System Inertia Monitoring National Grid ESO

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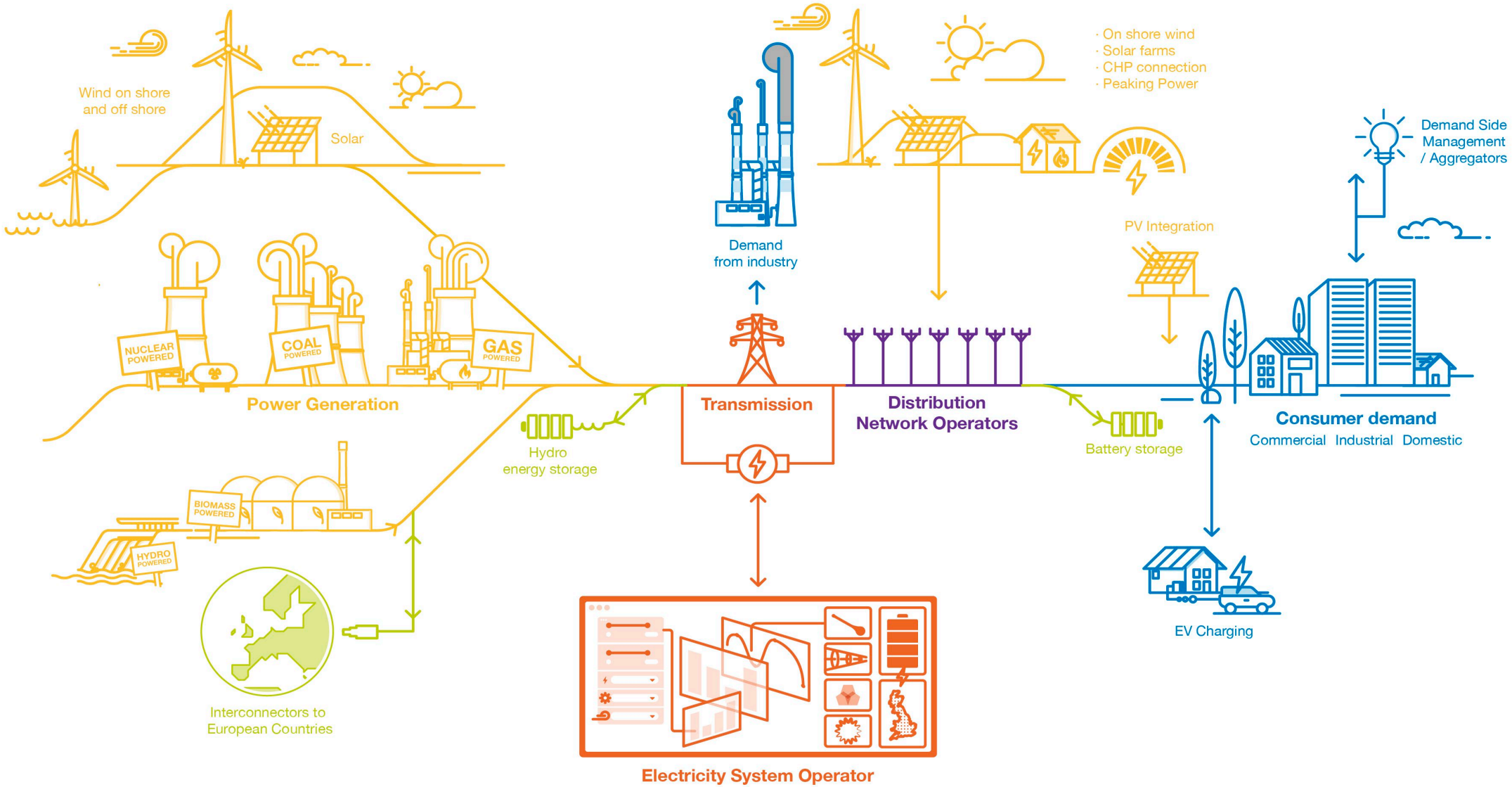
Agenda

- The role of National Grid ESO in the industry
- Outline our zero carbon by 2025 ambition
- Discuss why we measure inertia
- Illustrate the value of the inertia market in Great Britain
- A walk through of our two new inertia monitoring products
- Understand why have we chosen to develop two solutions

