Inertia, Oscillations and System Strength:

Measurement Solutions for an evolving power grid

Reactive Technologies
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We enable transmission and distribution grid operators to measure grid inertia and system strength to accelerate the transition to a low-carbon grid.

To Tackle Global Grid Challenges

AEMO
AUSTRALIAN ENERGY MARKET OPERATOR

"As the penetration of wind and solar on the system increases, operation of the system becomes significantly more complex. The **power system is being operated closer to its known limits** more frequently, with increasingly variable and uncertain supply and demand, and **declines in system strength and inertia**."

NESO
National Energy System Operator

"Zero carbon operation of the electricity system means a **fundamental change to how our system was designed to operate**; integrating newer technologies right across the system… **using new smart digital systems** to manage and control the system in real-time."

cigre

"It is recommended that system operators perform **inertial measurements** to get an **accurate, real-time** view of inertia levels to replace guesswork and conservative estimates."

entsoe

"Decreasing levels of inertia – as a result of the large-scale integration of renewable sources – **pose long-term challenges to frequency stability of the transmission system, with possible impacts on the resilience of the future system**."

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Beyond Connection Queues, Planners and Operators are facing new challenges

General

- Accurate Modelling of multi-IBR systems
- Changing System Behavior, power flows and voltage stability
- Increased variability/flexibility
- New standards and policies
- Significant investment need

Actions

- New modelling
- Greater System Visibility/Monitoring
- Control Room Training and new tools and forecasting
- Major updates to systems
- Expansion of key teams and capabilities

Increasing IBR Impacts and Mitigations

Frequency behavior increasingly localized	Reduced damping and more oscillations	Voltage stability issues linked to low SCL	More aggressive regional transients/RoCof	New Constraints for inertia /voltage /stability
Detailed /local regional security modelling	Modelling can replicate but can still be poor at predicting due to complexity	Continuous measurement of Inertia & SCL/Voltage	Fast Control helps but can create oscillations	Development of stability/ Grid Forming standards

You wouldn’t operate the grid without measuring and modelling voltage and current.

Today, it’s crucial to measure inertia and system strength for the IBR grid of tomorrow.

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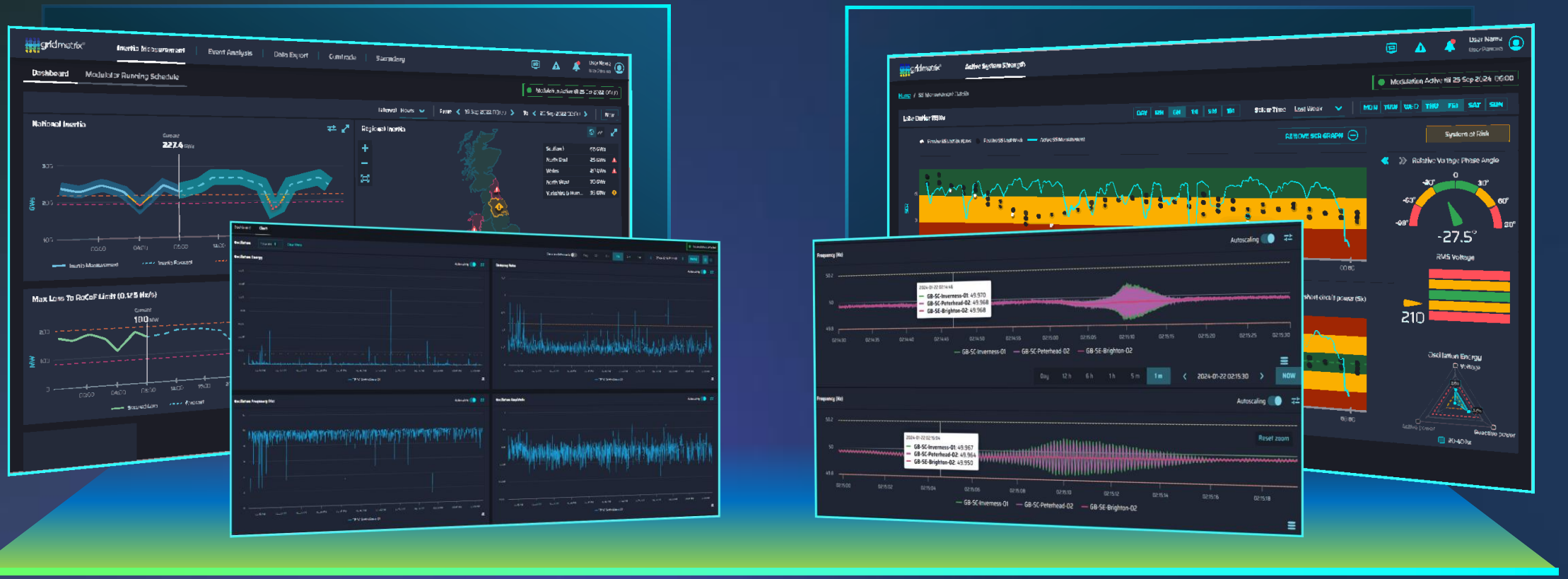
What We Offer – in GridMetrix®



