Grid Stability Services

Fact Active Power Services – Recent Learnings

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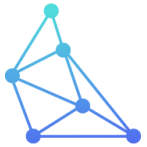

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Fast Active Power Service

Objective:

Define a metric for measuring the active power response of a resource to fast changes in voltage angle / frequency

With Attributes:

- Technology-agonistic (works for SM, GFL, GFM, loads, anything)
- Relates to our conventional understanding of fast active power response (i.e., synchronous machine-based inertia)
- Easy to determine
- Simple to understand

What we considered

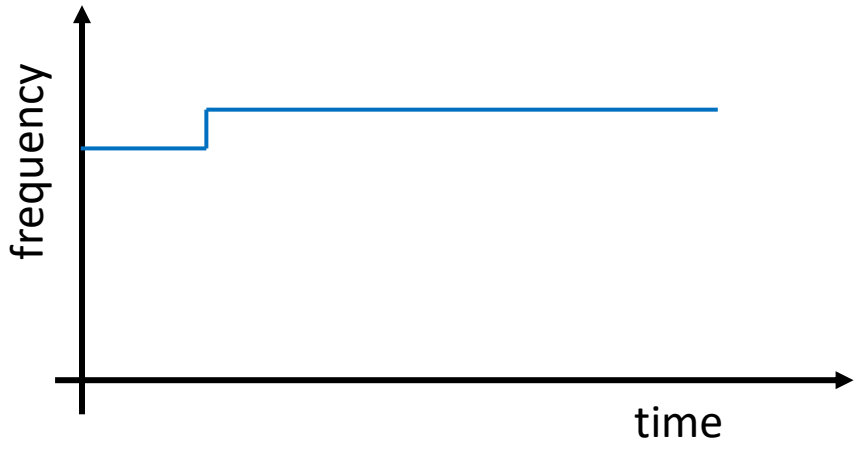
Evaluate the Active Power response to:

- Frequency Steps
- Frequency Perturbations
- Phase Jumps
- Frequency Ramps

Frequency Steps

Pros

- Technology-agnostic
- Simple to understand and apply



Cons

- Not simple physics for fast timeframes
  - Measuring frequency in fast timeframes can be tricky
  - Possibly mixed in phase jumps – care needed to apply in simulation
- Difficult to relate closely to synchronous machinery inertia
  - Electrical frequency is NOT rotor speed in short time-frames
  - Inertia relates to mechanical speed

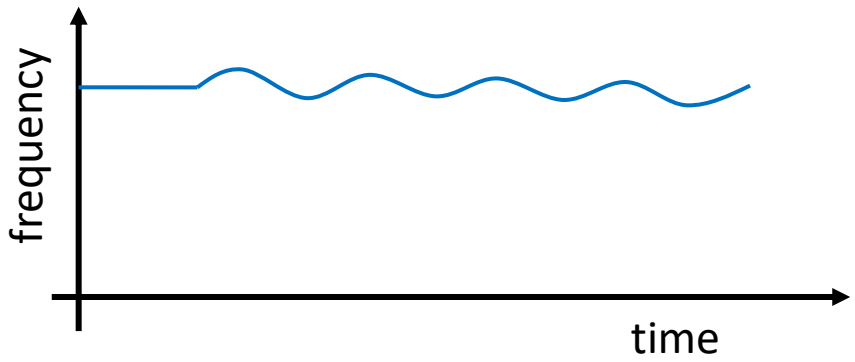
Frequency Perturbations (Sinusoidal)

Pros

- Technology-agnostic
- More accuracy on timeframes of response (well-suited for frequency domain analysis)
- Avoids complications of phase jumps

