

# GE Energy Consulting

Evaluation of the need for limitations  
on resources providing RRS-PFR



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[GEEnergyConsulting.com](http://GEEnergyConsulting.com)



**GE Reservoir Solutions**

[www.GEPower.com/EnergyStorage](http://www.GEPower.com/EnergyStorage)





## STUDY QUESTION:

*What limits should be defined for new resources providing primary frequency response (PFR) in ERCOT?*

- 1 | Overview
- 2 | Study objectives, process and key deliverables



# GE Energy Consulting

Power system experts for >100 years

~120 grid experts  
9 countries  
>100 patents



## 1 INTEGRATED STUDIES

**Economic analysis** | grid value of technology

**Network strategy** | complex grid interconnection

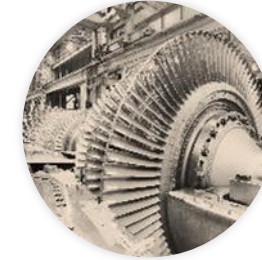
**Equipment integration** | voltage and frequency performance



System planning and strategy  
Financial modeling and forecasting



Stability studies  
Network risk assessment  
Grid upgrades



Interconnection support  
Grid code testing and compliance

## 2 MODELS

Planning  
years



Transients  
microseconds

## 3 SOFTWARE



**Capacity**  
GE MARS\*



**Energy**  
GE MAPS\*



**Power flow**  
GE PSLF\*

GE technology | 1/3 earth's power | #1 clean energy fleet

# Evaluate need for new PFR limits given likely risks

## *Targeted approach to simulations*



### Hypothesize likely risk areas

#### **Systemic risks** ... overall system reliability

1. Frequency response obligation (FRO) met?
2. Instabilities? e.g. oscillations, load-shedding, interactions
3. Resilient? e.g. vulnerable to single point of failure

#### **Locational risks** ... limitations due to location?

1. Inter-area stable? e.g. area constraints, oscillations, UFLS
2. Inter-equipment stable? e.g. control interactions
3. Locally resilient? e.g. local point of failure

#### **Other risks**

1. Modeling risk? e.g. shortcomings w/generic models
2. Procurement risk? e.g. transmission limitations
3. Under-performance risk? e.g. deployment failure
4. Torsional risk? e.g. w/synchronous generators
5. Protection risk

### Design scenarios to assess

#### **Dispatch condition**

1 scenarios ... TO BE DETERMINED (e.g. low/high load)

#### **Droop setting**

2 scenarios ... TO BE DETERMINED (e.g. 1%, 5%)

#### **Droop gain**

2 scenarios ... TO BE DETERMINED (e.g. low/high)

#### **Locational factors**

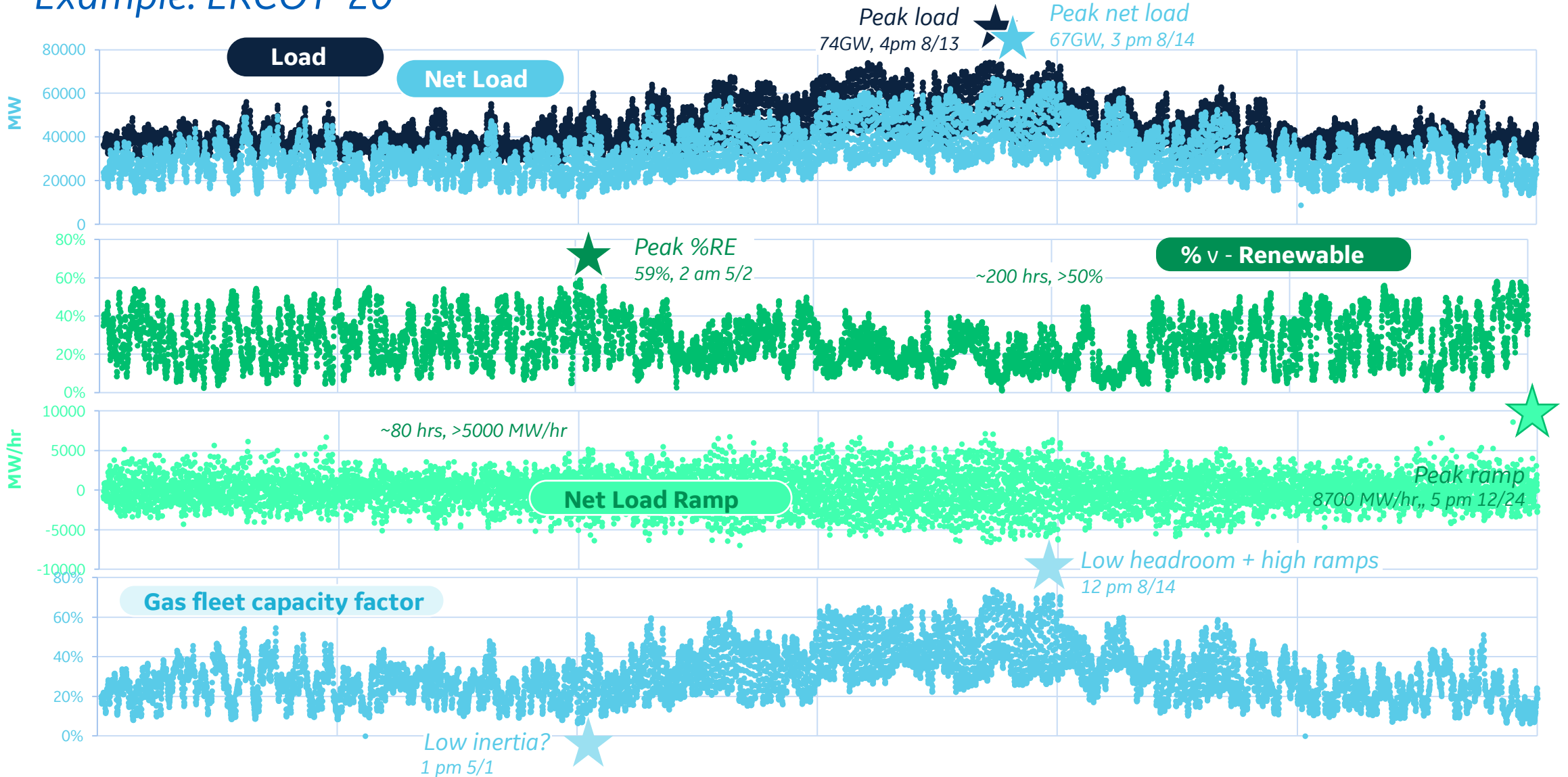
4 scenarios ... TO BE DETERMINED (e.g. low/high diversity, co-location w/load or generators)