Direct Inertia Measurement

System Strength Measurement

Real-time Oscillation Monitoring

Data Insights

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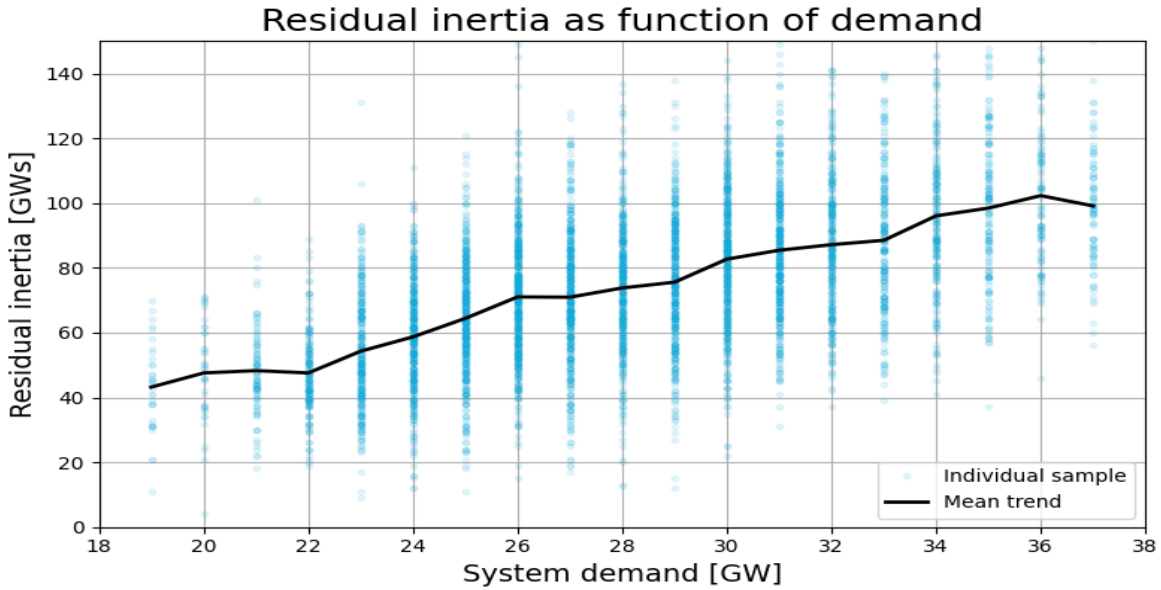
Disruptive Technology Today For The Modern Grid Of Tomorrow

