CENTRE FOR RENEWABLE & SUSTAINABLE ENERGY STUDIES

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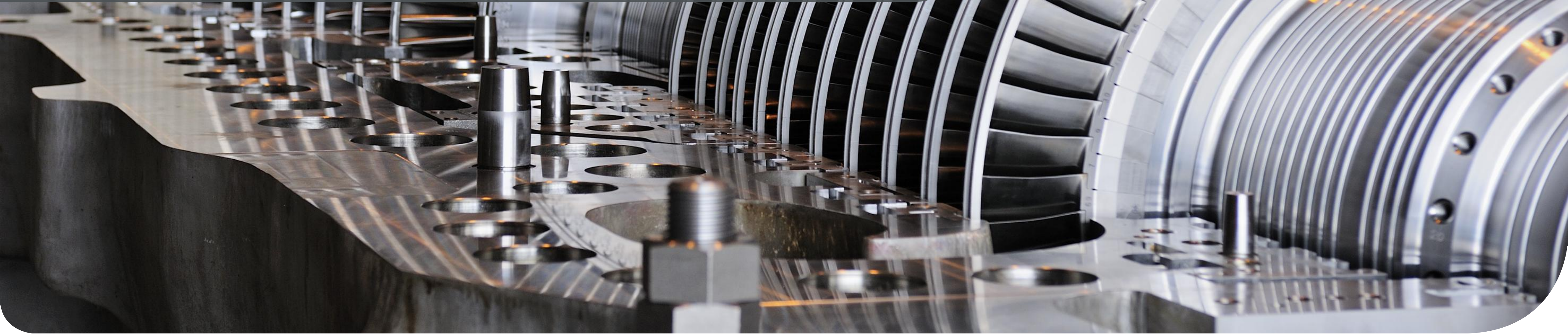
Insights into inertia management in the South African power system

11 July 2025
www.crses.sun.ac.za



Why does inertia matter?

Inertia from the kinetic energy of large rotating generators slows down frequency changes, adding stability to the power system

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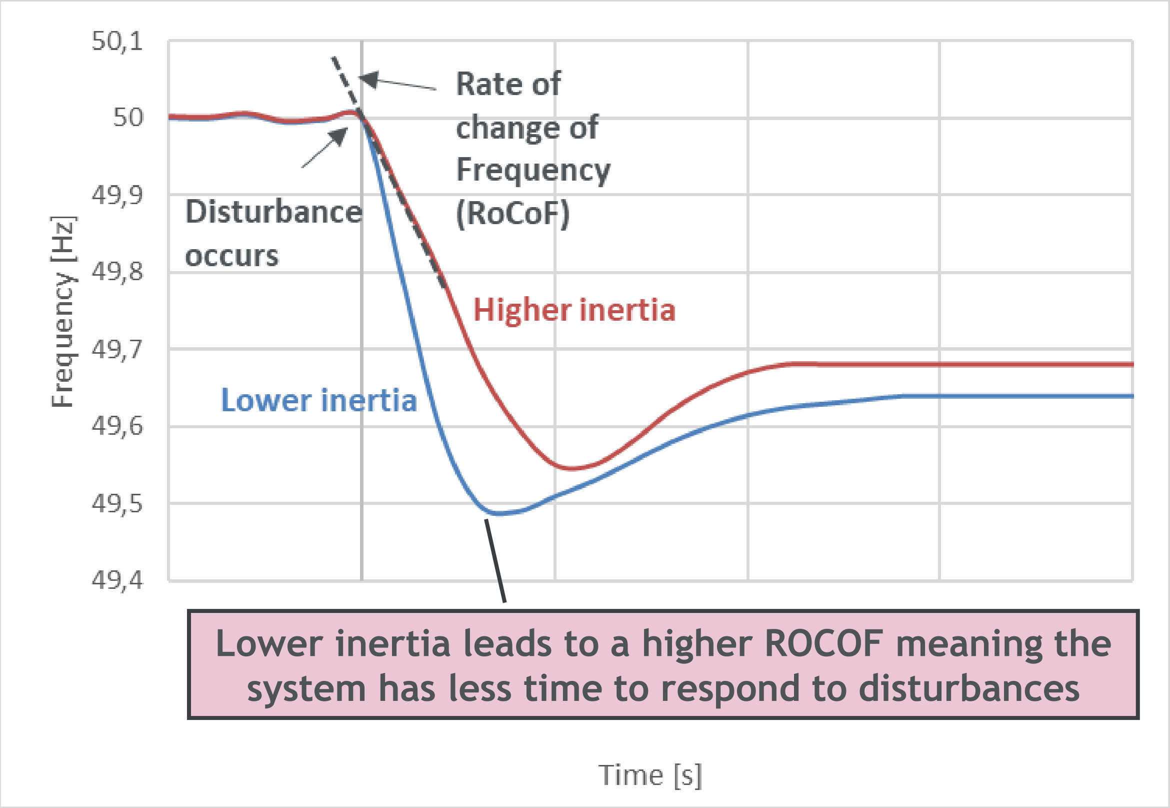
Illustrative frequency graph showing the impact of inertia on the rate of change of frequency:



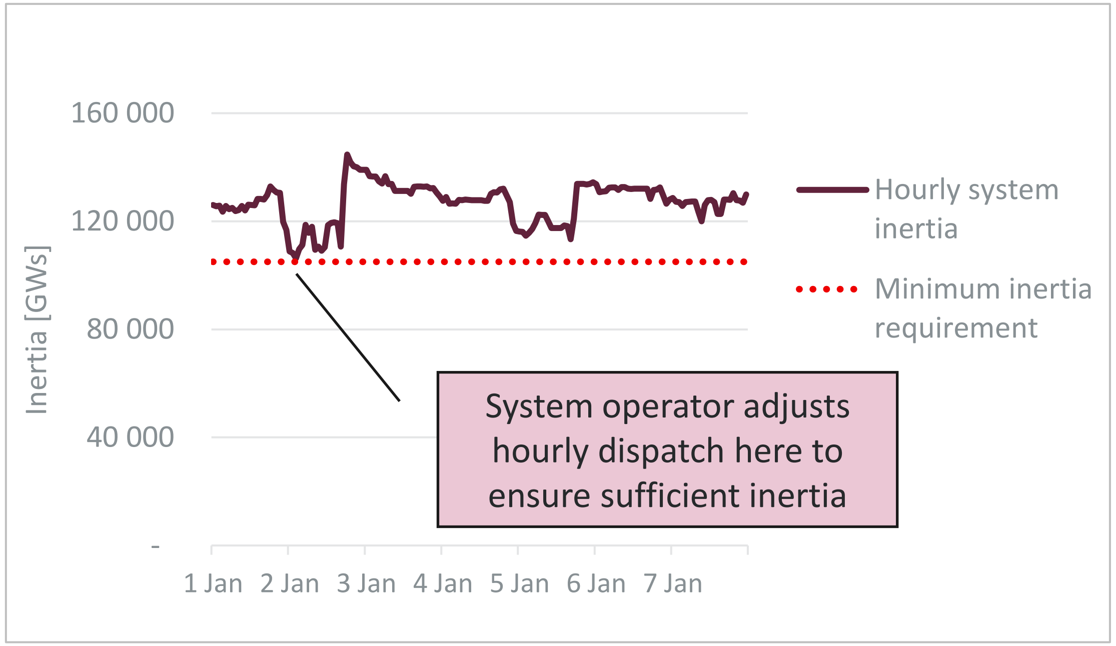
Lethabo power station has rotors weighing 3 000 tons rotating at 3 600 rpm. That's a lot of inertia!

https://www.eskom.co.za/heritage/lethabo-power-station/

How is inertia typically managed?

