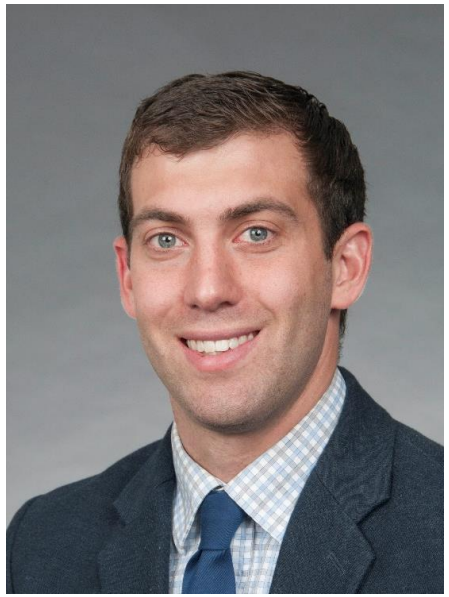
Inertia Ain't All It's Cracked Up to Be

Everything you wanted to know about inertia, but were afraid to ask!

ESIG Tutorial October 1st, 2018

Introducing Today's Speakers



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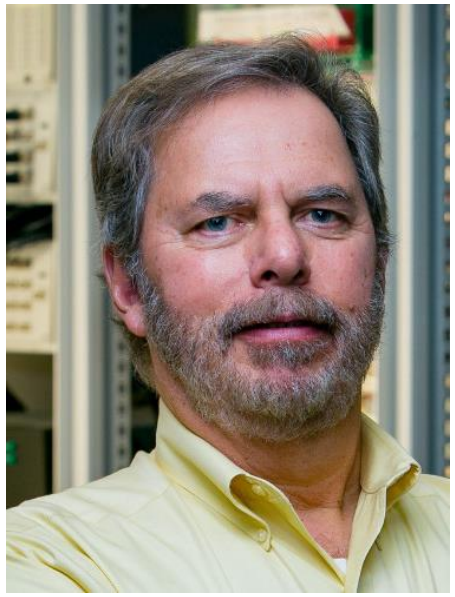

