Real-Time System Inertia Monitoring

NASPI Work Group Virtual Meeting

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April 2022

Presentation Topics

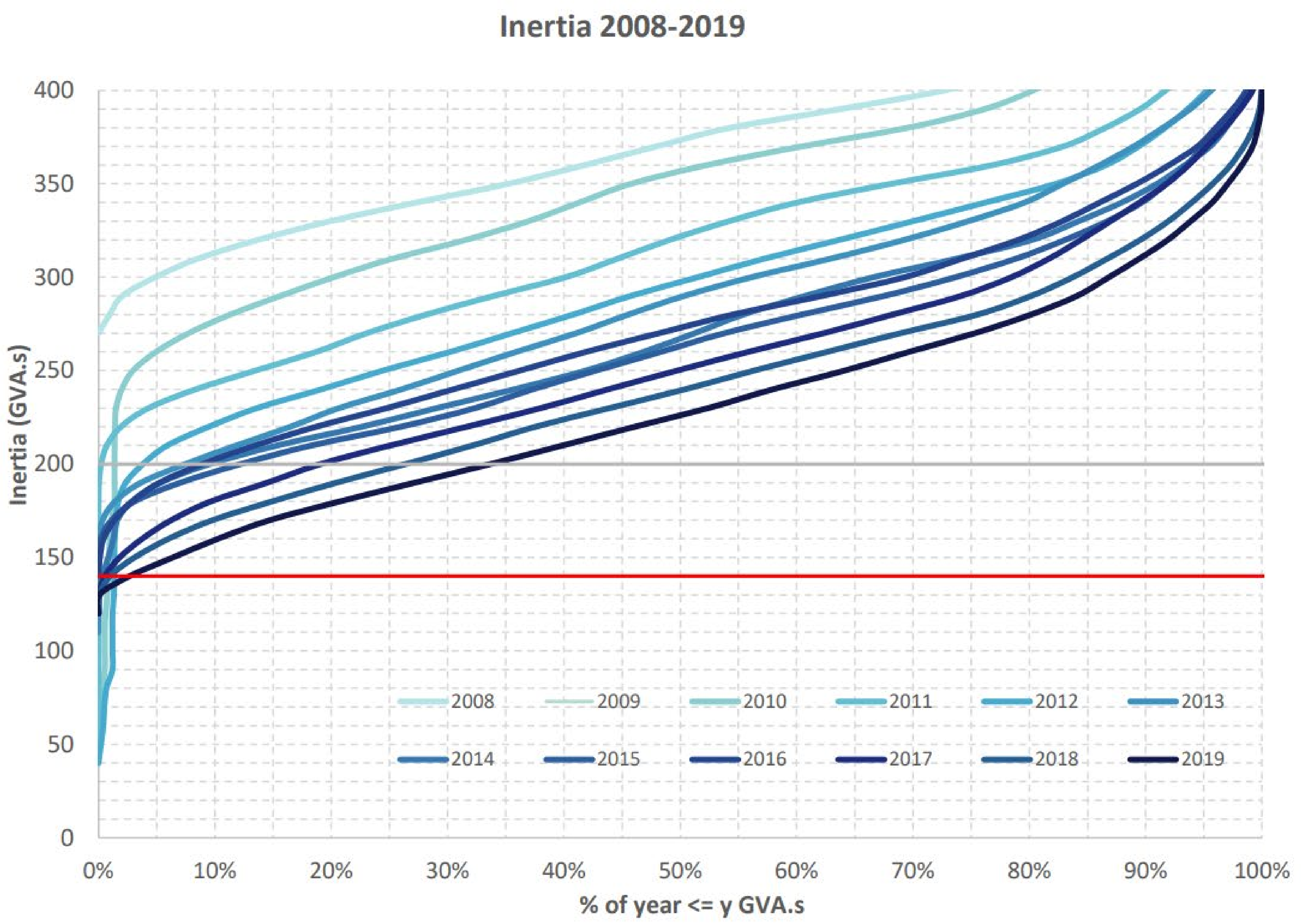
- Revisit traditional and other methods used by grid operators and electric utilities to monitor system inertia.
- Explain how time-synchronized measurements, along with Reactive's unique grid injection signal, can be used to monitor actual inertia levels more accurately than other techniques that are currently in use.
- Demonstrate how Real-Time System Operations personnel can use Reactive's GridMetrix technology to manage risk and identify potential stability issues before they occur.
- Describe the operator training challenges and opportunities associated with integrating such technology into the control room environment.