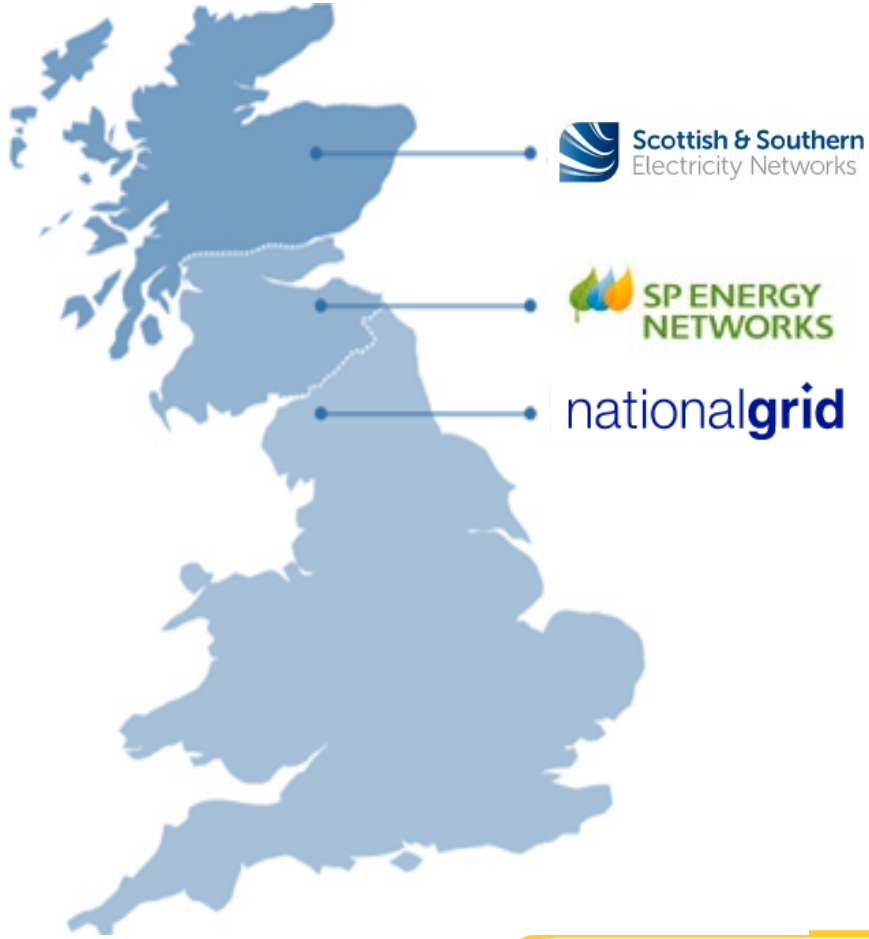
Where we fit in the system



National Grid ESO's role

- Operates and balances the system
- Widens access, promotes competition
- Network recommendations
- Operational planning
- Connection agreements
- GB charging and billing

The **transmission operators** (TOs) own, build and maintain Britain's transmission infrastructure.



Zero carbon by 2025

What it means

- Carbon free operation of the transmission system for short periods
- We're ready to accommodate whatever amount of zero carbon electricity is being generated by the market at a given time