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Ground Rules & Expectations

Keep it conversational

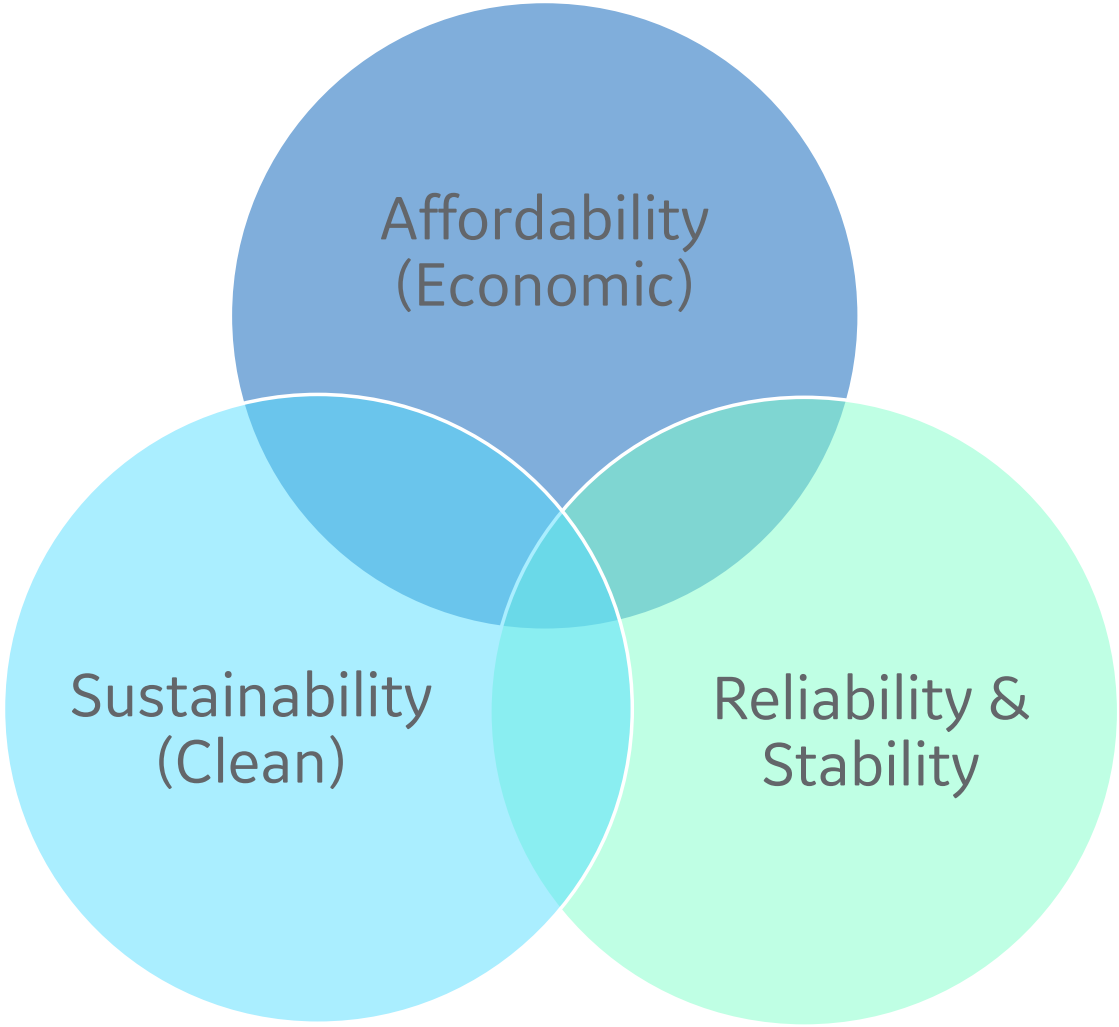
Ask questions, provide feedback

Share your experience, we want to learn what you are doing!

Three Pillars of Power System Planning & Operations

Don’t take reliability and stability for granted!

- Customers want their electricity to be affordable, clean, and reliable … all are important
- Part of a comprehensive analysis for power system planning
- Responds to emergency (contingency) events, not normal operations
- Important at different time scales of system operation; seconds to minutes