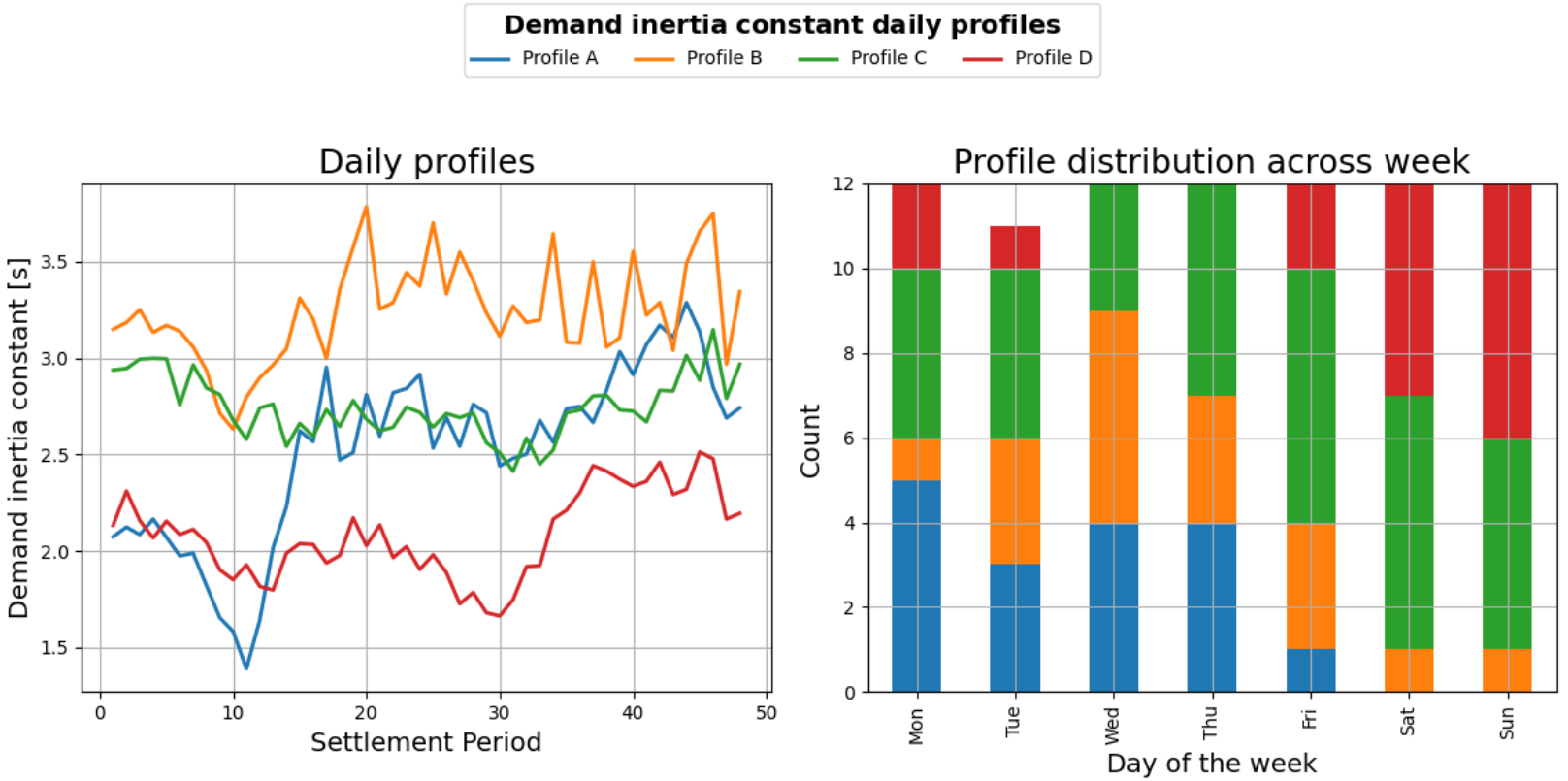
Great Britain Inertia Observations.

Residual inertia = Inertia Measurement – Generation Inertia
Residual inertia constant = Residual Inertia / Total Demand



- Key lessons:
  - Some Declared Generator H constants are inaccurate
  - Inertia from Demand Side varies significantly
- Measurement allows significant improvement in accuracy of forecast

Great Britain Inertia Observations.



- Demand Inertia daily behavior not proportional to demand
- Varies based on load profile of inertial devices

Stability in planning and operations.