Key challenges to overcome

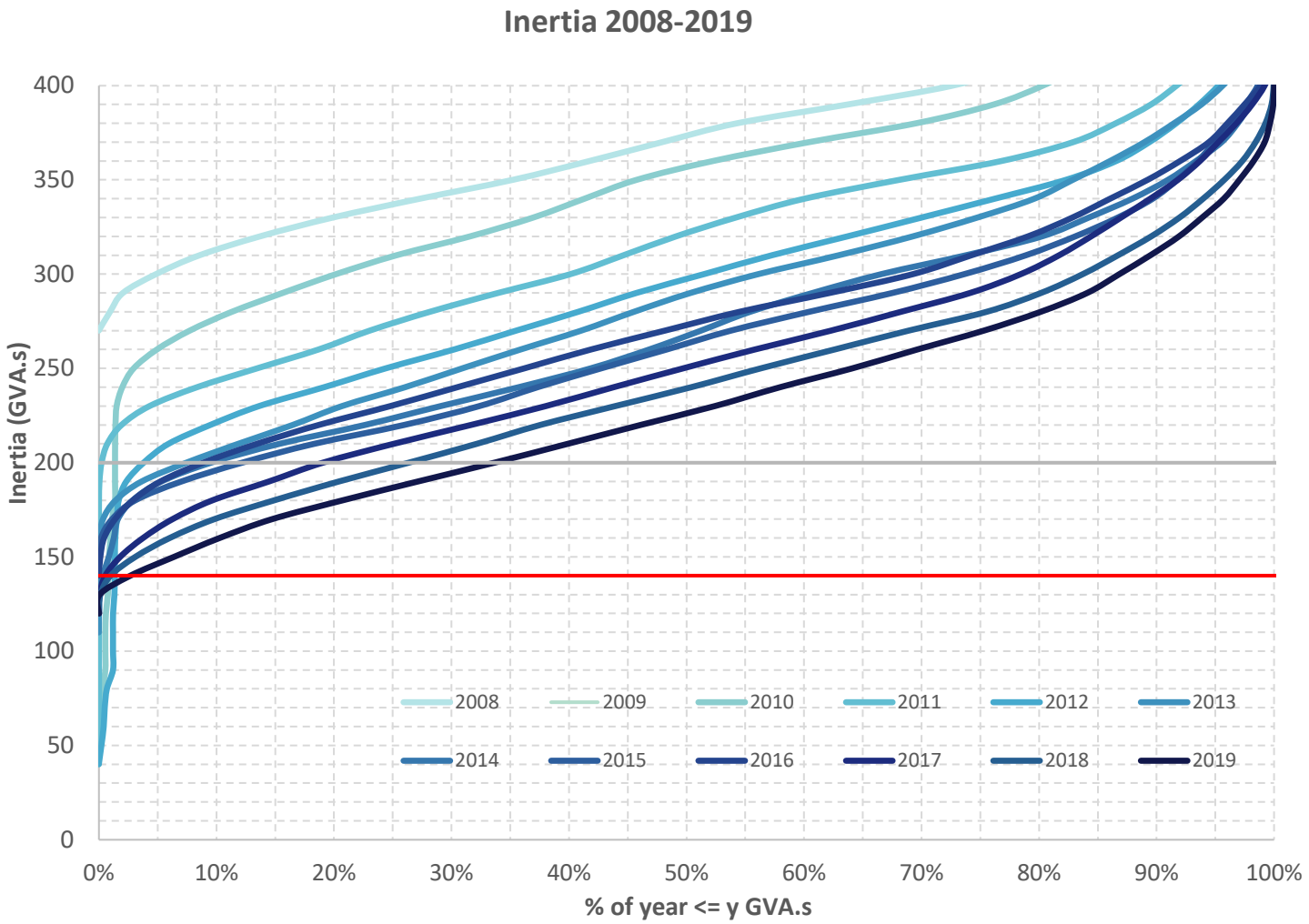
- Frequency management
- Inertia and voltage control

Notable records

- **88% zero carbon** on Aug 17 2019
- **85% zero carbon** on May 23 2020
- **60% share of wind** on Aug 26 2020

GB Inertia Levels

- Inertia reducing due to change in generation mix
- Minimum 140 GVA.s to manage largest generator loss, increases for high interconnector transfers



Zero carbon by 2025

Pathfinders

A new approach to managing key properties of the electricity system

- **Stability** – providing inertia without generating megawatts
- **Voltage** – finding new sources of and ways to absorb reactive power
- **Constraints** – reducing congestion and the cost of network constraints

Frequency management – Reserve and Response Roadmap

New, fast and flexible ways to keep frequency stable, including

- Dynamic containment – sub-second response to catch deviations
- ODFM – a paid service to turn smaller scale renewables off or down

Loss of Mains change programme

Changing embedded generation settings to reduce unnecessary tripping – nearly 6,000 sites changed to date, around 10.7GW of capacity.

System restoration

Distributed ReStart – Black Start but using distributed/embedded generators.

New Services and Products

Need to manage the trade off and balance between frequency response and inertia

Faster acting frequency response products

- increasing over time FFR, EFR and now Dynamic Containment
- Dynamic Containment (DC) is a fast-acting post-fault service to contain frequency within the statutory range of +/-0.5Hz in the event of a sudden demand or generation loss. The service delivers very quickly and proportionally to frequency but is only active when frequency moves outside of operational limits (+/- 0.2Hz). With full delivery in 1second.