Minimum inertia limits are determined and the system operator is mandated to ensure inertia remains above this critical level

1. **Determine the system's minimum / critical inertia requirement**
2. **Ensure inertia remains above threshold by:**
   - Adjusting hourly dispatch to ensure sufficient inertia
   - Implementing long-term contracts for inertia providers



UK is actively managing inertia

Long-term contracts + spot market adjustments

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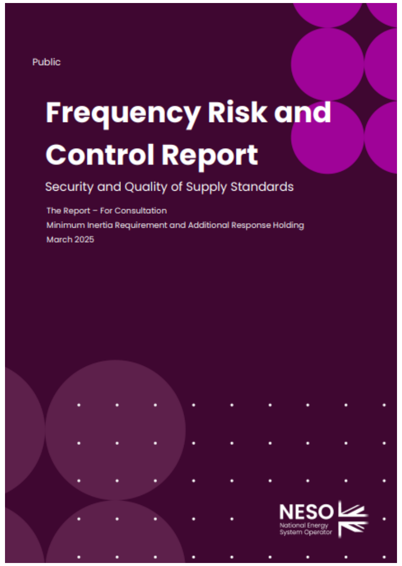
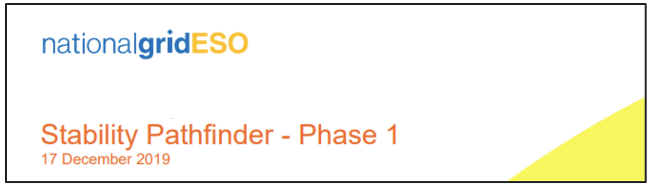
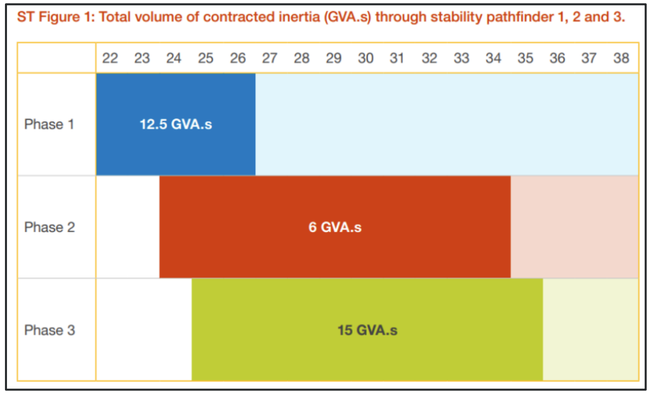
Minimum inertia limits:

1. Min inertia limits are regulated by OFGEM
2. Recently reduced min inertia from 140 to 120 GVA.s
3. Goal of reducing limit to 102 GVA.s

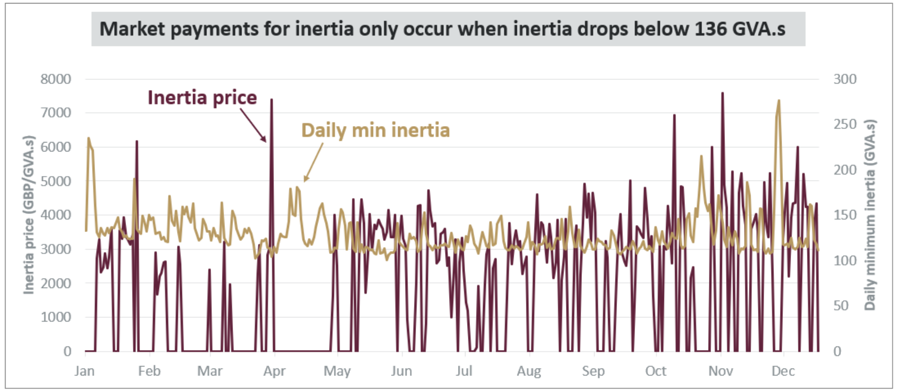


Long-term contracts for zero carbon inertia
synchronous condenser
& grid-forming batteries





When required, inertia procured using market Balancing Mechanism



https://www.neso.energy/document/356356/download ; https://www.neso.energy/news/national-grid-eso-launch-stability-pathfinder-phase-one