Cons

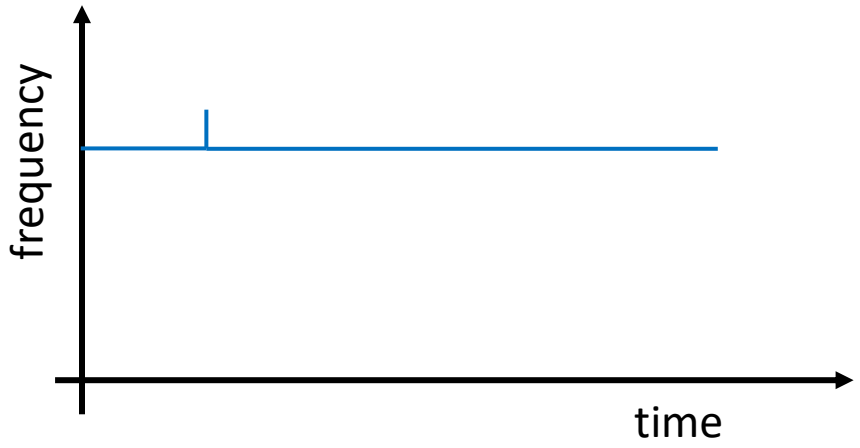
- Less simple to understand
- More complicated to apply
- Does not relate closely to synchronous machinery inertia for fast time-frames



Phase Jumps

Pros

- Technology-agnostic
- Simple to apply



Cons

- Less simple to understand
- Phase Jump Power is more indicative of EM phenomena (not what we are looking for)
- Phase Jump Energy does not relate closely to synchronous machinery inertia for fast time-frames

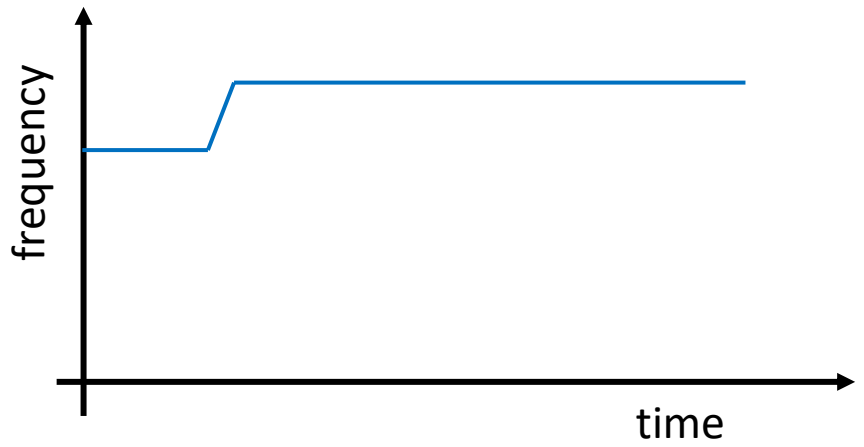
Frequency Ramps

Pros

- Technology-agnostic
- Simple to apply
- Simple to understand
- Relates closely to synchronous machine inertia constants

