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Microgrid Islanding with CHP The Evolution of a Project

Chuck Heidt (GRU)

Kyle Peterson (GRU)

Michael Dempsey (BMcD)

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Agenda

To provide a high level overview of the history of CHP at GRU South Energy Center and the considerations of islanding multiple generators under varying conditions.

- ▶ GRU/Shands Partnership
- ▶ SEC Configuration
- ▶ Phase 1 Islanding
- ▶ Phase 2 Islanding
- ▶ Stability Analysis
- ▶ Operational Restrictions

In the Beginning.....

- ▶ 2006 Master Plan
 - Phase 1:
 - ▶ Cancer Hospital (200 Beds)
 - ▶ 500,000 SF
 - ▶ Level 1 Trauma
 - 35 Year Plan
 - ▶ 3,000,000 SF
 - ▶ 1200 bed
 - ▶ 15 MW of Generation
 - ▶ 16,000 Tons of Cooling



GRU/Shands Partnership

- ▶ Partnership between hospital and municipal utility
- ▶ Combined heat & power for efficient generation of utilities
- ▶ Multiple levels of redundancy
 - Capable to fully island
 - Capable of providing all critical loads
- ▶ Fully load diesel generators during testing
- ▶ CHP yields 80% efficient operation
- ▶ Hospital achieved LEED Gold certification thanks to Energy Center



Phase 1 Complete

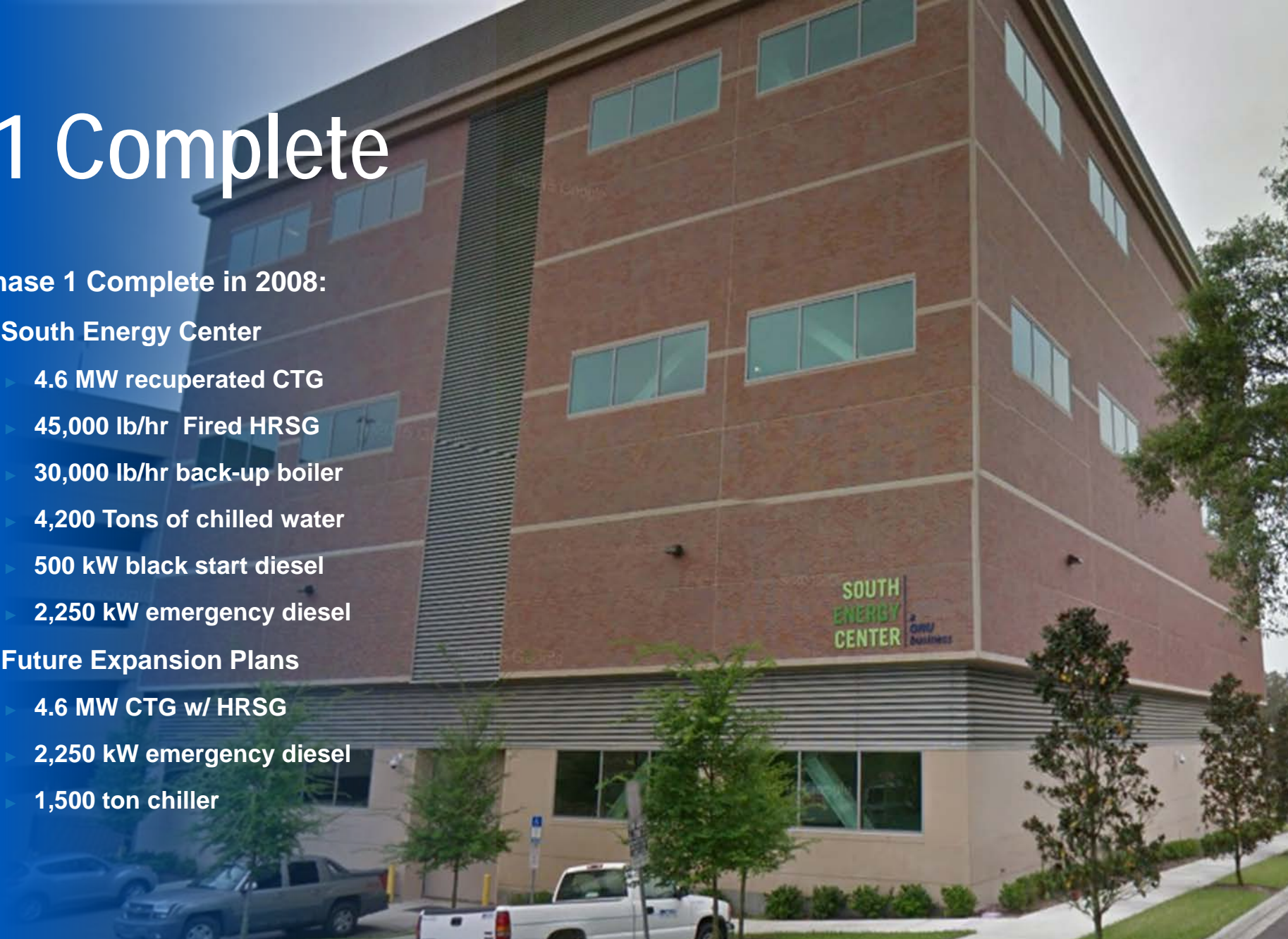
- ▶ **Phase 1 Complete in 2008:**

- **South Energy Center**

- ▶ 4.6 MW recuperated CTG
- ▶ 45,000 lb/hr Fired HRSG
- ▶ 30,000 lb/hr back-up boiler
- ▶ 4,200 Tons of chilled water
- ▶ 500 kW black start diesel
- ▶ 2,250 kW emergency diesel