State of inertia in South Africa

Lots of synchronous inertia from coal in the system, but an inertia threshold is required to determine whether inertia is sufficient

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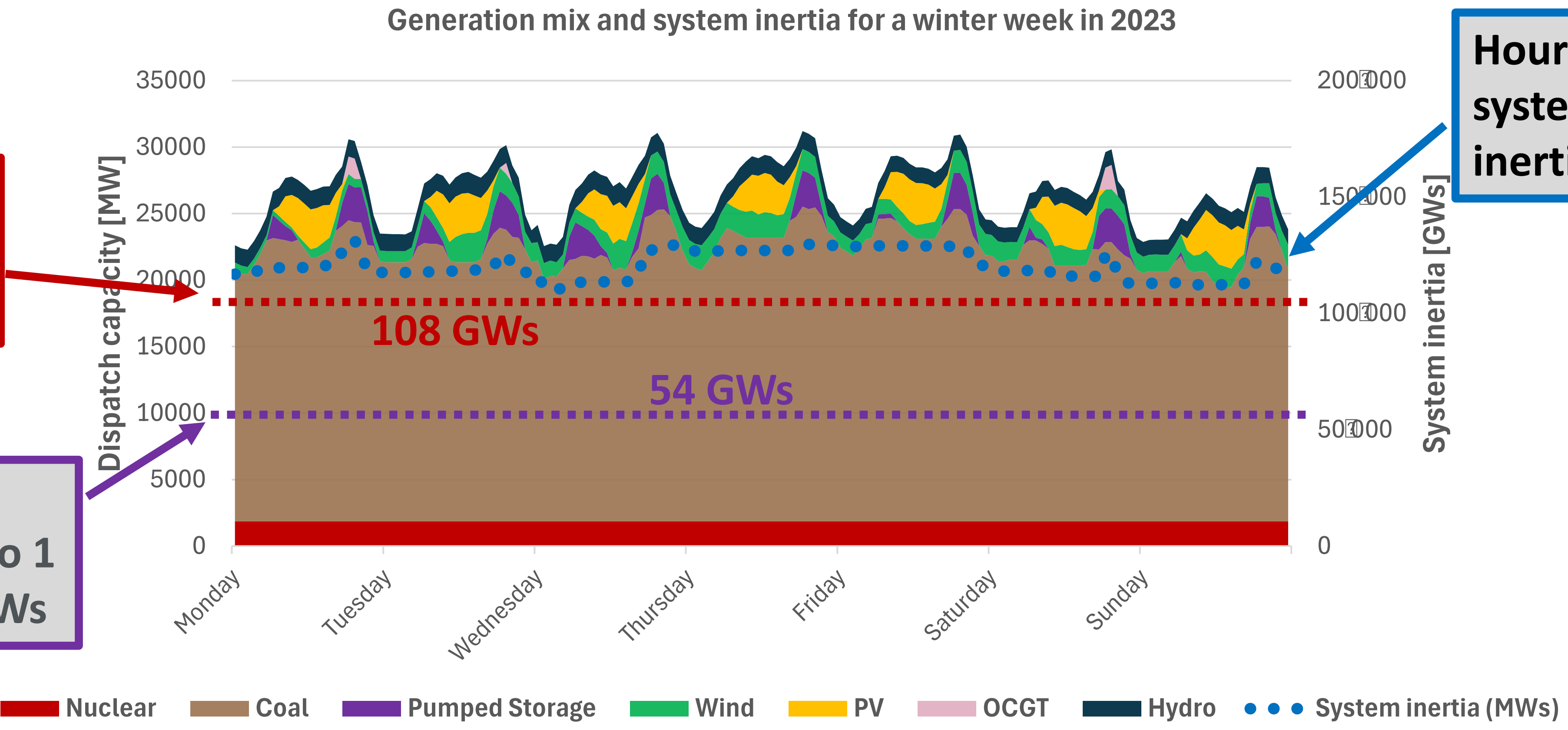
Conservative inertia limit (108 GWs) limiting ROCOF to 0.5 Hz/s