—  
**Design an experiment of 16 +16 scenarios to evaluate risks**

# Are there other dispatch conditions to consider?



## Example: ERCOT '20



# First deliverable

## Preliminary recommendations

### Simulations

**Power flow and dynamic stability**  
(50 scenarios)

**Small signal stability**  
(selected scenarios)



### Risk screening

**Post processing tools** (e.g. torsional, locational, damping)

**Down-selection:** Some risks dismissed, some elevated

Risk types		50 scenarios							
		1	2	3	...	48	49	50	
Systemic	FRO met?	●	●	●		●	●	●	
	Stable?	●	●	●		●	●	●	
	Resilient?	●	●	●		●	●	●	
Locational	Inter-area stable?	●	●	●		●	●	●	
	Inter-equipment stable?	●	●	●		●	●	●	
	Locally resilient?	●	●	●		●	●	●	
Other	Torsional risk?	●	●	●		●	●	●	
	Modelling risk?	●	●	●		●	●	●	
	Procurement risk?	●	●	●		●	●	●	
	Under-performance risk?	●	●	●		●	●	●	

## Recommendations

... if current ERCOT procurement is not ok

### Individual resource qualification

- **Resource qualification criteria** (e.g. frequency control validation, torsional screening w/nearby synchronous machines)
- **System impact analysis & mitigation** (e.g. site specific gain limits, add'l controls, protection)
- **Re-study criteria** (e.g. new topology, change in control or rating)