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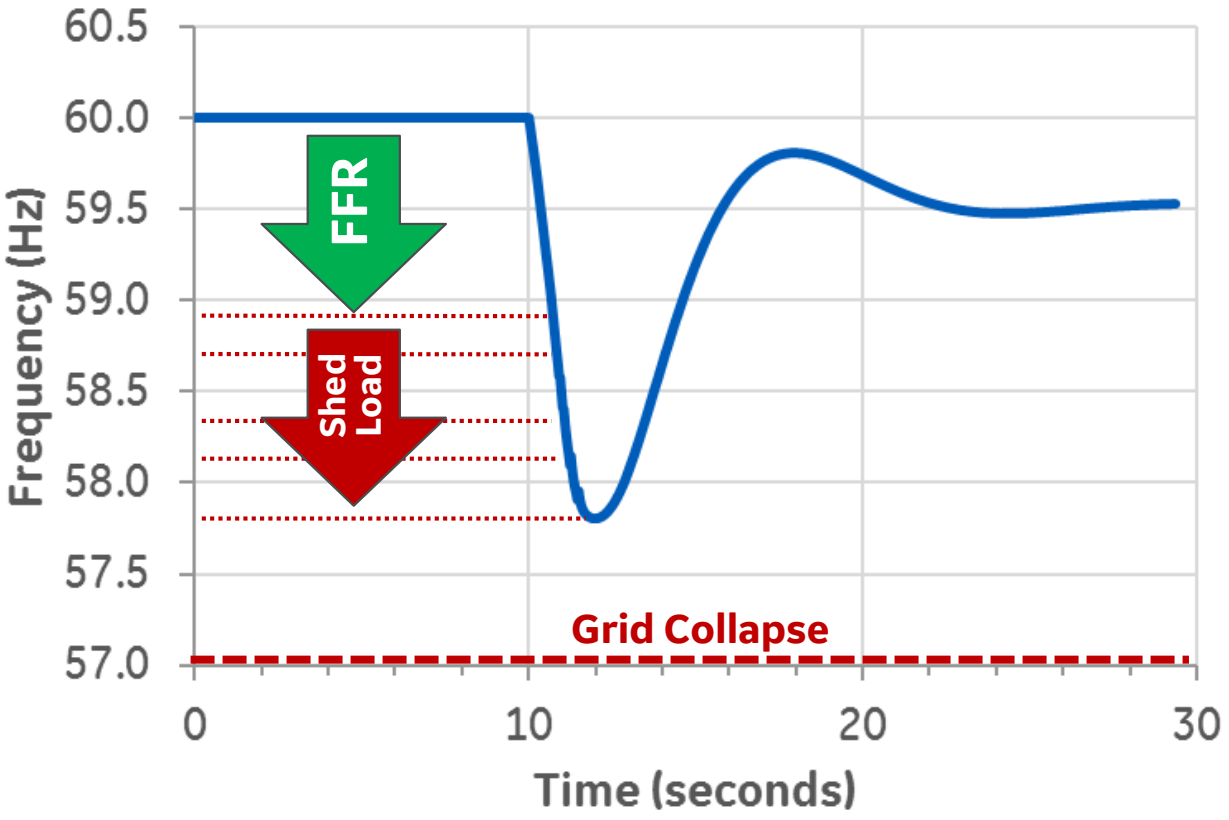
Why Does this Matter?



1. Keep the lights on! Grid **stability** and reliability can not be taken for granted... ever!

2. Dispatch decisions are being made in some places today solely for synchronous inertia... potential **curtailment** and fuel costs!

3. Grid **investments** are being considered globally... are you sure the new asset is giving you what you need?

Managing frequency stability… the overly simplified view

Generation and load must be balanced within ~~seconds~~ cycles to maintain grid stability & wind and solar are eroding the grid's *conventional* approach to maintaining balance. What comes next?

Yesterday

Managed by governor response of fossil generators,

Inertia was a by-product of synchronous fossil based generation,

Grid had sufficient time for governors to respond to events,

Only a concern in very small power systems,

Today

Increased wind and solar is displacing synchronous generation (mostly dispatch),

Grids are becoming lighter, less inertia – frequency moves faster (seconds to respond),

Combined response from sync. inertia, conventional governors and power electronics (UFLS?),

Growing concern in smaller grids and corners of grid with high vRE.

Tomorrow

or today in some places

Synchronous generation is limited (commitment changes),

High RoCoF, limited time to respond to contingency events (cycles to respond),

Requires a *coordinated* response from sync. inertia, and power electronics,

Governor response is too slow to respond, power electronics are doing the heavy lifting,

Future

Synchronous generation is almost non-existent (100% PE?),

Inertia is no longer relied on for balancing generation and load,

Wind, solar, and other power electronics are *grid forming* → provide a functional substitute for synchronous machines…

Full flexibility and capability of inverter technology is deployed.

