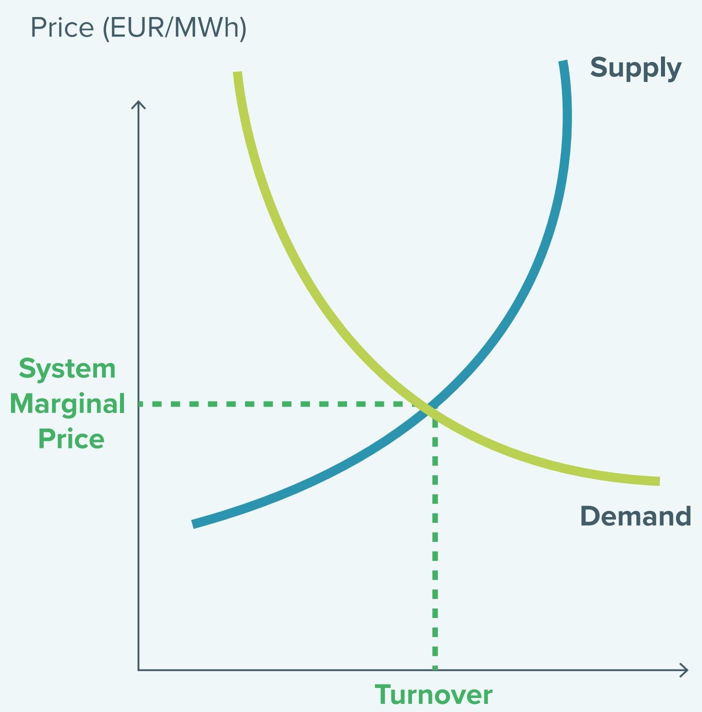

Figure 3. System Marginal Price and power volumes for both supply and demand curves

This initial market balance point is an **unconstrained result**, independent of any physical network constraints. However, the inclusion of network constraints is necessary to ensure the physical viability of the dispatch orders. Therefore, the volumes of power to be produced by each generator are recalculated to incorporate network constraints (called a constrained result). If a party's unconstrained schedule is reduced due to this re-calculation, it will be allowed to keep its "lost opportunity payment" for the constrained volume.

Example to demonstrate lost opportunity payment

a) A generator offers a generating unit at a price of R500 for a given hour.

b) The unconstrained market result is that this generator should produce 50 MWh at a SMP of R700.

c) However, due to network constraints, its production schedule is reduced to 45 MWh.

The generator's financial settlement for that specific hour would then be:

Total payment	=	production payment + lost opportunity payment
	=	(electricity produced SMP) + (lost opportunity generator offer price)
Total payment	=	(45 MWh R700) + [(50MWh – 45MWh) (R700 – R500)]
	=	R31 500 + R1 000
	=	R32 500

The constrained result is then used by the System Operator to formulate dispatch instructions for the next day. In addition to a Day Ahead market, in the future, **intraday markets** can be used throughout the day to balance production and consumption. These markets function in the same way as Day Ahead markets but within a shorter timeframe (for example, auctions take place every four hours). However, the shorter time frames do create more onerous requirements and, while there is an ambition to create this type of market in the future, it will not be created within the initial model.

3.2 Balance responsibility and ancillary services

If all parties adhere to their predicted production and consumption, the system remains in balance. However, there are inevitably deviations from predicted production and consumption and these imbalances are addressed through **balance responsibility, Day Ahead reserve markets and ancillary services.**

Balance responsibility is defined as a participant's obligation to pay the costs associated with any imbalance caused due to the difference between real and predicted supply or demand; if a generator produces less power than predicted or consumers consume more power than predicted, the participant is required to pay the costs associated with procuring additional power and coordinating the balancing of the system in real time.