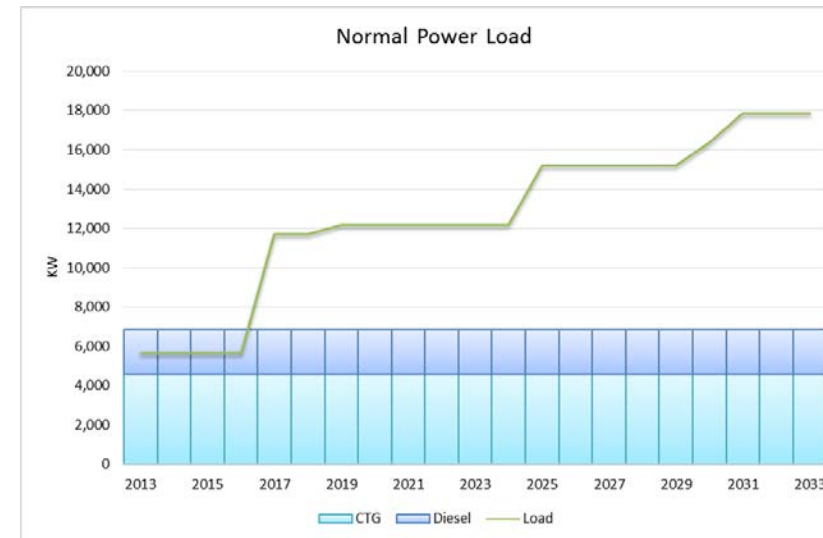
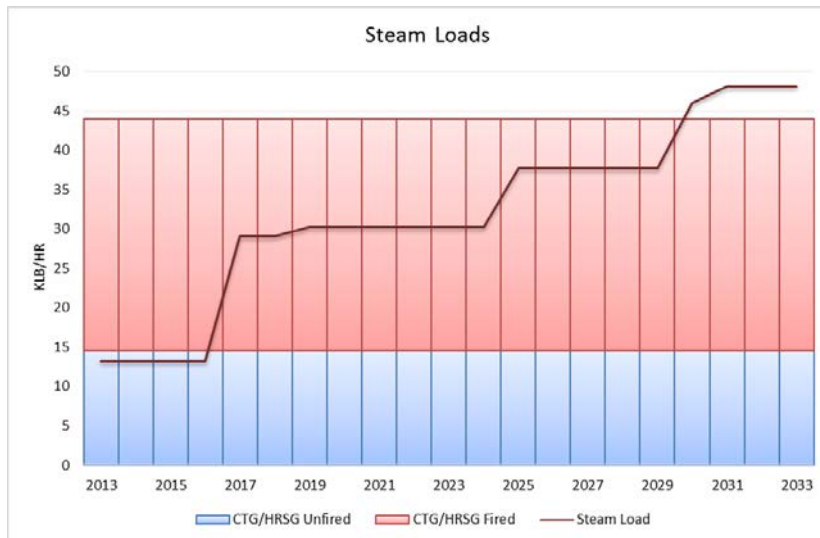
- **Future Expansion Plans**

- ▶ 4.6 MW CTG w/ HRSG
- ▶ 2,250 kW emergency diesel
- ▶ 1,500 ton chiller



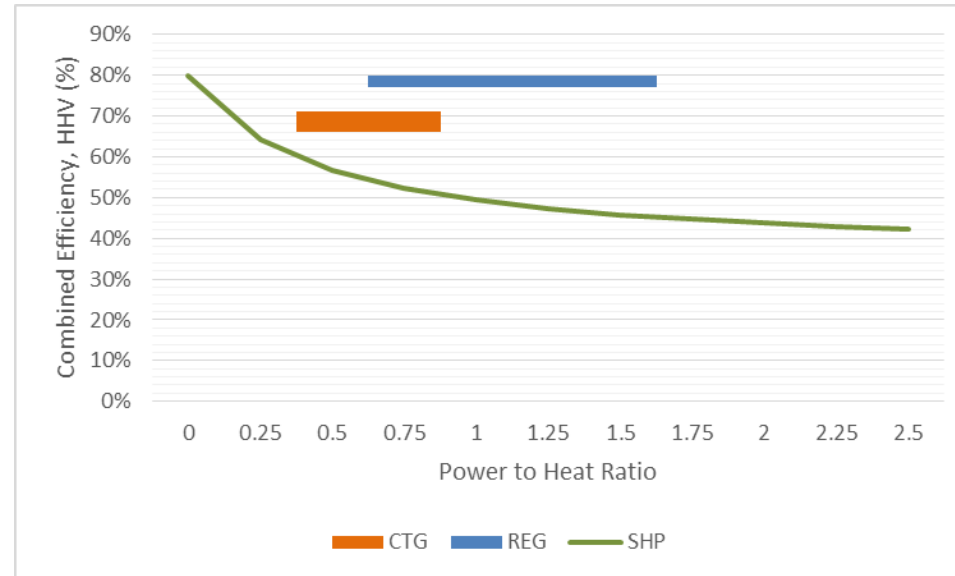
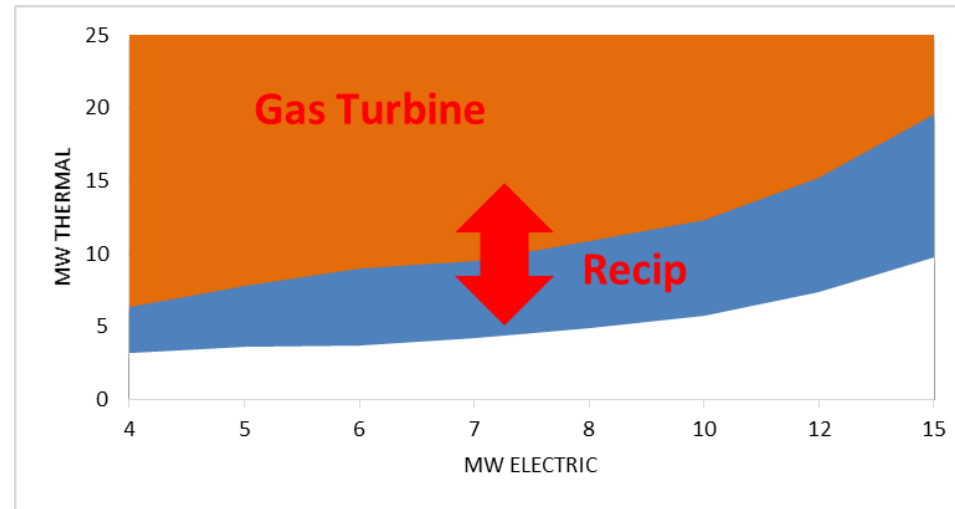
Phase 2 – SEC Expansion