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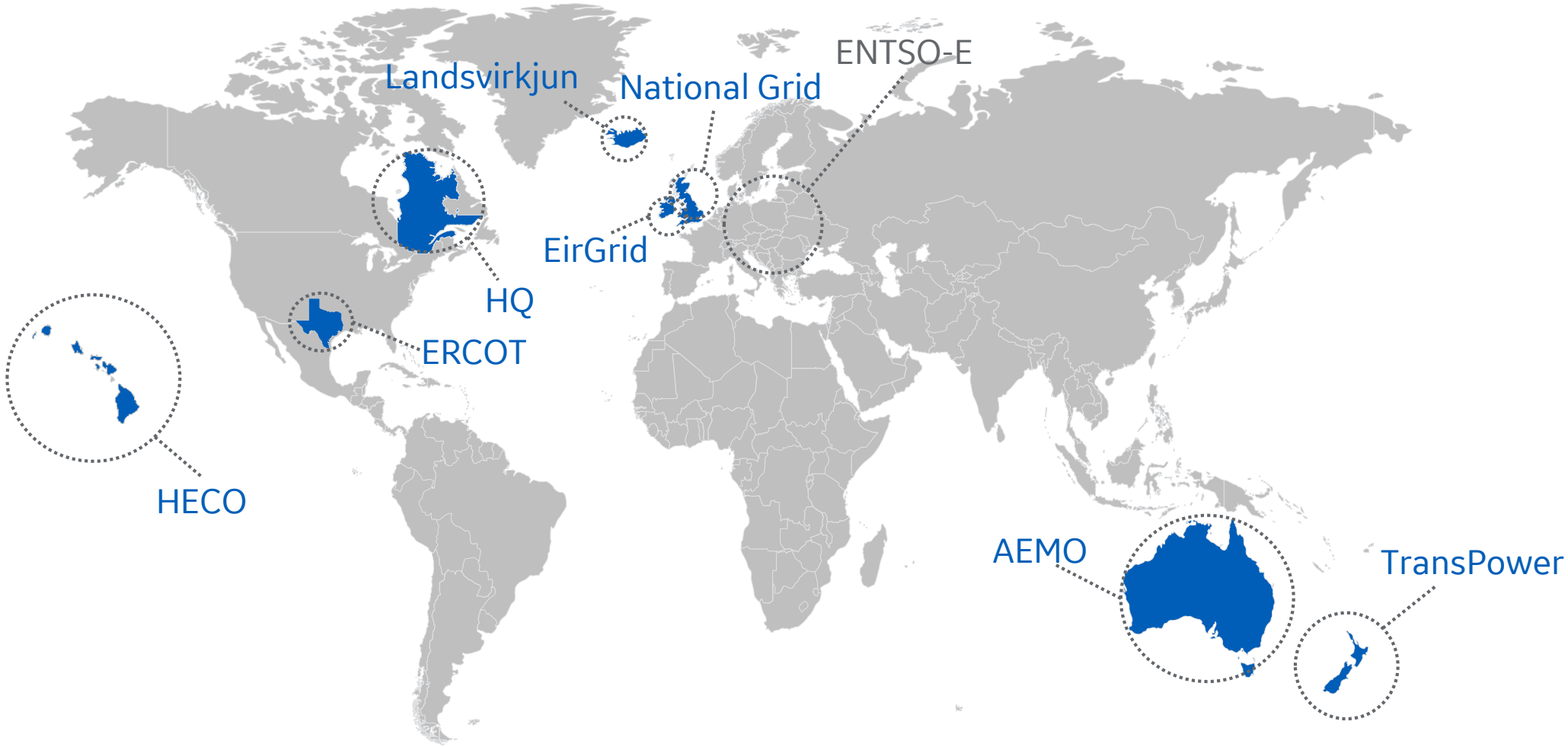
Where are low inertia grids being operated or analyzed today?



Coming Soon to a Grid Near You?