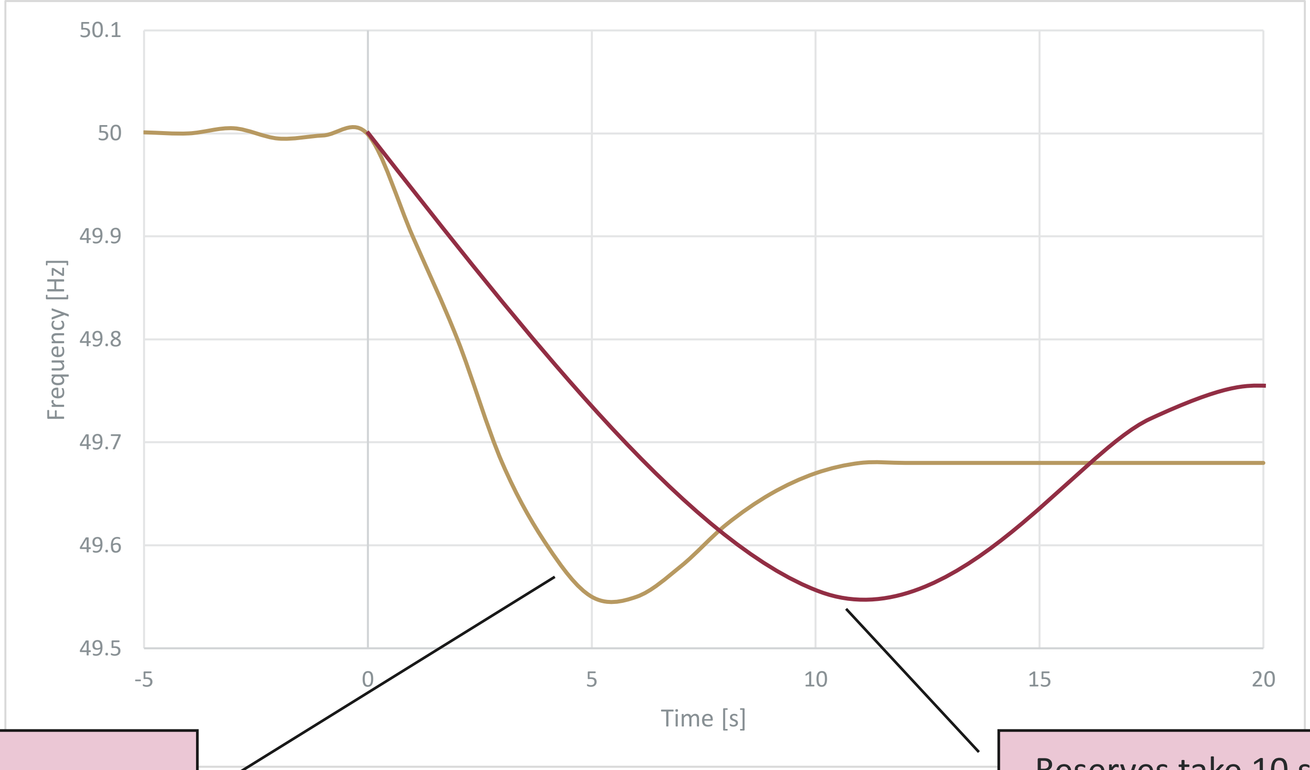
Aligned with global best practice to limit ROCOF to 1 Hz/s – inertia limit: 54 GWs

Hourly system inertia



Inertia versus fast frequency response

The more fast frequency response in a system, and the faster it can response, the less inertia is needed



FFR responds within 5 seconds, meaning frequency limits are adhered to with a higher ROCOF

Reserves take 10 seconds to respond meaning a lower ROCOF is required to remain within frequency limits