Traditional Methods for Monitoring Inertia

Until recently, grid operators and electric utilities relied on planning studies to determine the amount synchronous generation that must remain online to maintain BES reliability.

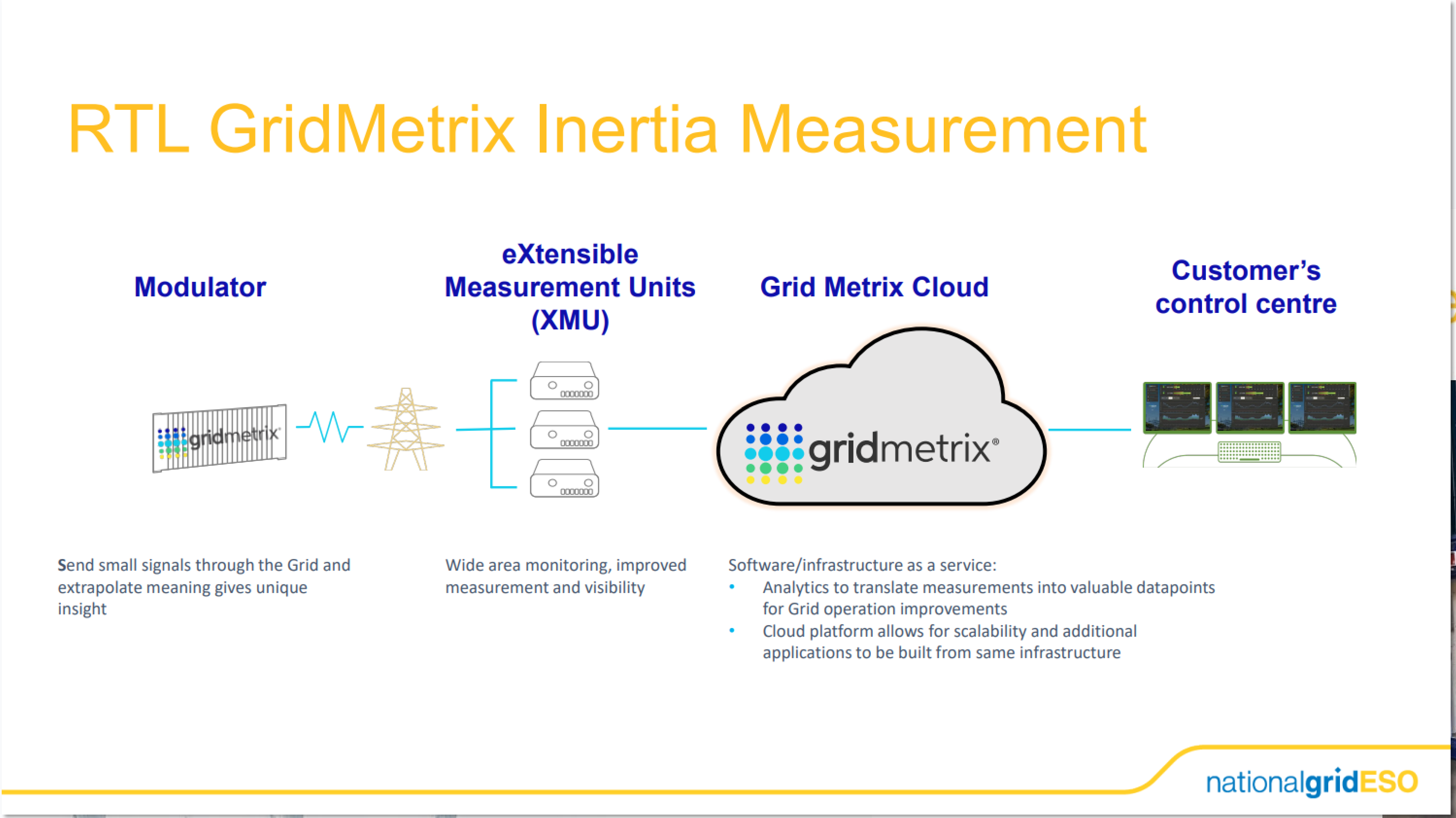
GB Inertia Levels

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



Source: National Grid ESO System Inertia Monitoring Webinar – June 2021

National Grid June 2021 Presentation



Inertia Estimation and Inertia Measurement

Method	Continuous results	Transmission Inertia	Distribution inertia	Accurate Power Measurement	Accurate RoCoF Measurement	Better accuracy at lower inertia?
1 Sum inertia constant on monitored synchronous generators	✓	✓	✗	N/A	N/A	✗
2 Estimation from large frequency excursions	✗	✓	✓	✗	✗	✗
3 Estimation from small frequency excursions	✓	✓	✓	✗	✗	✗
4 Active power injection; real-time inertia measurement	✓	✓	✓	✓	✓	✓