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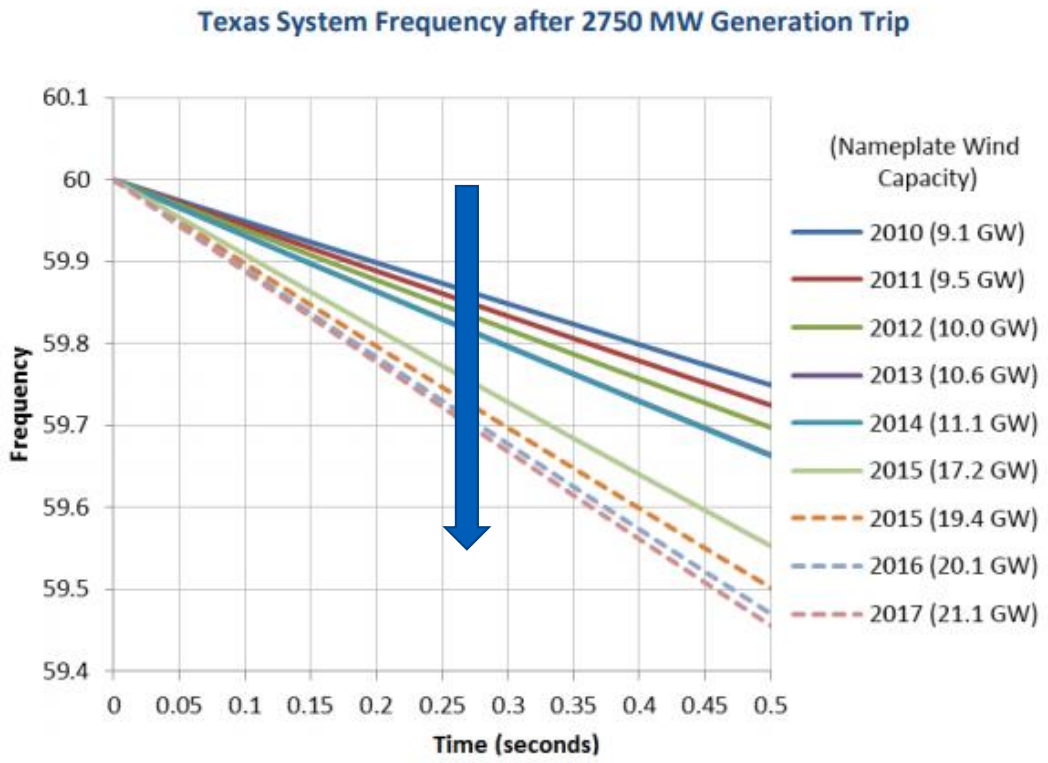
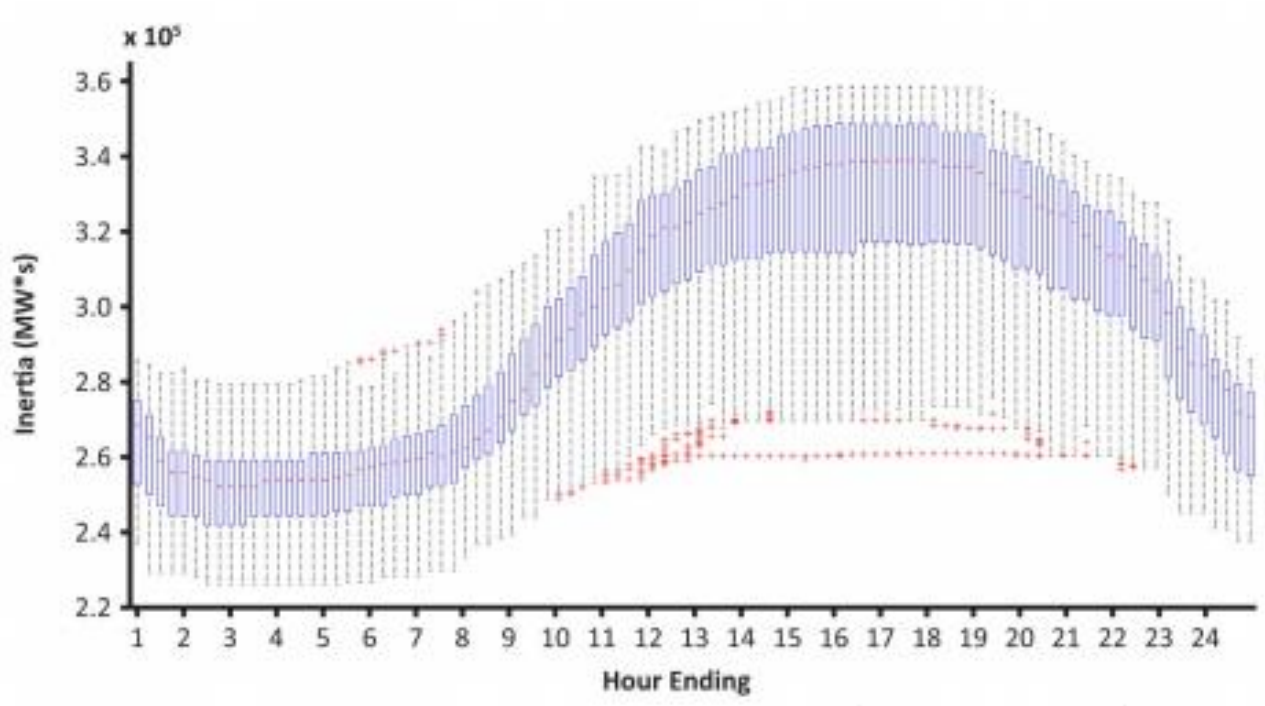
Trends in Low Inertia Operations (ERCOT)