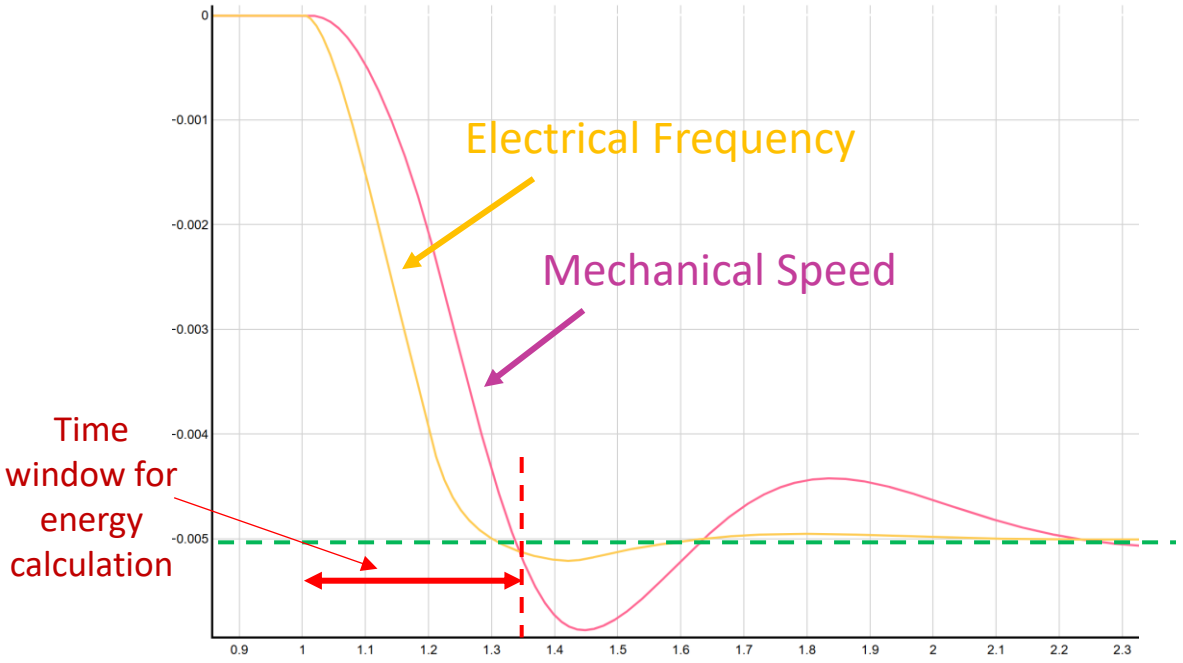
Cons

- Some adjustments needed for GFL resources

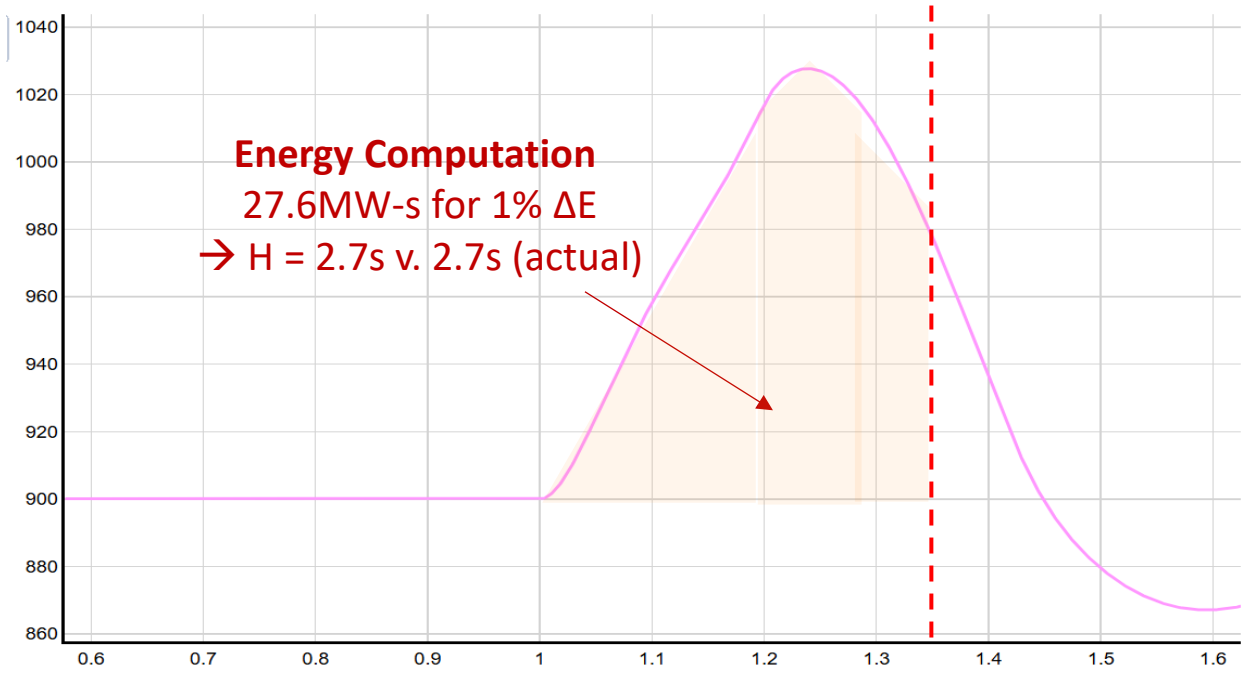


Preliminary Results of Frequency Ramp, SM