Based on the Swing equation (methods 2–4)

$$E_{sys} = \frac{\Delta P f_o}{2(\frac{df_{sys}}{dt})}$$

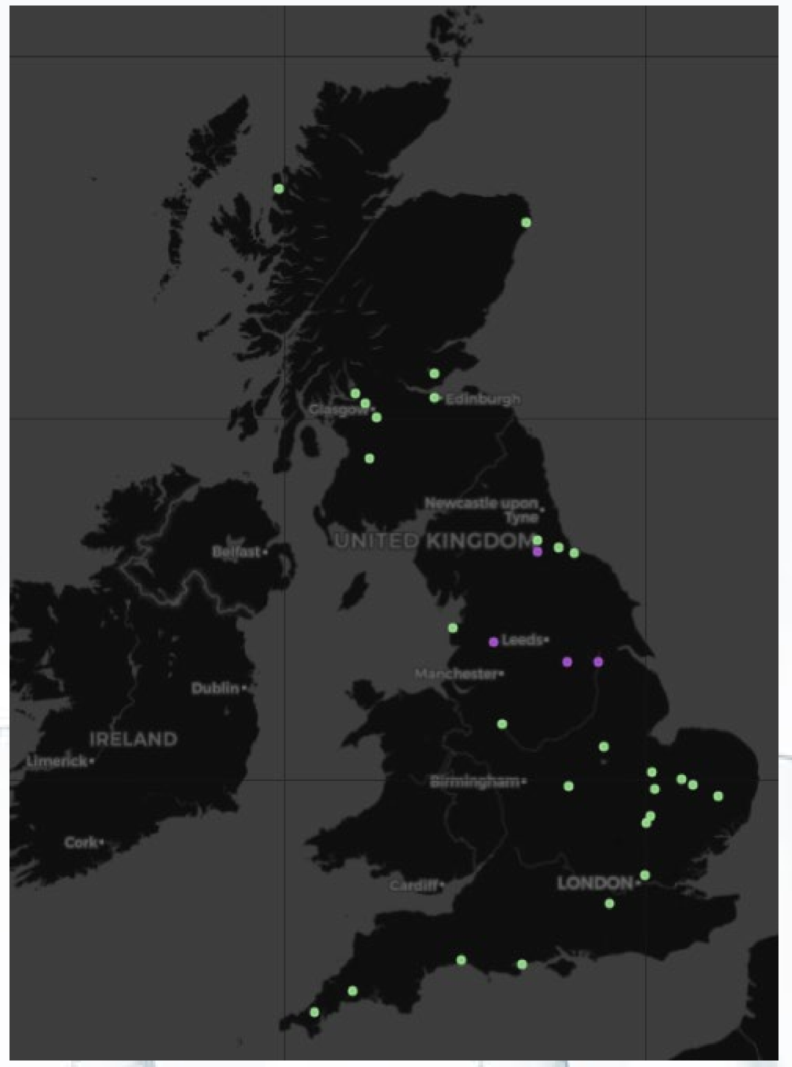
gridmetrix®

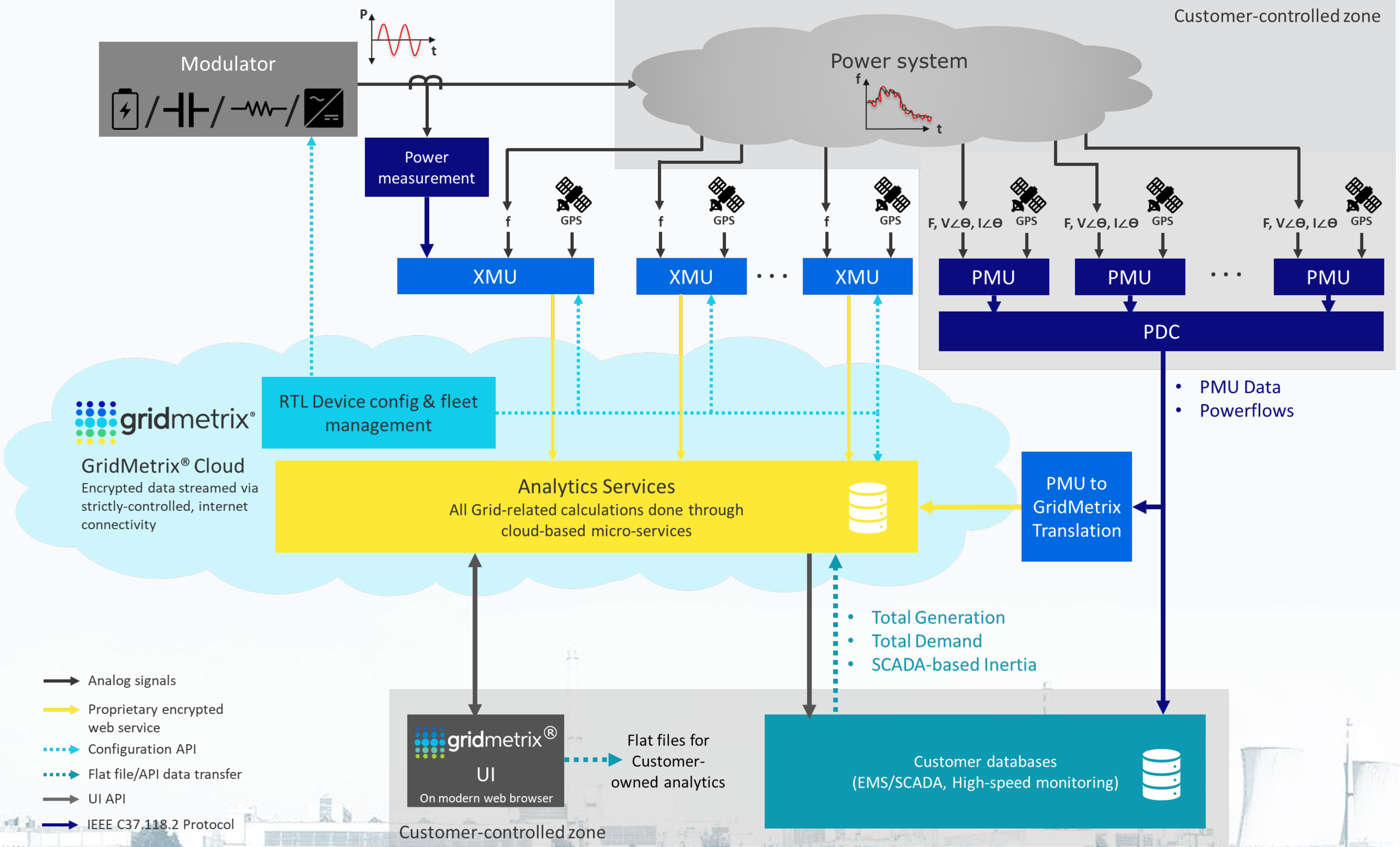
World’s First Grid Stability Measurement System

TRUST REAL DATA

reactive technologies

Overall Reactive Architecture





TOTAL RELIABILITY SOLUTIONS

XMUs supplement PMU measurements rather than replace them

XMU	PMU

• 'Grid edge' measurement
  ◦ Single-phase at 110/220 V
  ◦ Frequency, Voltage, Voltage-angle
• Lower cost device & installation
• More data points -> more insight
• 'Extensible'
  ◦ Firmware can be changed remotely
  ◦ Functionality can change per application
• Cloud connection
  ◦ Quicker installation for piloting
  ◦ Cheaper telecommunications link
  ◦ Scalable to big-data due to cloud-computing and infrastructure
• Technology as a service
  ◦ Lower CAPEX investment
  ◦ Maintenance part of the service
  ◦ Good data without the hassle
	• Transmission-level measurement
	  ◦ 3-phase at >132 kV typically
	  ◦ Frequency, Voltage, Voltage-angle, Current, Current-angle, Power, Reactive Power
	• Expensive cost for device & installation
	• Less data points due to expensive installation
	• Fixed functionality
	  ◦ PMUs boast a lot of functionality, but
	  ◦ This is dependent on its configuration, i.e.
	  ◦ M class or P class depending on application
	• Internal telecommunications connection
	  ◦ Quicker installation for piloting
	  ◦ Expensive telecommunications link
	• High CAPEX costs for
	  ◦ Installation
	  ◦ Maintenance
	  ◦ Upgrade