Stability Pathfinders

- Trial by doing – define the need, let the market innovate
- Phase 1 contracted January 2020 – 12GVAs equivalent to 5 to 8 machines £320M for 6 years
- Phase 2 – Scotland focus for Short Cct infeed and inertia – contracted summer 2021
- Phase 3 Nationwide inertia requirements – process to be launched later in 2021

Accelerated Loss of Mains Protection Changes

All generation has a loss of main protection system

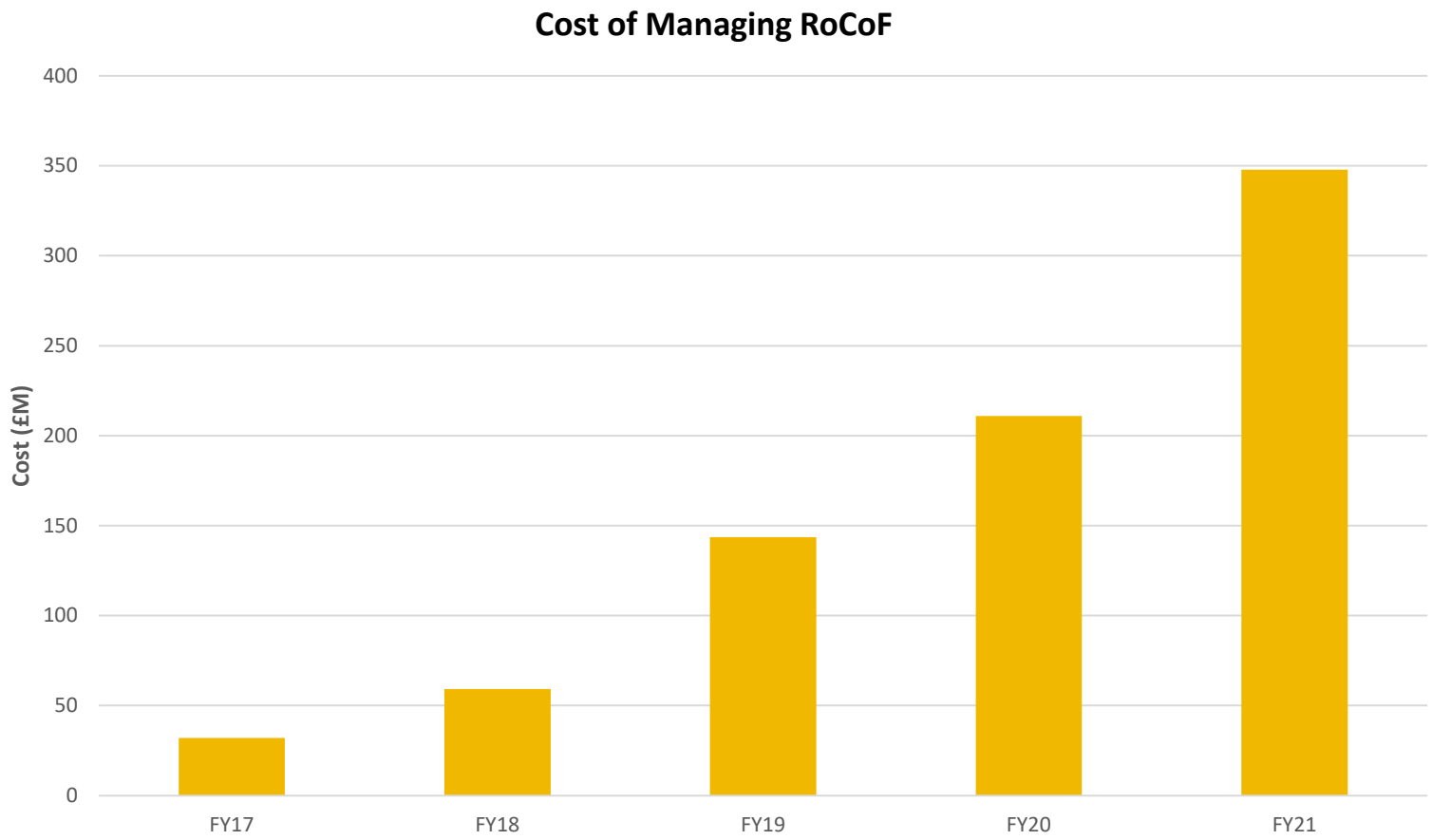
As the system changes, it has become clear that many embedded generators need to change their protection settings