- ▶ Expansion Feasibility Study
 - ▶ Original calculated thermal loads ~ 30% greater than actual loads
 - ▶ SEC had excess steam capacity
 - ▶ Needed chilled water and power generation capacity
 - ▶ Evaluated **CTG** and **Reciprocating Engine(REG)** based CHP addition



Gas Turbine		
MW	MWt	Power / Heat
3.5	6.3	0.553
4.6	7.8	0.590
5.7	8.9	0.638
6.3	9.5	0.666
8.0	10.9	0.736

Recip		
MW	MWt	Power / Heat
4.0	3.8	1.041
4.5	4.2	1.071
5.4	3.7	1.456
6.5	5.8	1.123
7.4	4.9	1.523



- *Recip. thermal performance based on availability to recover engine heat*

Wartsila 16V34SG

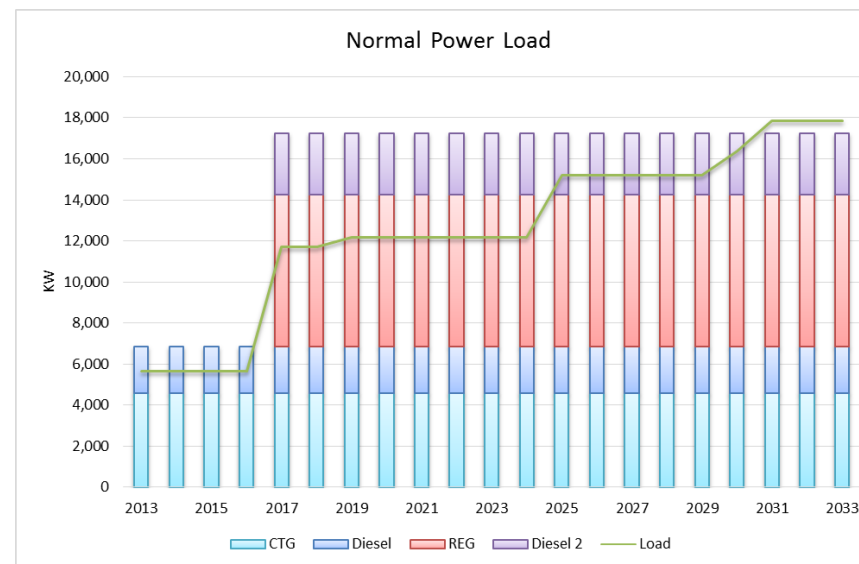
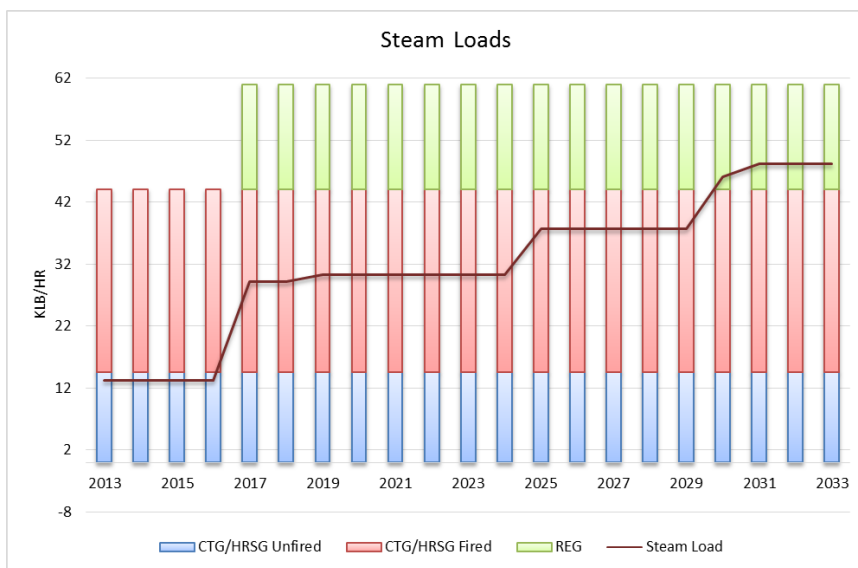
- 7.4 MW Power Generation
- 8,775 lb/hr 110 psig steam
- 8,500 MBH of 140°F- 160°F