The power required to balance the system in real time can be procured through **ancillary services and Day Ahead reserve markets,** where generators declare that they are available at specified times to produce a certain amount of power, if there is a shortfall. These generators are compensated both for making themselves available on standby and for any electricity produced during this timeframe. Due to the higher dispatchability and system coordination requirement for this type of generation, the price of electricity on this market is also higher; a cost that is borne by the balance **responsible party (BRP)**. Consumers can also declare that they are available at specified times to reduce consumption by a specified amount (demand response), for which they will be compensated for. The requirement for the amounts and types of reserves is a calculation that is done by the System Operator to ensure system security (**reserve optimisation**). The Market Operator is responsible for procuring these ancillary services on behalf of the System Operator. These balancing mechanisms create a cost incentive for all parties to predict and declare their power production or requirements accurately and adhere to their predictions.

3.3 Co-optimisation of energy and reserves

To facilitate the trading for each market, the Market Operator uses **individual unit-based complex orders** from BRPs (on both the consumption and generation side) in **different markets**, to optimise for both cost and system security. This is split into two main processes: Energy optimisation and reserve optimisation. The energy optimisation, represented by the energy balance between supply and demand is solved using the Day Ahead and future intraday markets, while the reserve optimisation, according to the System Operator's requirements, is solved in the reserve market.

Both the energy and reserves optimisations are solved in one algorithm. This algorithm will be run by the Market Operator, using the same unit-based complex orders on both markets. The algorithm will calculate the optimal results for both the energy balance between supply and demand, and the System Operator's requirement for reserves as part of one process. Thereby the name co-optimisation, as it optimises both the energy balance and the reserve requirement as part of one process or algorithm. This co-optimisation is one of the key features that distinguishes the proposed South African market model from, for example, its European counterpart.

Example to demonstrate co-optimisation

This is a simplified example based on one inflexible demand-side requirement of 600 MW and one reserve requirement (in reality, there will be three) from the System Operator of 150 MW. There are no network constraints in this example.

Three generating units (GU) with the following (simplified) parameters are offered to the market:

GU1	(1) 300 MW, priced at R400/MW, non-flexible
	(2) 100 MW, priced at R500/MW, flexible
GU2	(1) 100 MW, priced at R600/MW, flexible
GU3	(1) 200 MW, priced at R550/MW, non-flexible
	(2) 100 MW, priced at R700/MW, flexible

If you do a pure energy market calculation, the result would be:

GU 1:	All its output would be taken (400 MW),
GU 2:	None of its output would be taken,
GU 3:	200 MW would be taken (Order 1),

and the SMP would be R550 (the price of the last unit used in a merit-order selection).

However, the co-optimisation will also need to consider the reserve requirement from the SO.

Based on the orders on the previous page, the selection process would therefore be:

Reserves (this requires flexible generation):

GU 1:	100 MW from Order (2)
GU 2:	50 MW from Order (1)

Energy (both flexible and non-flexible generation can be used):

GU 1:	300 MW from Order (1)
GU 2:	50 MW of its Order (1) (remaining after reserve selection)
GU 3:	200 MW of its Order (1) and 50 MW of Order (2)

Resulting in a SMP for energy of **R700/MW** (the price of the last unit used in a merit-order selection) and a SMP for reserves of **R300/MW** (based on the lost opportunity cost from being kept outside the energy market calculated as the difference between the lowest cost offered – R400 for order 1 for GU 1 and the SMP – calculated at R700/MW).

Payments would then end up as:

GU1	Energy 300 MW * R700 = R210.000
	Reserve 100 MW * R400 = R40 000
GU2	Energy 50 MW * R700 = R35 000
	Reserve 50 MW * R400 = R20 000
GU3	Energy 250 MW * R700 = R175 000
	No reserve payment

4. Central Purchasing Agency

A **Central Purchasing Agency** (CPA) is a market support entity that will be created to fulfil the role of counterpart to contracts necessary to facilitate the transition to a competitive market as well as a special purpose vehicle managing non-market agreements or services aligned with the competitive market.

It will be financially responsible for the existing Power Purchase Agreements with IPPs (**legacy contracts**) and will participate as a balance responsible party in the market for the electricity produced under these agreements. It can also enter into new PPAs with IPPs to enhance system stability.