Lessons from literature for inertia management in South Africa

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While SA may currently have sufficient inherent inertia from synchronous generators, the following will prepare our system for a low-inertia future:

1. The System Operations Grid Code can require the System Operator to publish an annual Frequency Risk Report outlining the how grid stability is managed
2. A minimum inertia requirement can be introduced as a regulated value with a transparent methodology
3. Appropriate procurement mechanisms for inertia can be introduced to ensure the long-term stability of the power system

Step 1: Define inertia as an explicit service in the System Ops Grid Code

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Current grid code makes provision for the following ancillary services:

The Grid Code should require that:

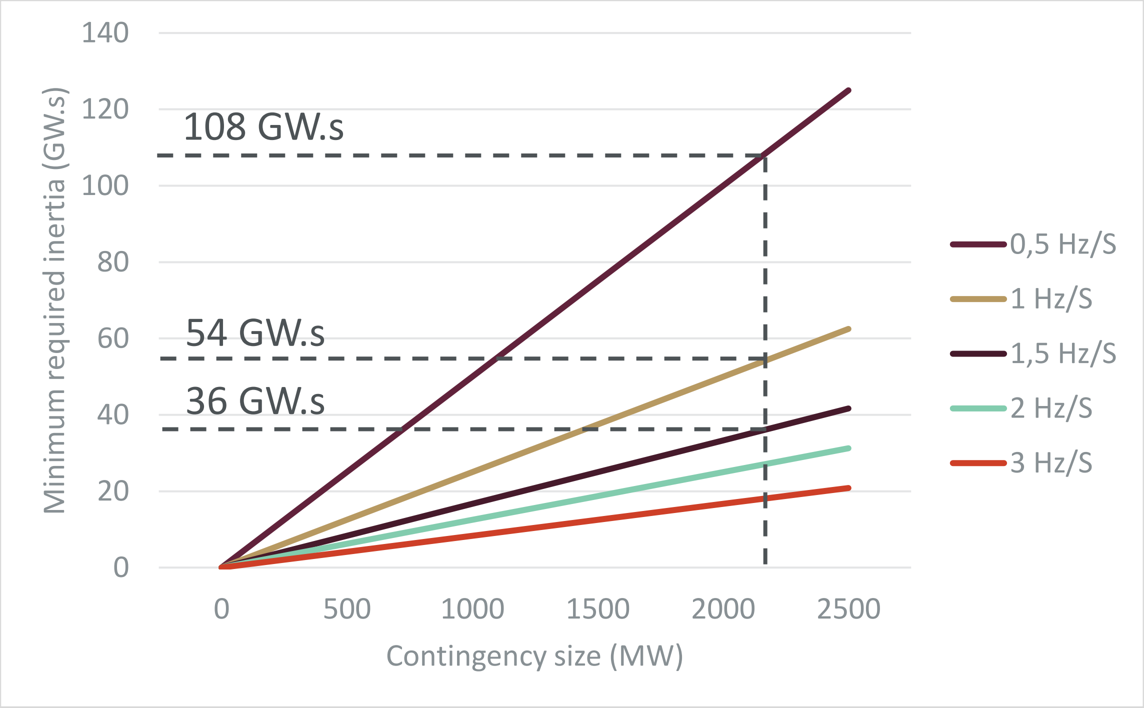
1. The System Operator produces an annual Frequency Risk Report and consults with the industry on its assessments.
2. The Frequency Risk Report should define a minimum inertia requirement.
3. The system operator procures inertia services in a least cost manner to society.