Hot Water

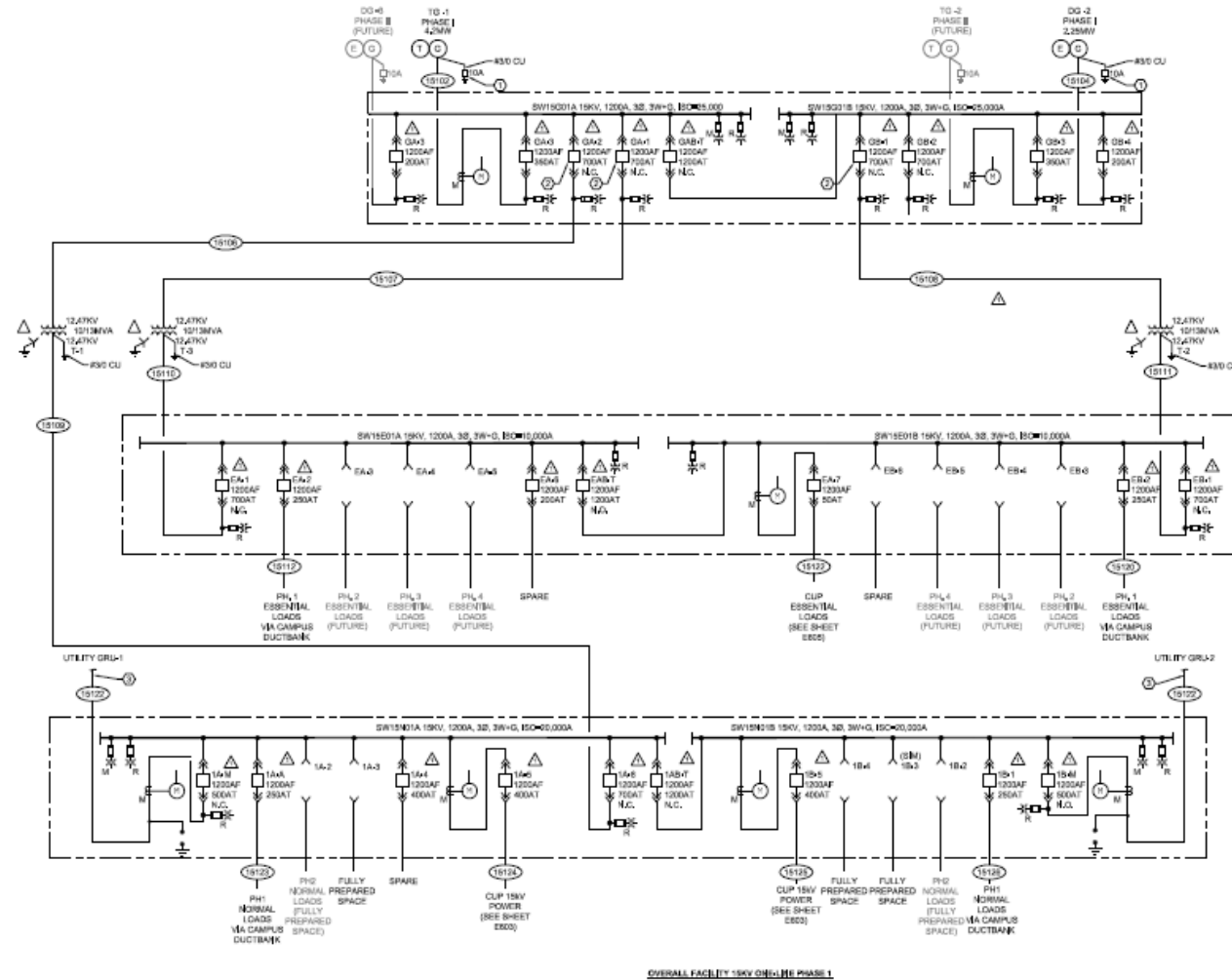


Phase 2 – SEC Expansion

- ▶ Load Impact
 - ▶ Excess steam/hot water capacity throughout the full load projections
 - ▶ Power generation capacity to serve normal power loads over the next 10-15 years
 - ▶ Most likely future expansion will be driven by critical power and chilled water demand