Frequency → 0.5% speed change, ~1% energy change



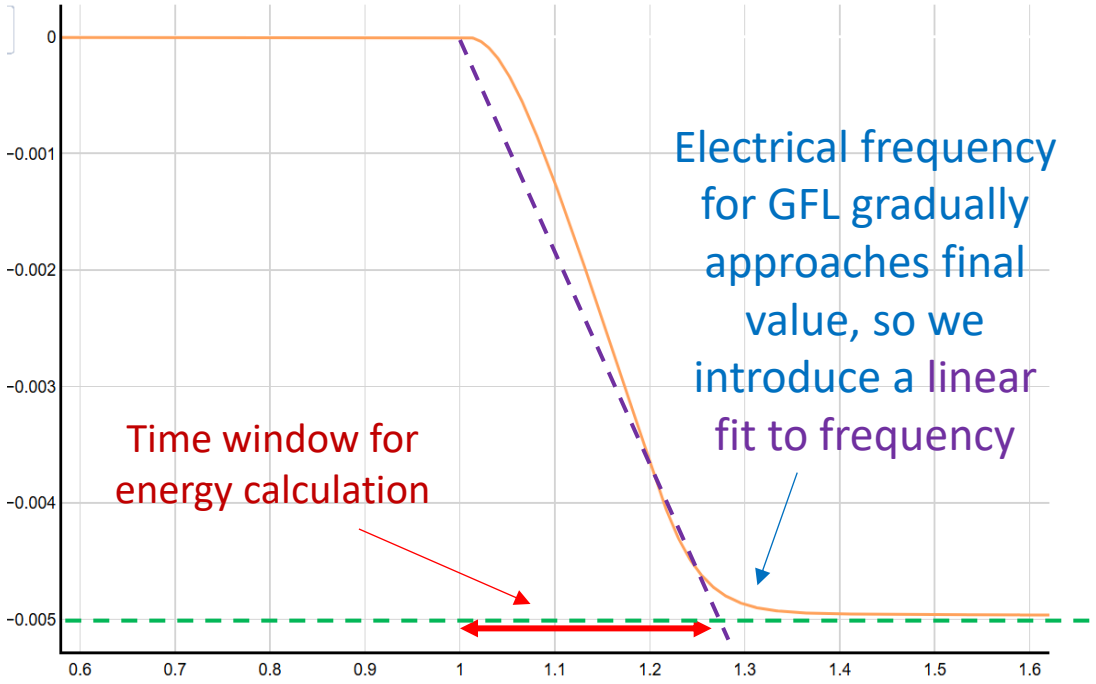
Active Power Response, Synchronous Machine



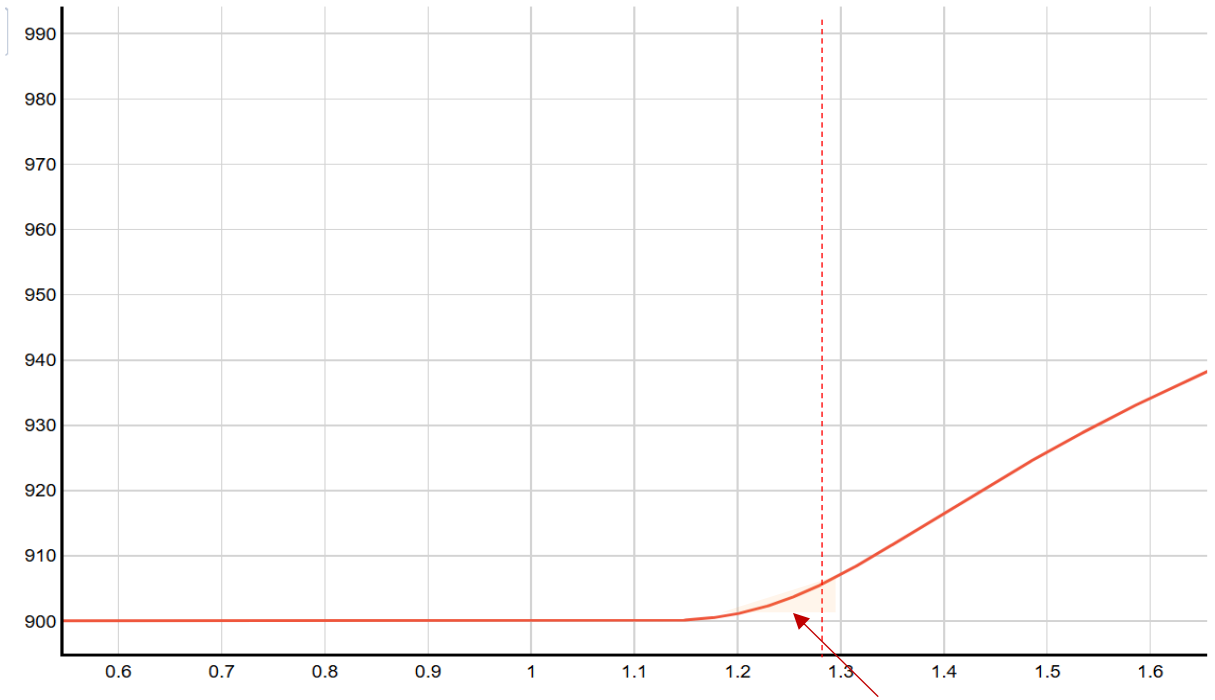
Near-identical match with model inertia parameter; however…
mechanical speed is not a technology-agnostic signal! So we pivot to electrical frequency…