Inertia and System Strength Policy
1. RoCoF & nadir limits
2. Largest loss limit
3. Minimum Post-Disturbance Frequency Response Level
4. FFR and GFM plan

Forecast
Plan for operation up to 10 years ahead to ensure adequate system-wide and regional frequency stability

Operating Plan
Constrained Schedule above minimum stability Forecast Minimum number of Synchronous Units 'Must Run' per region

Secure System Operation
Real time Measurement to ensure safe operation

Post Event Review: Frequency and oscillations performance

Measurement data helps update Frequency Security Policy

Summary Observations and Actions

Continuous Measurement is key alongside modelling

Global Observations of High IBR Systems:

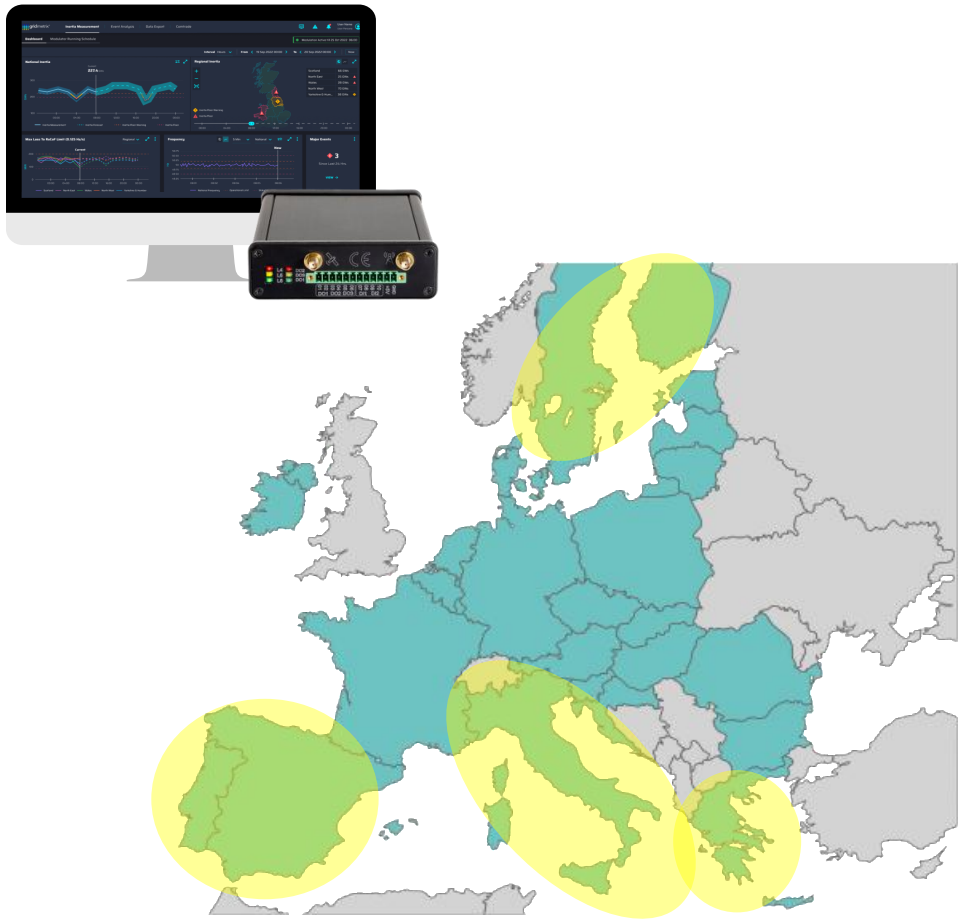
- Frequency behavior increasingly localized
- Reduced damping and more oscillations
- Voltage stability issues linked to low SCL
- New Constraints for frequency/voltage/stability
- More aggressive regional transients/RoCof

Best Practice Mitigations

- Continuous measurement of Frequency behavior
- Modelling can replicate but can still be poor at predicting due to complexity
- Fast Control helps but can create oscillations
- Detailed /local regional security modelling based on measurement data
- Development of stability/Grid Forming standards