### Procurement (e.g. amt/locational requirements)

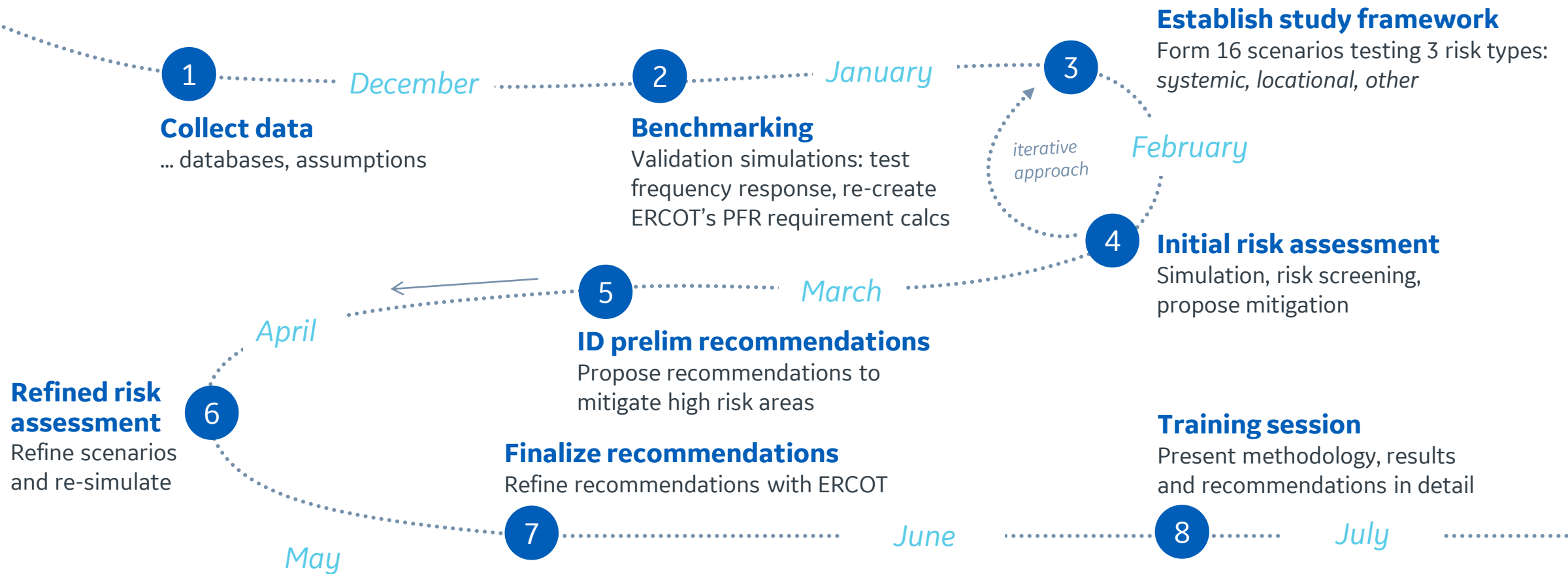
- **Overlap w/FFR** product?
- **Add'l limits:** locational, performance (e.g. transient gains limited), proximity (e.g. SCR or other resource proximity)
- **Efficacy:** high response resources ↓ PFR need while clustering of resources may ↑ need

### Operational (e.g. is current monitoring enough?)

- **New monitoring metrics** (e.g.  $K_t$ ,  $R_{frac}$ , etc.)
- **Extreme event** needs
- **Commitment and dispatch**/headroom and footroom availability
- **Updates to rules/procedures** for PFR limit management
- Adherence of individual resources to PFR delivery obligations