Preliminary Results of Frequency Ramp, GFL

Frequency → 0.5% speed change, ~1% energy change



Active Power Response, GFL



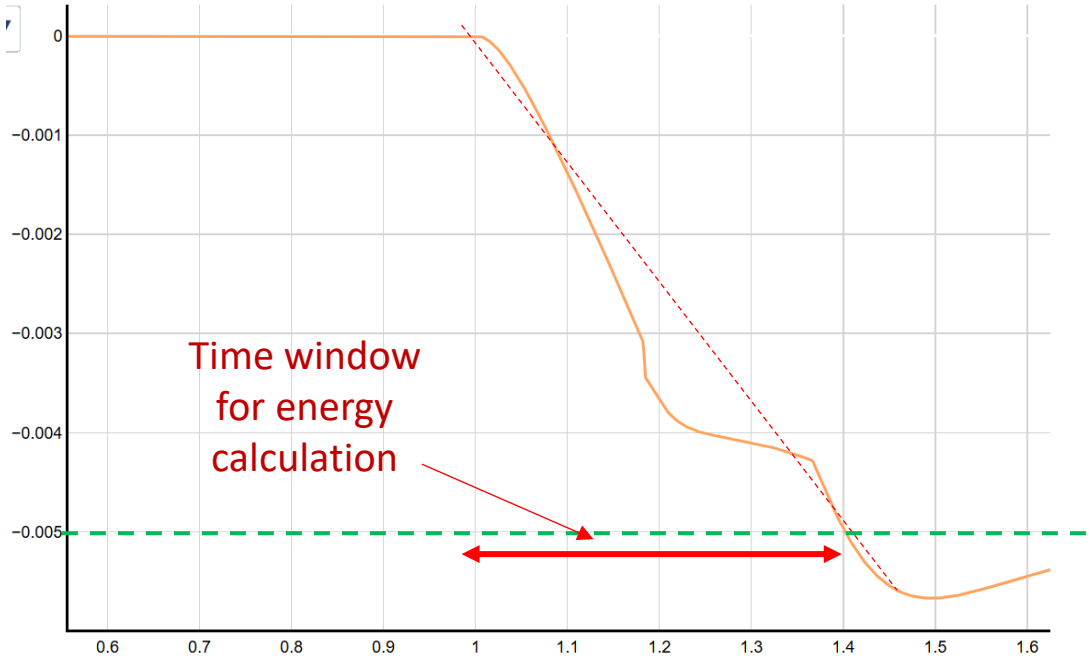
Energy Computation

0.4MW-s for 1% ΔE

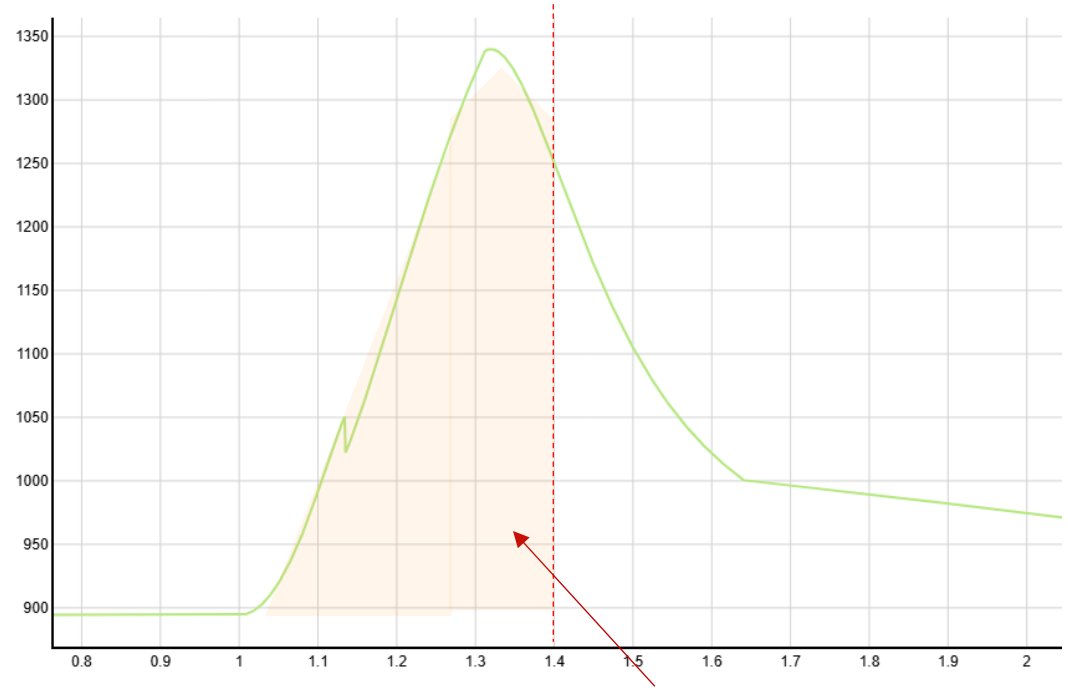
→ H_{eq} = 0.04s

Preliminary Results of Frequency Ramp, GFM

Frequency → 0.5% speed change, ~1% energy change



Active Power Response, GFM



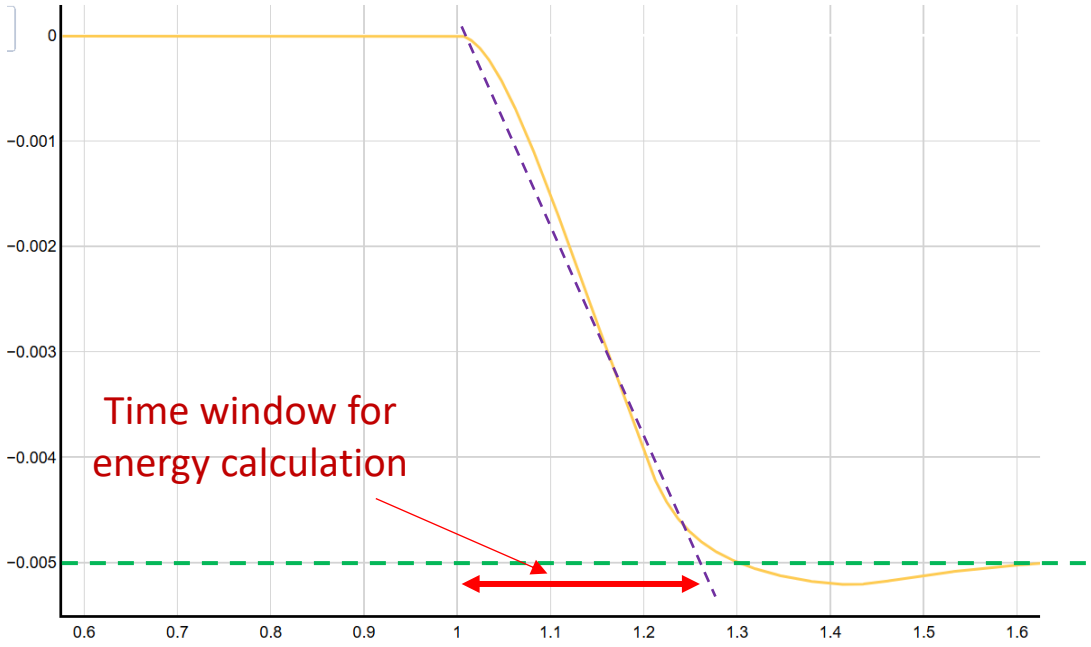
Energy Computation

77MW-s for 1% ΔE

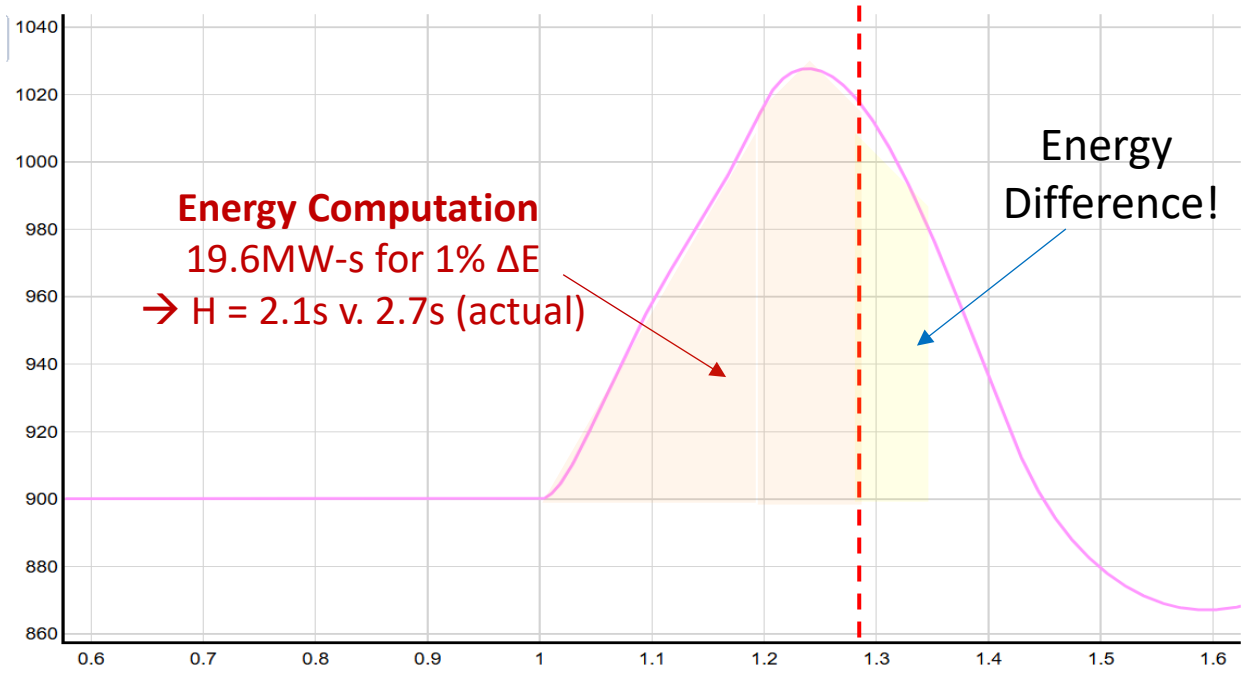
→ H_{eq} = 7.7s

Revisiting Frequency Ramp for SM

Frequency → 0.5% speed change, ~1% energy change



Active Power Response, Synchronous Machine



Using a fit with electrical frequency for SMs does not correspond as closely to the H constant

More refinement is needed for a technology-agnostic measure of fast-active power service that corresponds with inertia

Thank You! Questions?

Special thanks to the support provided by EPRI and TVA!

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