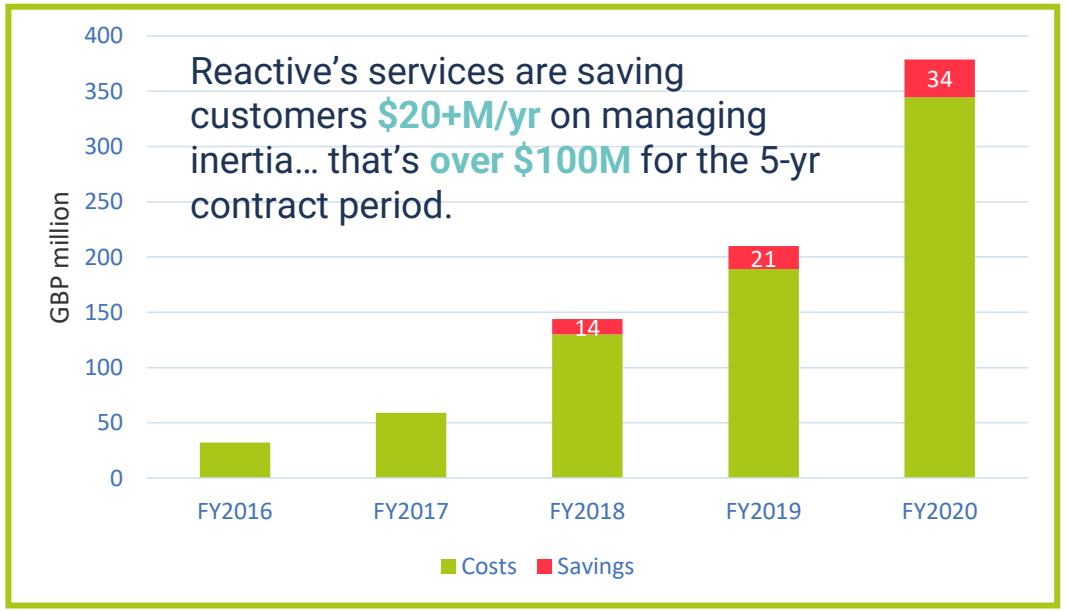
Summary

- You wouldn't operate the system without measuring/modelling voltage and current
- **Now also need to measure/model frequency stability**



Inertia Measurement is core to NESO's Zero Carbon Plan

Inertia Measurement is saving **~10%** of the cost of managing decreasing inertia in the UK



Source: NESO Cost of Managing RoCoF

NESO's goal of zero carbon operation by 2025 requires direct inertia measurement being in place

- **Commercial Services Operational** – exceeding expectations
  - Rapidly deployed, stand-alone secure IT service
  - Faster renewable integration
  - Data used in control room for real-time optimization
- **Results show**
  - **~80% time measured inertia >10-30+% higher** than estimates (minimize/optimize inertia procurement)
  - **~20% time measured inertia is lower** than estimated inertia (evaluate system operational risk)
- **Reactive's inertia data to be used by NESO to establish a market for inertia in 2025**
- **NESO ROI <1 year**

"Inertia will become much more important in the years to come, I think today it is taken for granted… Inertia is at the heart of everything we do"

NESO National Energy System Operator

Fintan Slye
Chief Executive, UK National Energy System Operator

Ensuring the safe and reliable large-scale deployment of renewables to meet NY State targets.

Real-time measurements support increased integration and reliable deployment of renewables to advance NY State Climate Goal for Carbon-free Power Grid by 2040

Background

New York State has set ambitious climate targets under The Climate Act, aiming to quadruple offshore wind capacity, double distributed solar deployment, and deploy significant energy storage by 2030. In support of these goals, Reactive Technologies collaborated with utilities across New York, including National Grid US, Coned INC, Avangrid, and Long Island Power Authority, backed by NYSERDA, the New York Independent System Operator, and the New York Power Authority. The project objective is to deploy Reactive's real-time inertia measurement service to ensure the safe and reliable integration of renewable generation resources.

Benefits

Enables efficient utilization of existing grid infrastructure capacity to meet NYS CLCPA targets.	Minimizes operational risk by offering accurate real-time data and grid visibility, enhancing operational decision-making.	Highlights actual needs, reducing the cost of providing unnecessary ancillary services or excessive grid reinforcement.

"NYISO is pleased to work with Reactive Technologies and NYSERDA as a Technical Advisor to explore the applicability of their groundbreaking technology in New York as we work to deliver the grid of the future."

Rana Mukerji, Senior VP, Market Structures at NYISO

NEW YORK STATE | NYSERDA | reactive technologies

In collaboration with:

nationalgrid | LIPA | NEW YORK STATE | NY Power Authority | conEdison | Avangrid | New York ISO Independent System Operator

Net Zero – Safer, Faster.