This will allow the embedded generation to stay connected when:

- there is a transmission system fault creating a voltage disturbance
- there is a large loss of transmission generation causing a rapid change in frequency. Move from 0.125Hz/s to 1Hz/s
- 50,000 sites with circa 25GW of generation are in the programme due to complete summer 2022

GB Inertia Costs

- Increased costs of managing Rate of Change of Frequency (RoCoF)
  - Increasing renewables
  - Increasing Interconnectors



Inertia Monitoring Projects

NGESO Existing System

"Estimate" based on transmission connected generation plus factor of demand

- Calibrated against large frequency excursions

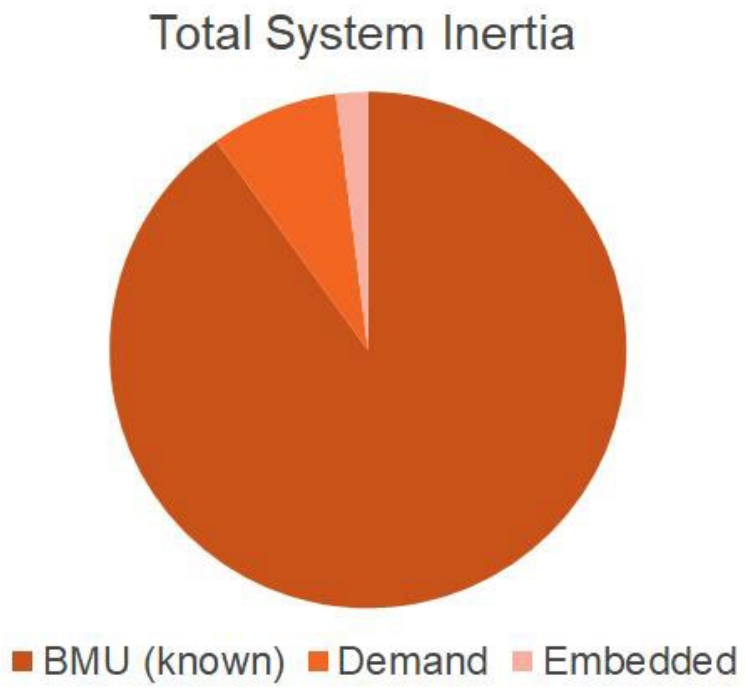
January 2019 tendered for Real-time Inertia Monitoring System

Contracted for 2 "first-of-their-kind" Inertia tools:

- Reactive Technology (RTL) GridMetrix Inertia Measurement System
- GE Digital Effective Inertia Measurement & Forecasting System

Traditional Inertia Estimation Methods

- System inertia = Sum of synchronised transmission generation + representation of residual inertia (factor * transmission demand)



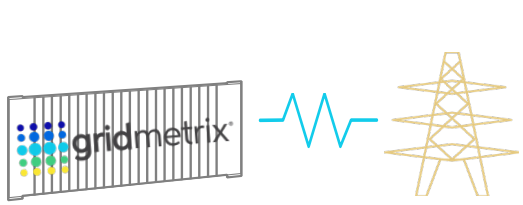
- Verified using swing equation against large loss of load events.

Why two new products?

- Transmission System
  - Transmission Owner roll out of PMUs will take time
- Innovation
  - New technology
  - Compare results to build confidence
- Accuracy
  - End consumer will benefit from high accuracy

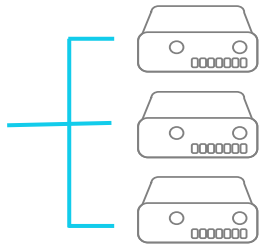
RTL GridMetrix Inertia Measurement

Modulator



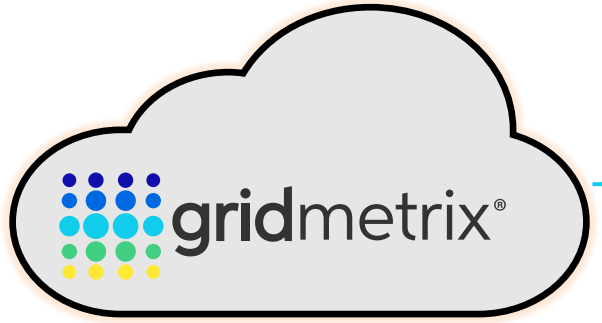
Send small signals through the Grid and extrapolate meaning gives unique insight

eXtensible Measurement Units (XMU)