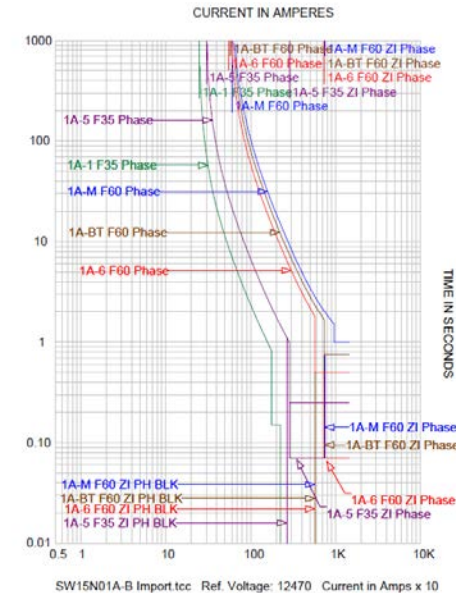


Phase 1 Arrangement

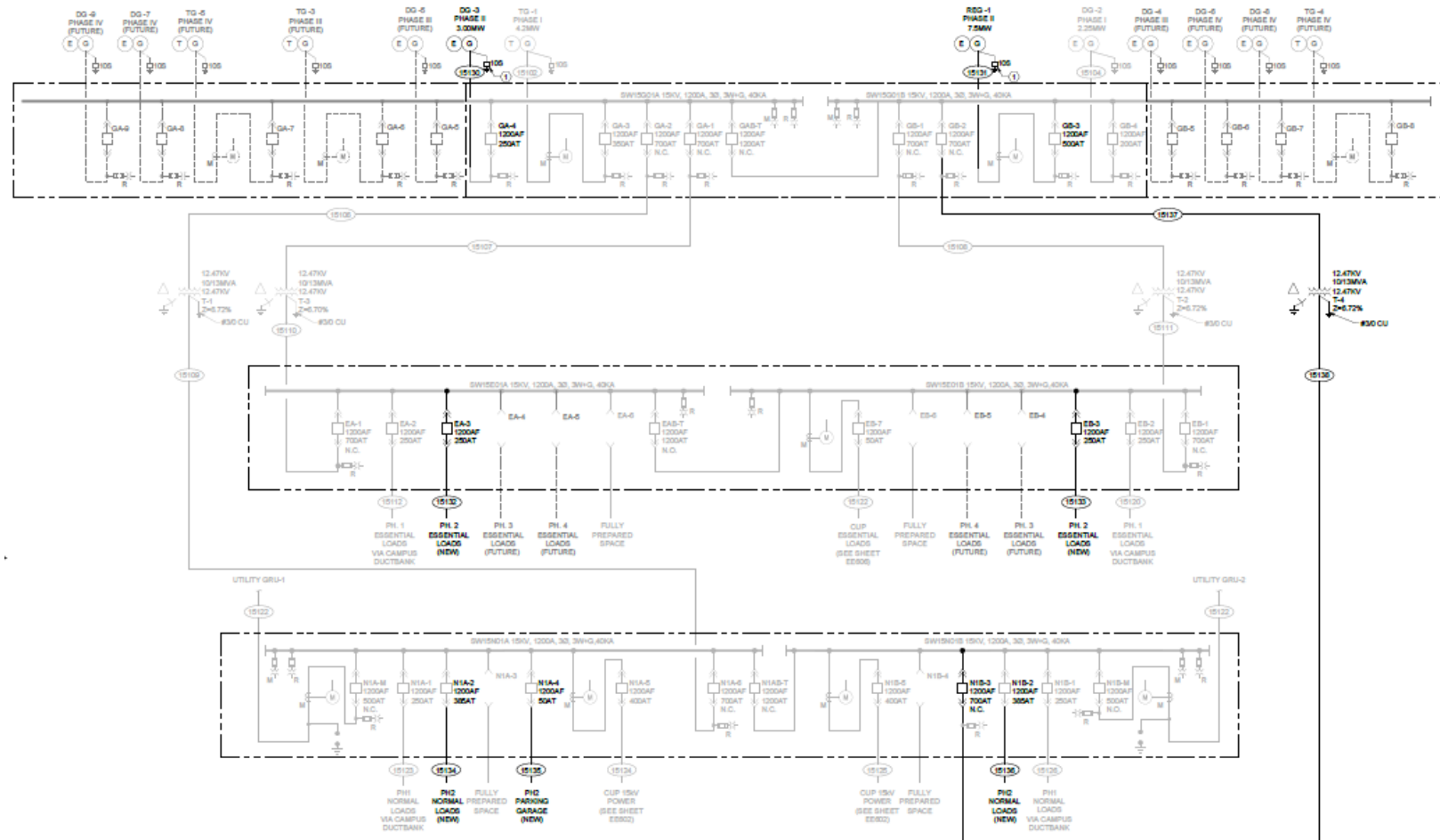


Phase 1 Microgrid Operation

- ▶ Utility source considered backup to onsite generation
- ▶ Operator manual islanding
 - Proactive islanding ahead of storms successful
- ▶ Automatic islanding due to utility disturbances
 - Initially sporadic success
 - Overhead exposure
 - Undervoltage protection time delay
 - Voltage restrained time overcurrent time delay