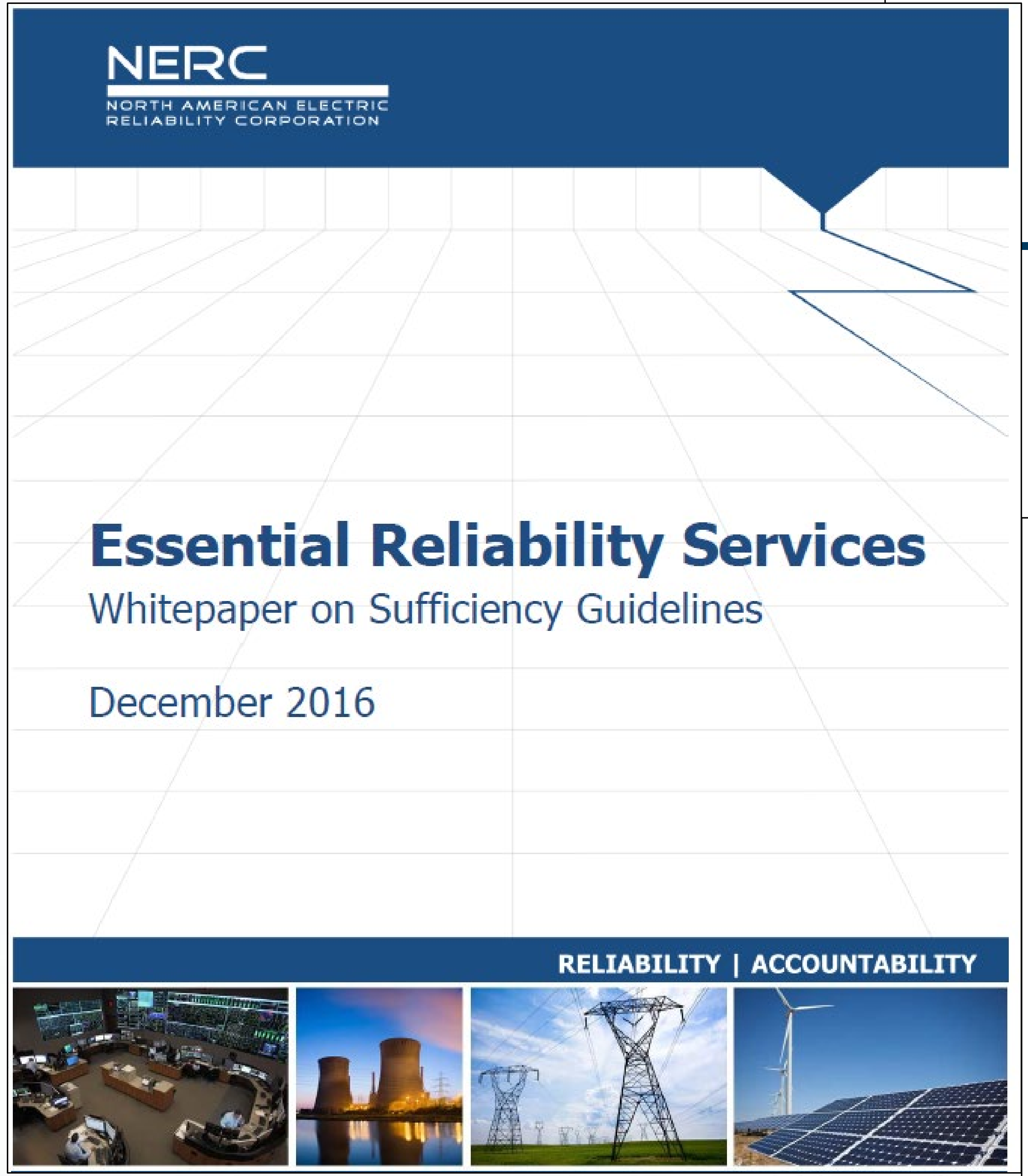
Inertia Measurement User Interface

Operator Training Challenges

- Ensure electric industry trainers meet the knowledge requirements to providing training.
- Define the training needs of System Operations personnel based on assigned roles and responsibilities and expected use of the technology.
- Identify the skills and knowledge that System Operations personnel must have to gain the full benefit of the technology.
- Design training courses that engage learners and keep their attention throughout.
- Implement training in an iterative fashion to deepen knowledge and address changes to required skills/knowledge as the technology evolves.