Step 2: Determining the minimum inertia requirement

Minimum inertia is typically a <u>regulated value</u> which the system operator must maintain

Minimum inertia is a function of:

1. Largest contingency size (MW)
2. Acceptable rate of change of frequency (ROCOF)



Step 3: Develop inertia procurement mechanisms

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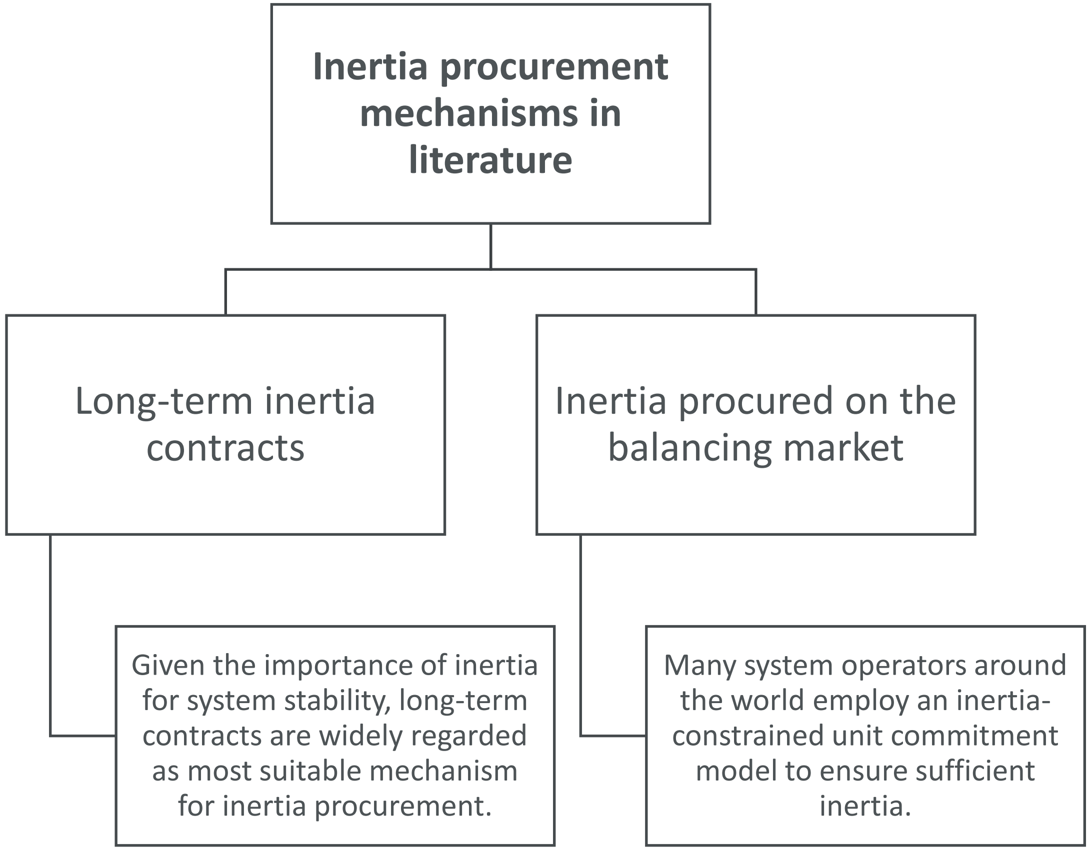

Extract from Market Code showing procurement of ancillary services:

Long term auction

- System restoration (black start and islanding)
- Reactive power
- Synchronous condenser operation
- Emergency reserves
- Supplemental reserves

Dynamic market

- Constrained generation
- Regulating reserve
- Instantaneous reserves
- Ten-minute reserves

*Note: inertia not mentioned but synchronous condensers are

Comparison of key inertia metrics across SA, Aus & UK

Jurisdiction	RoCoF limit	Minimum inertia requirement	Inertia procurement mechanism
UK (NESO)	1 Hz/s (500ms)	120 GVAs (shortly reducing to 102 GVAs)	Long-term contracts + market adjustments
Ireland (Eirgrid)	1 Hz/s (500ms)	23 GWs	Long-term contracts + market adjustments
Australia (NEM)	1 Hz/s (500ms), 3 Hz/s (300ms)	Dynamic by region	Future spot market + studies ongoing
South Africa	Not defined (1.5 Hz/s RPP Grid Code only)	Not specified (Estimated 54-108 GWs)	Draft Market Code proposes mix

Supported by:

Thank you
Enkosi
Dankie