In addition to contracts with IPPs, the CPA will serve as the financial counterpart for electricity generated by Eskom Generation (**vesting contracts**). These contracts are signed with each power plant and typically consist of two parts; the first applied over the lifetime of the plant and the second expiring over time. The first section specifies an agreed upon payment to cover the fixed capital, operational and maintenance costs required by the plant and special ancillary services such as black starting and islanding. The second section specifies a fixed energy and reserve capacity price (**hedge price**) to be applied at the start of the contract and the process by which this fixed price will gradually transition to the market price over time. When applying a hedge price, power is first bought or sold in a competitive market then hedged back to the agreed upon fixed price. Eskom Generation will be the BRP for all its generation. (For more details on the CPA please refer to Eskom Transmission research paper entitled "The Role of the Central Purchasing Agency".)

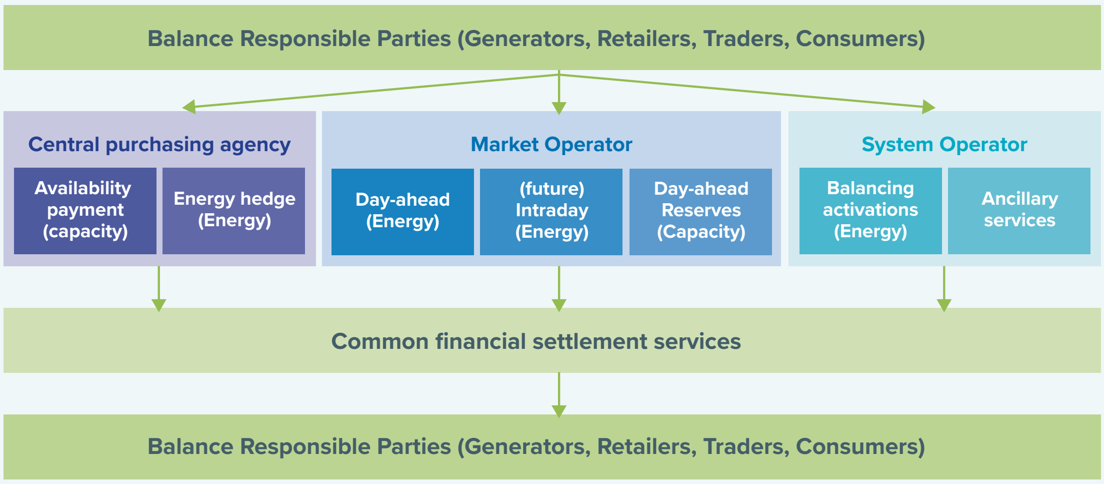

Figure 4. Organisational aspects of the market model

Figure 4 illustrates the resultant organisational aspects of the market model. The existing Eskom Dynamic Energy Market and PPAs form part of a regulatory "sandbox" environment. This means that the market is already being used as designed, with prices determined according to the market. Similarly, the PPAs with Eskom Generation and Eskom Distribution are applied as per the agreed calculations and principles in these contracts. However, once these payments are determined according to the market, they are hedged back to a regulated revenue determination made by the National Energy Regulator of South Africa (NERSA). The "sandbox" operation means that the parties are not subject to the financial effect of the payments and charges but are able to learn how these processes will work in the future market.

5. Governance and regulatory structures

Figure 5 illustrates the regulatory and legislative environment for the South African electricity supply industry.