Phase 2 Arrangement

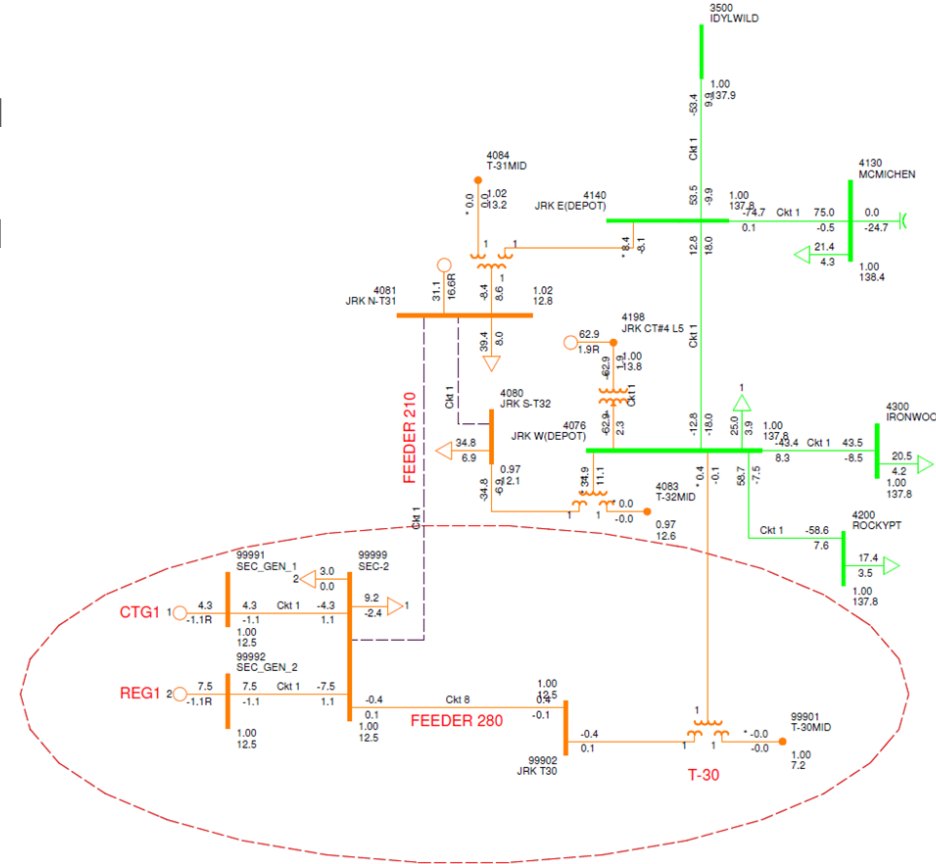


Phase 2 Microgrid Operation

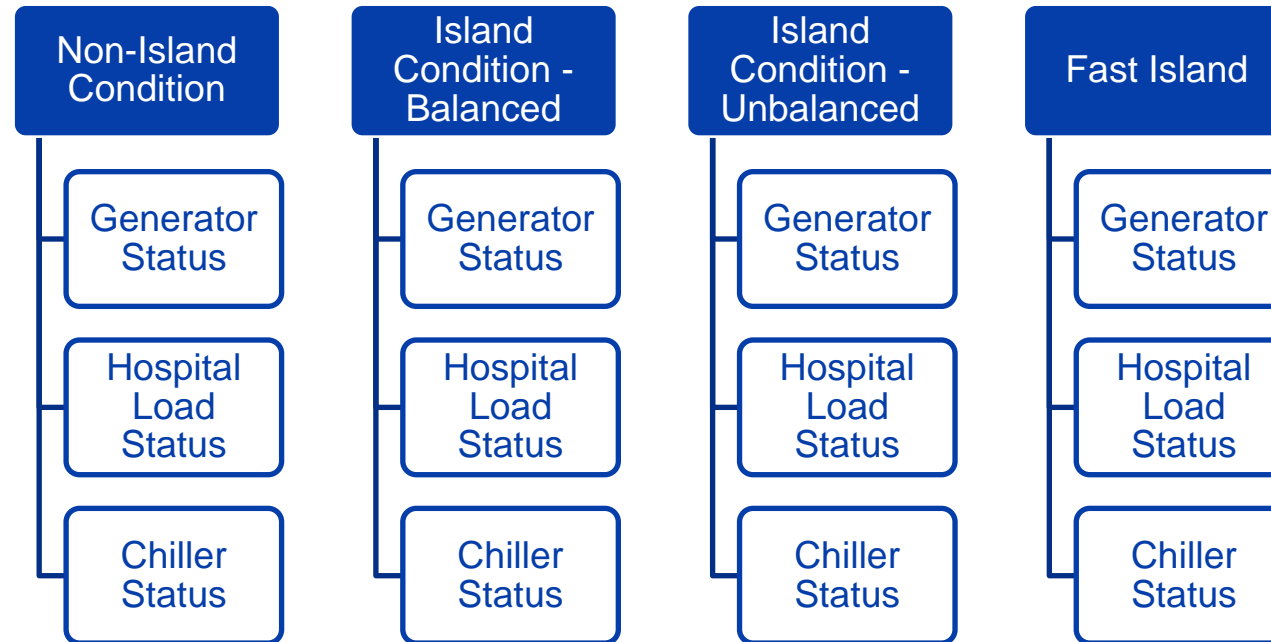
- ▶ Utility source considered backup to onsite generation
- ▶ Operator manual islanding
- ▶ Automatic islanding due to utility disturbances
 - Significantly more complicated
 - CTG and/or REG
 - Varying loads and operating scenarios
- ▶ Stability Study completed
 - Operational limitations developed