Meeting Underlying Knowledge Requirements

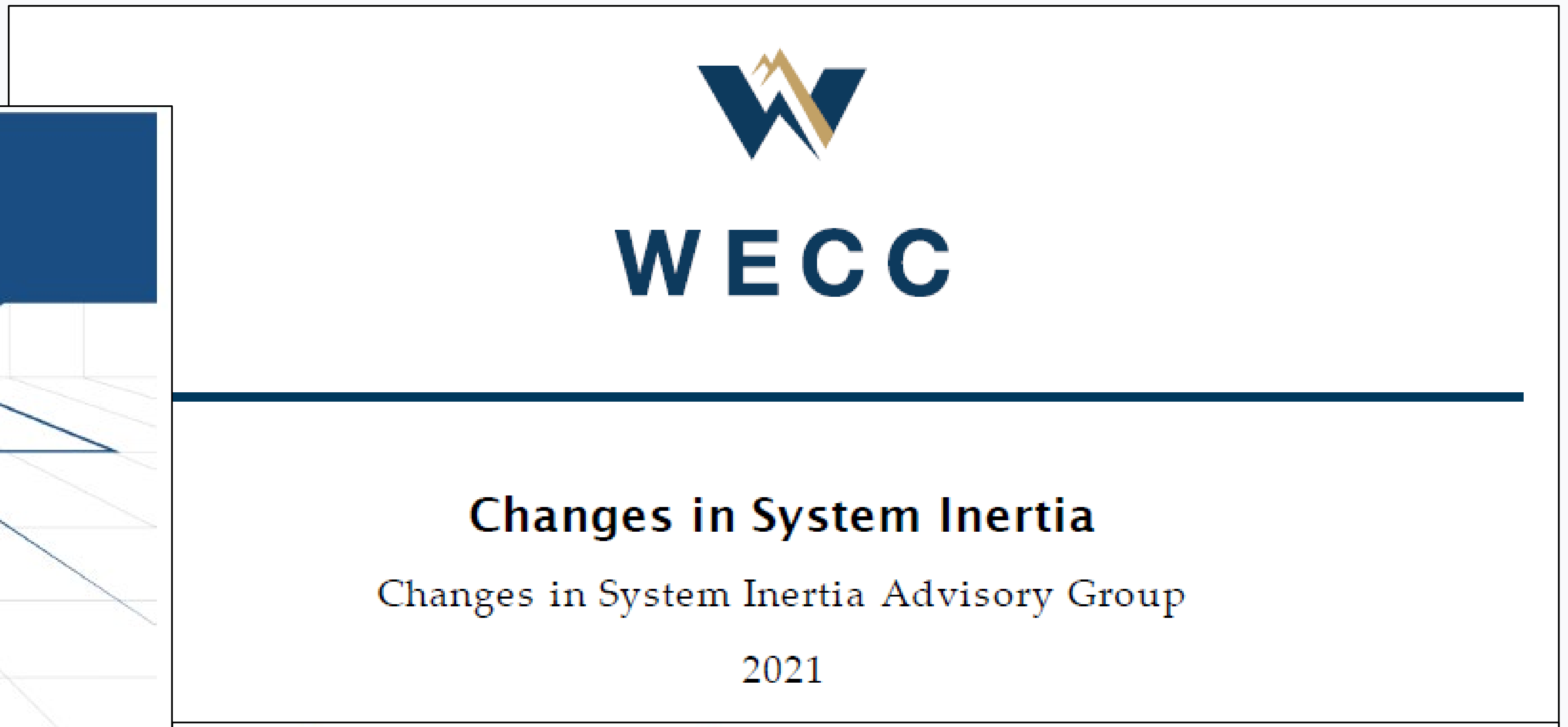
When electric industry trainers are asked to provide training on a new subject, they must perform the research necessary to become knowledgeable on the topic and capable of answering questions that the learners may have.


NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

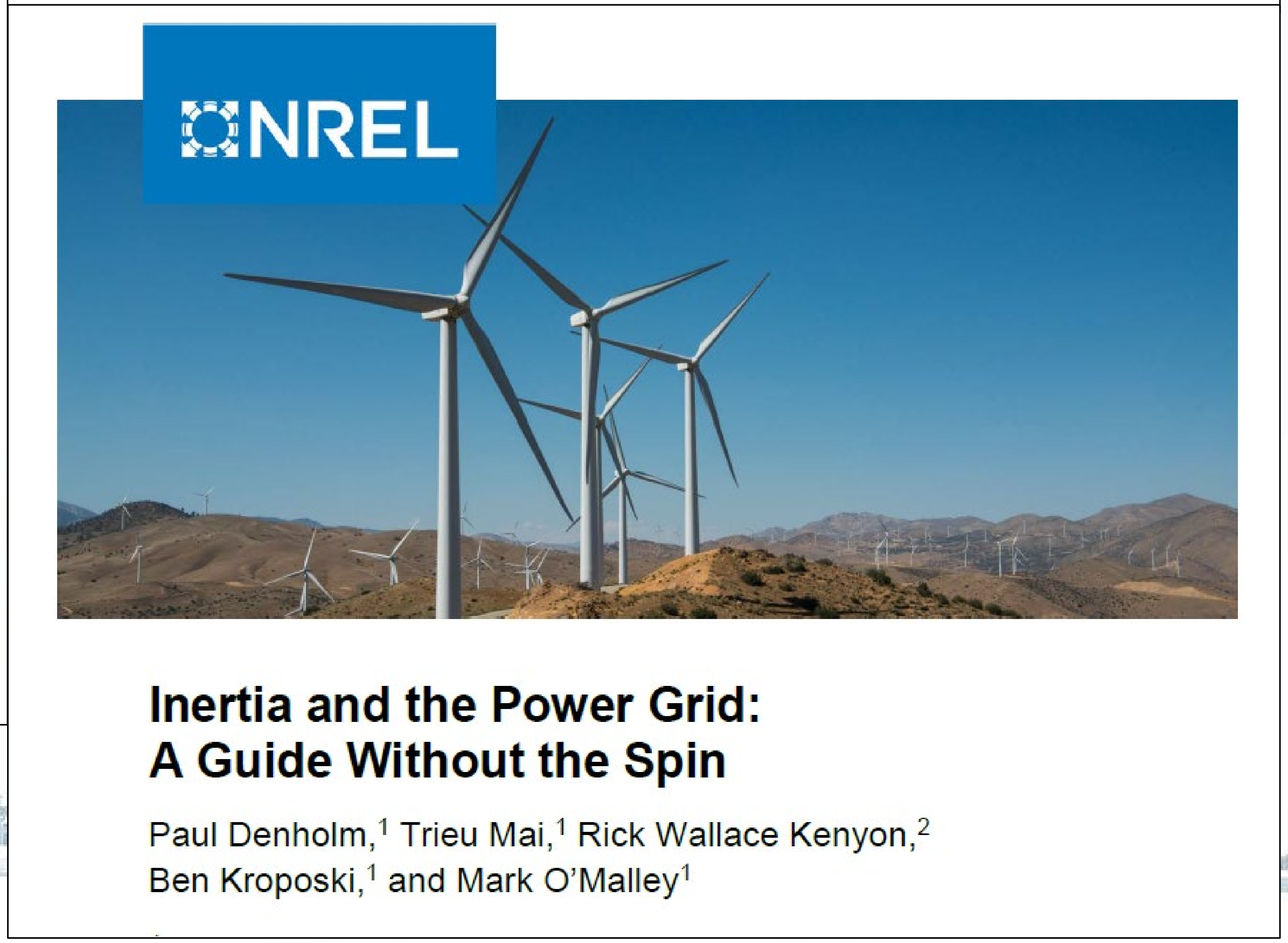
Essential Reliability Services
Whitepaper on Sufficiency Guidelines