# ERCOT-GE collaborative study approach

*Hypothesize risks, evaluate, mitigate ... repeat!*





# Project schedule & deliverables

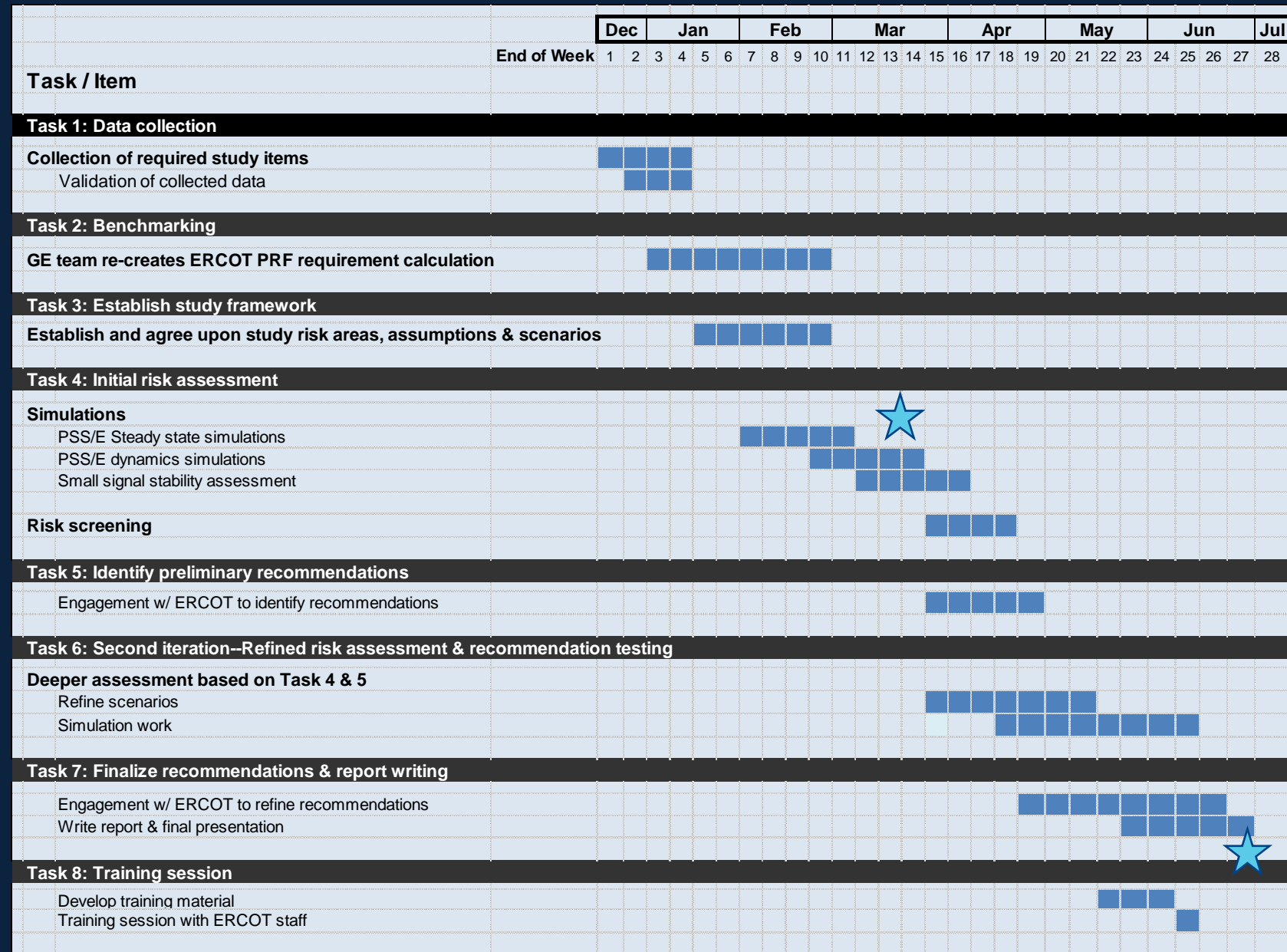
## ERCOT Engagement

Monthly pacing meetings

Data collection

Strategy sessions

1. Benchmarking
2. Scenario development
3. Identify recommendations



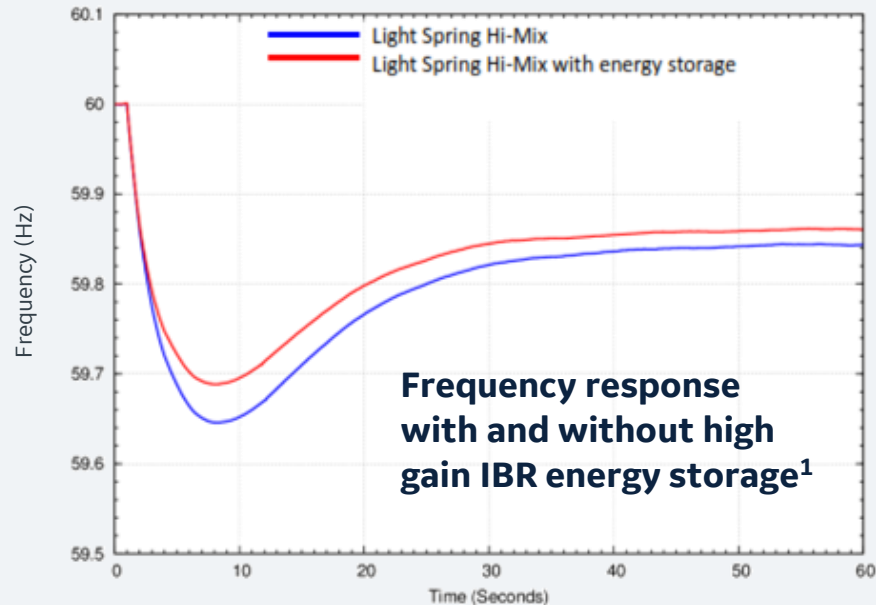
TOP DELIVERABLES

Prelim results presentation

Final Results presentation



# We've studied using IBRs for PFR before ... *though every system is different*



**Figure 16.** Frequency response to two Palo Verde unit trip for Light Spring Hi-Mix – with and without energy storage.

## Top GE studies relevant to this study question:

### 1. Western wind and solar integration studies<sup>1</sup>

- Investigation of PFR and stability risks w/high wind and solar
- Examined PFR and FRR from batteries and IBR generation

### 2. Eastern frequency response study<sup>2</sup>

- First industry study highlighting divergence of EI system models for frequency response from observed behavior
- Investigated contributions and challenges (e.g. governor squelch) of IBRs towards PFR and FRR

### 3. Hawaii

- Investigated utilizing batteries for PFR in coordination w/a commercial wind plant subject to strict operating constraints of small island system

<sup>1</sup> GE for NREL “Western Wind and Solar Integration Study Phase 3 – Frequency Response and Transient Stability” <http://www.nrel.gov/docs/fy15osti/62906.pdf>

<sup>2</sup> GE for NREL “Eastern Frequency Response Study”, June 2013; <http://www.nrel.gov/docs/fy13osti/58077.pdf>

**We have also enabled interconnection of  
>70GW wind, solar and batteries globally**



Building a world that works

# GE Renewable integration study references (page 1 of 2)



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