Stability Study

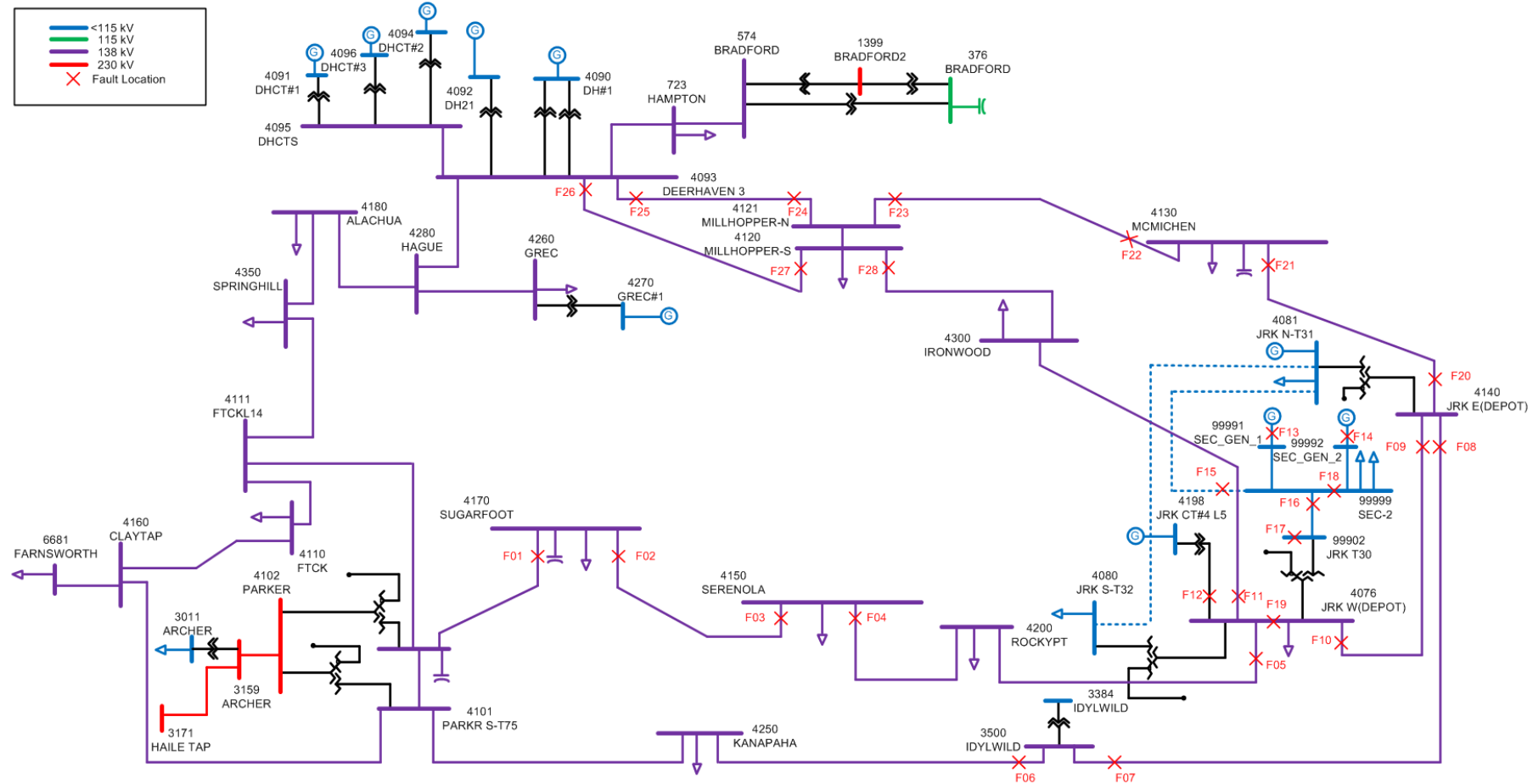
- ▶ PTI PSS\E Model
- ▶ Florida Reliability Coordinating Council (FRCC) 2014 Loadflow Rev 2
- ▶ SEC generation and plant loads added to model
- ▶ Multiple scenarios developed and evaluated



Stability Study Scenarios



Stability Study Non-Island



Stability Study Non-Island

- ▶ Most scenarios returned stable results
- ▶ SEC 15kV bus fault resulted in unstable system response
 - CTG-1 and REG-1 online
 - REG-1 online
- ▶ SEC 15kV utility feeder fault resulted in unstable system response
 - CTG-1 and REG-1 online
 - REG-1 online
 - CTG-1 online

Table 4-1: Study Scenarios for Non-Island Condition

Scenarios	Generator Status		Load		
	CTG1	REG1	Hospital	Network	Chiller
SC01	On	On	On	On	On
SC02	On	On	On	On	Off
SC03	On	On	Off	On	On
SC04	On	On	Off	On	Off
SC05	On	Off	On	On	On
SC06	On	Off	On	On	Off
SC07	On	Off	Off	On	On
SC08	On	Off	Off	On	Off
SC09	Off	On	On	On	On
SC10	Off	On	On	On	Off
SC11	Off	On	Off	On	On
SC12	Off	On	Off	On	Off

Scenarios	Event 12		Event 13		Event 16		Event 18	
	2016S	2023S	2016S	2023S	2016S	2023S	2016S	2023S
SC01	Stable	Stable	Unstable	Unstable	Unstable	Unstable	Unstable	Unstable
SC02	Stable	Stable	Unstable	Unstable	Stable	Unstable	Unstable	Unstable
SC03	Stable	Stable	Unstable	Unstable	Unstable	Unstable	Unstable	Unstable
SC04	Stable	Stable	Unstable	Unstable	Unstable	Unstable	Unstable	Unstable
SC05	Stable	Stable	Stable	Stable	Unstable	Unstable	Stable	Stable
SC06	Stable	Stable	Stable	Stable	Unstable	Unstable	Stable	Stable
SC07	Stable	Stable	Stable	Stable	Unstable	Unstable	Stable	Stable
SC08	Stable	Stable	Stable	Stable	Unstable	Unstable	Stable	Stable
SC09	Stable	Stable	Stable	Stable	Unstable	Unstable	Unstable	Unstable
SC10	Stable	Stable	Stable	Stable	Unstable	Unstable	Unstable	Unstable
SC11	Unstable	Stable	Stable	Stable	Unstable	Unstable	Unstable	Unstable
SC12	Unstable	Unstable	Stable	Stable	Unstable	Unstable	Unstable	Unstable

Stability Study Island

- ▶ Balanced island resulted in stable response
- ▶ Unbalanced island scenarios
 - Some results stable
 - Excessive import/export unstable
- ▶ Fast island scenarios
 - Fault on 138kV side of utility source transformer
 - Some results stable
 - Excessive import/export unstable
- ▶ Import/Export restrictions warranted