Wide area monitoring, improved measurement and visibility

Grid Metrix Cloud



Software/infrastructure as a service:

- Analytics to translate measurements into valuable datapoints for Grid operation improvements
- Cloud platform allows for scalability and additional applications to be built from same infrastructure

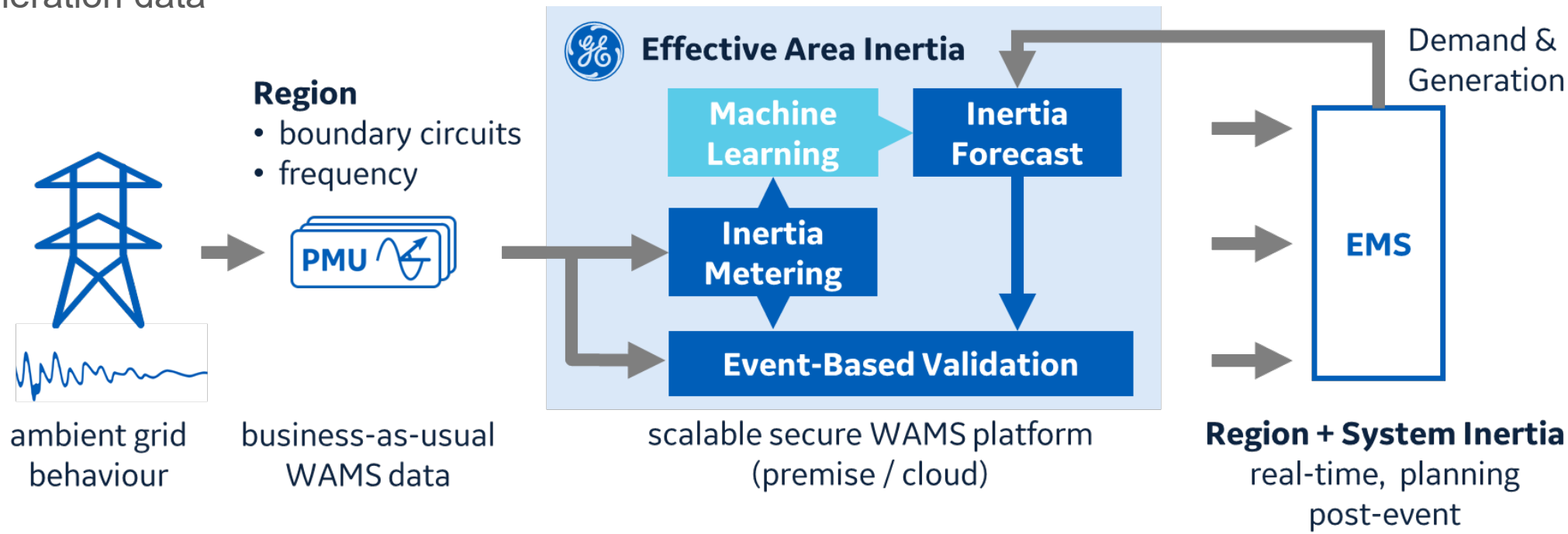
Customer's control centre

RTL GridMetrix Inertia Measurement

- Modulator due on site in July 2021
- Go-Live late summer 2021

GE Digital Effective Inertia Forecasting & Metering

- Initially divide GB into 4 regions - monitor oscillations between regions via frequency and power flow changes
- Machine learning forecasting model uses live operational data for calibration
- Forecasting model integrates Control Room systems to receive same forecasts of demand and generation data



GE Digital Effective Inertia Forecasting & Metering

Summary

- Rapid decarbonisation of the electricity supply is changing the way we need to operate the system
- The ESO is leading the World with our ambition to be able to operate a zero carbon grid by 2025
- New technologies and innovative solutions are coming through multi million pound new markets
- Resulting in maintaining one of the worlds most reliable and fastest decarbonising networks and saving costs for consumers

Questions?