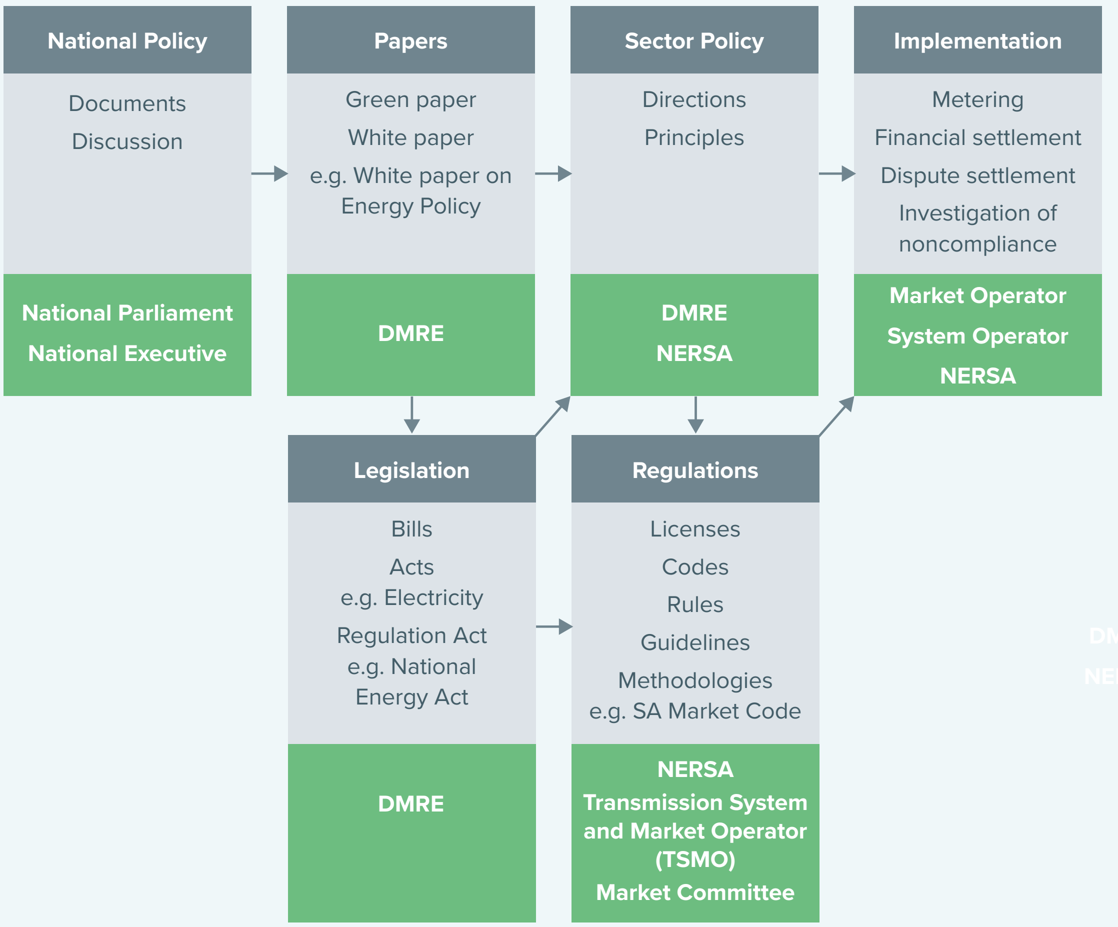

Figure 5. Regulatory and legislative environment for the South African electricity supply industry and market (adapted from the Electricity Pricing Policy)

At the highest level of governance are national documents and discussions by the **National Parliament** or the **Executive**. These address priority multisectoral issues, for example, the National Development Plan 2030 and State of the Nation addresses. White or green papers and legislation provide high-level guidance within the sector and are therefore the responsibility of the **Department of Mineral Resources and Energy** (DMRE). These documents include the 1998 “White Paper on the Energy Policy of the Republic of South

Africa", which introduced several reforms and market liberalisation measures, and the Electricity Regulation Act 4 of 2006, which is currently being amended to address the ESI's market structure, the establishment of a Transmission System Operator and different stakeholder's regulatory responsibilities within the reformed sector. The subsequent level of regulatory framework consists of sector policy and regulations; these are documents with detailed specifications for how elements of ESI and market would operate. The new South African Market Code would fit within this level and could be maintained by the **Transmission System and Market Operator** (TSMO) as the secretariat. In addition, it is expected that a Market Committee will be formed by industry stakeholders and ultimately approved by NERSA. The Market Committee will play a supporting role in maintaining and updating the market rules. The details of the foundation, rules and operation of this committee shall be defined in the Market Code.