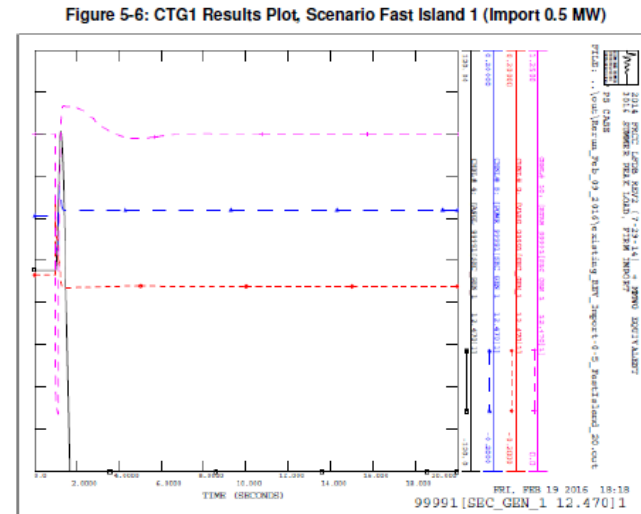
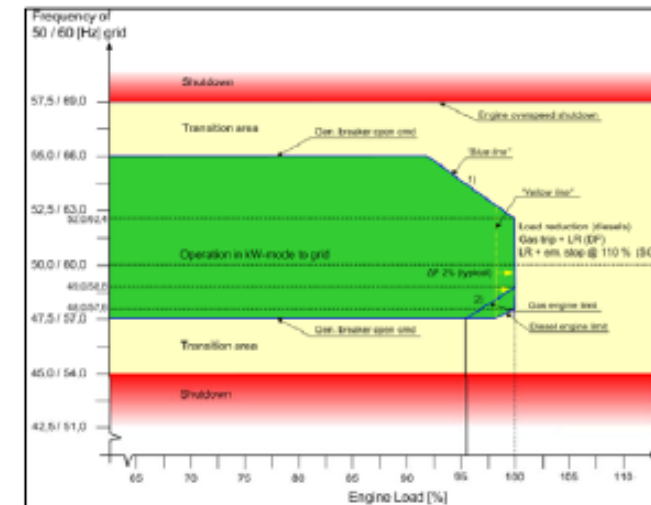
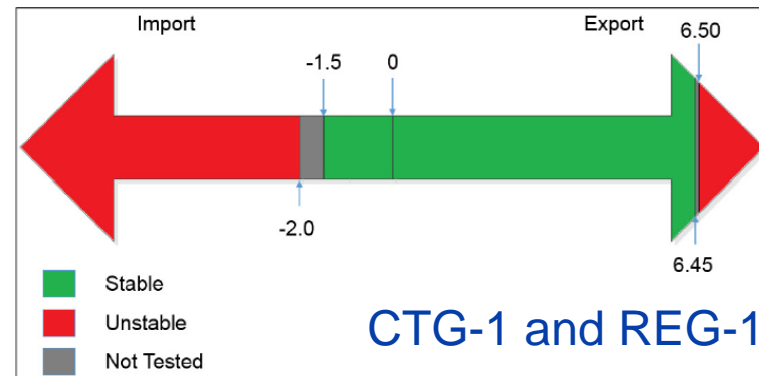
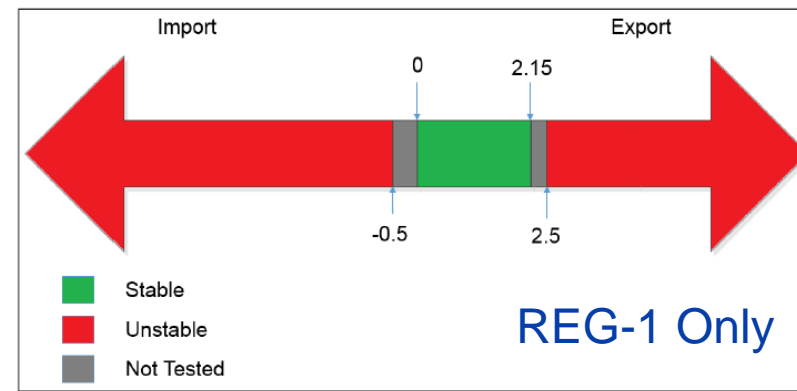
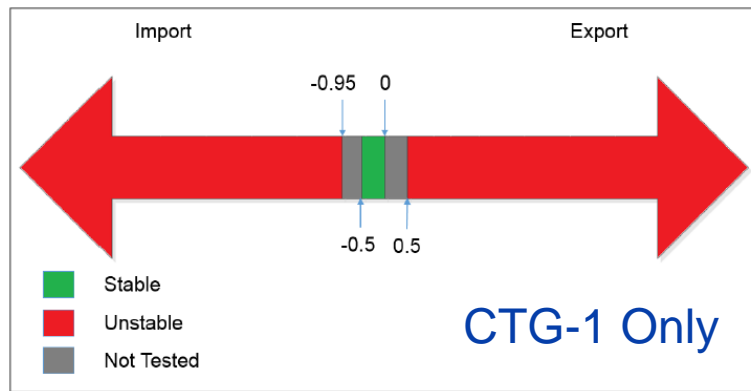


Figure 3-1: REG1 Frequency Limits



Stability Study Island Import/Export Restrictions



Summary

- Utility Interconnection Evaluation (Stability Study)
- Protective Relay Schemes and Settings Critical
- Proactive Islanding – Minimize Intertie Load Flow
- Develop Operational Limitations
- Close in Faults Cause Trips

Question/Answers?



CONTACT

Michael Dempsey, P.E.
Senior Associate Electrical
Engineer
P 817-733-8186
E mdempsey@burnsmcd.com

Chuck Heidt, P.E.
Project Manager/Asset Manager
P 352-393-1735
E heidtcs@gru.com

Kyle Peterson
Title
P 123-456-7890
E petersonmk@gru.com