December 2016

RELIABILITY | ACCOUNTABILITY


WECC

Changes in System Inertia
Changes in System Inertia Advisory Group
2021

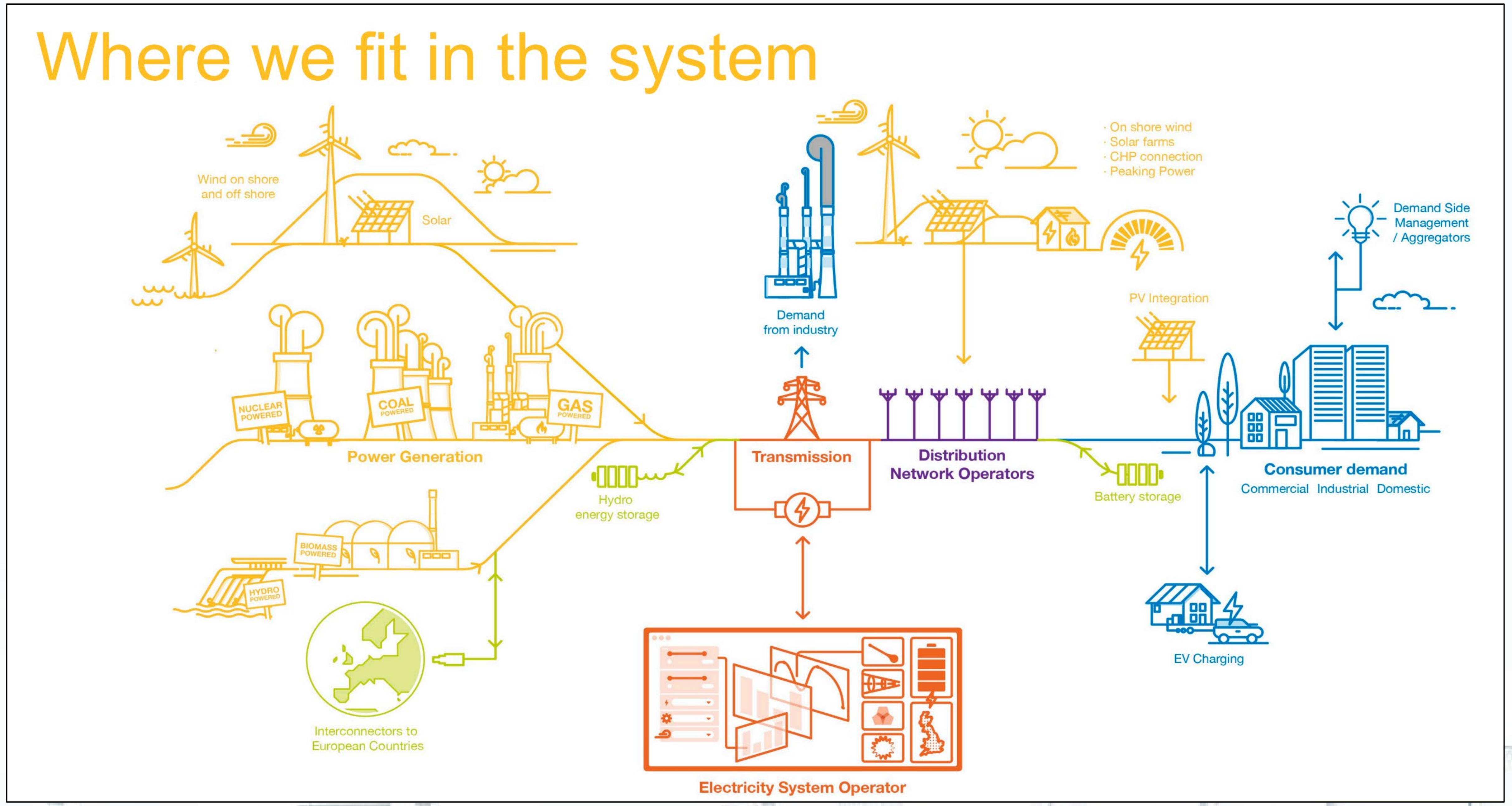

NREL

Inertia and the Power Grid: A Guide Without the Spin

Paul Denholm,[1] Trieu Mai,[1] Rick Wallace Kenyon,[2] Ben Kroposki,[1] and Mark O'Malley[1]

Defining Training Needs of System Ops Personnel

We must define the training needs of System Ops personnel based on their assigned roles and responsibilities and expected use of the technology.



Source: National Grid ESO System Inertia Monitoring Webinar – June 2021

Identifying Skills & Knowledge

Training courses should be designed to provide learners with the skills and knowledge required gain the full benefit of the new technology.

- How are critical systems/tools designed to operate?
- How are learners expected to use the functionality and attributes of the critical systems/tools?
- Which Operating Plans, Procedures and/or Processes will be in place to provide instruction and guidance in the use of the critical systems/tools?
- Have operational use cases been developed to define how users are expected to interact with critical systems/tools and access the data and info needed to identify and address abnormal conditions or unacceptable system performance?

Designing Engaging Training Courses

How can training courses be designed to engage the learners and keep their attention throughout?

Simulated Scenarios – Instruct learners to perform operational tasks with systems/tools and debrief to highlight value add.

Interactive Exercises – Allow learners to interact directly with the new systems/tools, instructor and each other (if possible).

Technical Content – Review electrical theory and fundamental concepts as needed to understand new technology.

Deliver Training in Iterative Fashion

Implement training in an iterative fashion to deepen knowledge and address changes to required skills/knowledge as the technology evolves.

System Inertia Monitoring Training Program (Example)

Use of Time-Synched Measures in Real-Time Ops Horizon – Foundational course to provide an intro to synchrophasor technology and describe the value it can provide in the control room environment.

Oscillation Detection & System Inertia Monitoring – Additional training on specific topics of interest to increase knowledge and encourage additional interaction with associated systems/tools.

System Inertia Monitoring – Emer. Ops Response – Series of additional courses delivered over a longer period to enable learners to continue building knowledge and improving skills. Each course may be based on specific operational scenarios or events where learners must act in accordance with establishing Operating Plans, Procedures and/or processes and used to highlight new functionality and attributes of associated systems/tools.

Contact Information

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