Source: NERC LTRA 2015



Source: NERC LTRA 2016

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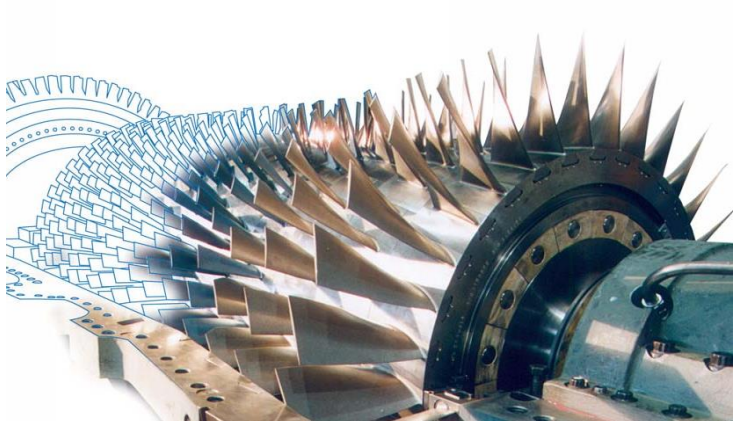
What are the options?



As the grid transitions to power electronic equipment, what are the new sources of frequency control & stability?

Battery Energy Storage

Fast to respond, easy to deploy, but relatively expensive and requires SoC management (power & energy headroom)
other options are available, a resource mix is best…

Wind Turbines

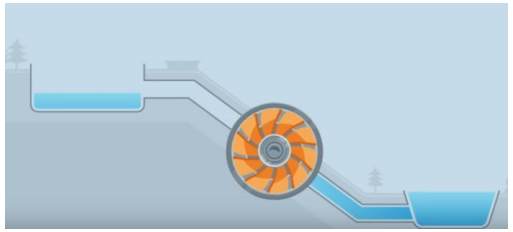
Wind Inertia can provide a short duration (~6sec) response that can be an effective way to arrest system frequency decline…
curtailed wind energy allows longer response for under frequency events, but opportunity cost associated. Very effective for over frequency

Solar PV

Curtailed solar can respond quickly to under frequency events, but opportunity cost associated. Very effective for over frequency.

Frequency Responsive Loads

Demand response can be very effective because it is only required for rare, short duration events. But must be able to detect and respond to frequency deviations locally (no time for communication signals).



Other Options: variable speed pumped hydro, synchronous condensers* and flywheels*

*provide arresting power to respond quickly to changes in system frequency, but must be coupled with longer duration resources

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Workshop Agenda

8:15 – 8:45	Common Definitions, What's What, Matt Richwine
8:45 – 9:15	Island Grid Perspective, Matt Richwine
9:15 – 10:00	Large System Perspective, Nick Miller
10:00 – 10:30	Coffee Break
10:30 – 11:00	Market Design, Derek Stenclik
11:00 – 11:40	System Operator Experience, Sandip Sharma
11:40 – 12:00	Open Discussion & Questions