On an implementation level, the **Market Operator** is responsible for managing the markets, balancing mechanism and financial settlements. The **System Operator** manages the real-time balancing of supply and demand and performs the function of metering agent for the Market Operator and market participants. **NERSA** is responsible for the settling of disputes and the investigation of alleged discrimination regarding tariffs, conditions of access, as well as alleged failure to abide by licensing conditions.

6. International trade

In addition to the intra South African markets, the market model also needs to take into account how trading is conducted in the **Southern African Power Pool** (SAPP). The international trade concept is still under development and thus the following presents the most recent version of the concept. International trade covers both bilateral trading with the regional counterparts and the trade in the organised markets governed by SAPP. The objective of the concept is to ensure that the regional trade is performed in such a manner that it brings benefit to the South African power sector, ensuring participation based on sound economics.

A generic requirement for all parties that shall be trading on SAPP is that they hold an export license in South Africa and that they are a market participant in the SAPP markets. Any party participating or interacting in the SAPP markets will be under SAPP governance as well as the South African Market Code. The CPA shall manage and maintain the historical regional bilateral contracts and schedule these according to the SAPP Market Book of Rules. The following Parties will interact with SAPP markets:

System Operator

- Provides the available transmission capacities for all international interconnections from South Africa to the SAPP markets
- Acts as a Transmission System Operator under the SAPP regulations
- Nominates the total scheduled flows to the Market Operator
- Acts as the balance responsible party towards SAPP.

Market Operator

- Represents (trading proxy) the South African market participants for those volumes that are traded through the South African market
- For the Day Ahead market, creates a Net Export Curve representing the aggregated purchase and sales offers from the orders in the South African Day Ahead market, using the order information from the different market participants, including adjusting for any capacity payments
- For the SAPP intraday and balancing markets, makes available national orders according to a set of detailed rules
- Takes the scheduled flows from the SAPP markets as a deemed flow in the market clearing in the South African market.

South African market participant with a capacity payment agreement with the CPA

- Shall always offer their full capability to the national market of South Africa and will not be allowed to participate directly in the SAPP regional markets
- Will indirectly be participating through the Market Operator, which will use its orders in the short-term markets (Day Ahead market, intraday market and balance market) and thereby have implicit access to the regional markets.

South African market participant without a capacity payment agreement with the CPA

Has a choice regarding who it will buy from or sell its requirement to in a market, and thus can buy or sell power through the following channels:

- A bilateral physical contract with a South African counterpart: In this event, the participant will have to nominate its planned schedule to the Market Operator to be considered in the South African market. The bilateral contract will be settled between the parties.
- A bilateral financial contract with a South African (or regional) counterpart: In this event, it should participate in the South African market to secure a physical position. This financial bilateral contract will be settled between the parties.

- Subject to being a SAPP market participant: Participate in the SAPP organised physical markets. If successful, nominate its schedule to the System Operator to be considered in the management of the transmission capacity towards SAPP. The settlement of this trade will be towards SAPP.
- Participate in the South African short-term physical market as a market participant under the South African Market Code; or
- Any combination of the above.

A regional bilateral physical contract with an international counterpart will not be allowed in the future.

7. Conclusion

In conclusion, the proposed liberalisation and ongoing unbundling of Eskom represents a significant change in the historic landscape of the South African ESI. To manage this transition to a competitive wholesale market, the introduction of market platforms (such as the Day Ahead, intraday, reserve and ancillary services market) and participants will need to occur gradually over time. In addition, the Market Operator, System Operator and CPA will have critical roles to play, to facilitate the functioning of a market.

8. Further reading

DMRE (Department of Mineral Resources and Energy) (2022) Electricity Regulation Amendment Bill. *Government Gazette* 45898, 10 February. Available at: https://www.gov.za/sites/default/files/gcis_document/202203/45898gon1746

DPE (Department of Public Enterprises) (2019) *Roadmap for Eskom in a Reformed Electricity Supply Industry.* Available at: https://dpe.gov.za/wp-content/uploads/2019/10/ROADMAP-FOR-ESKOM_0015_29102019_FINAL1.pdf