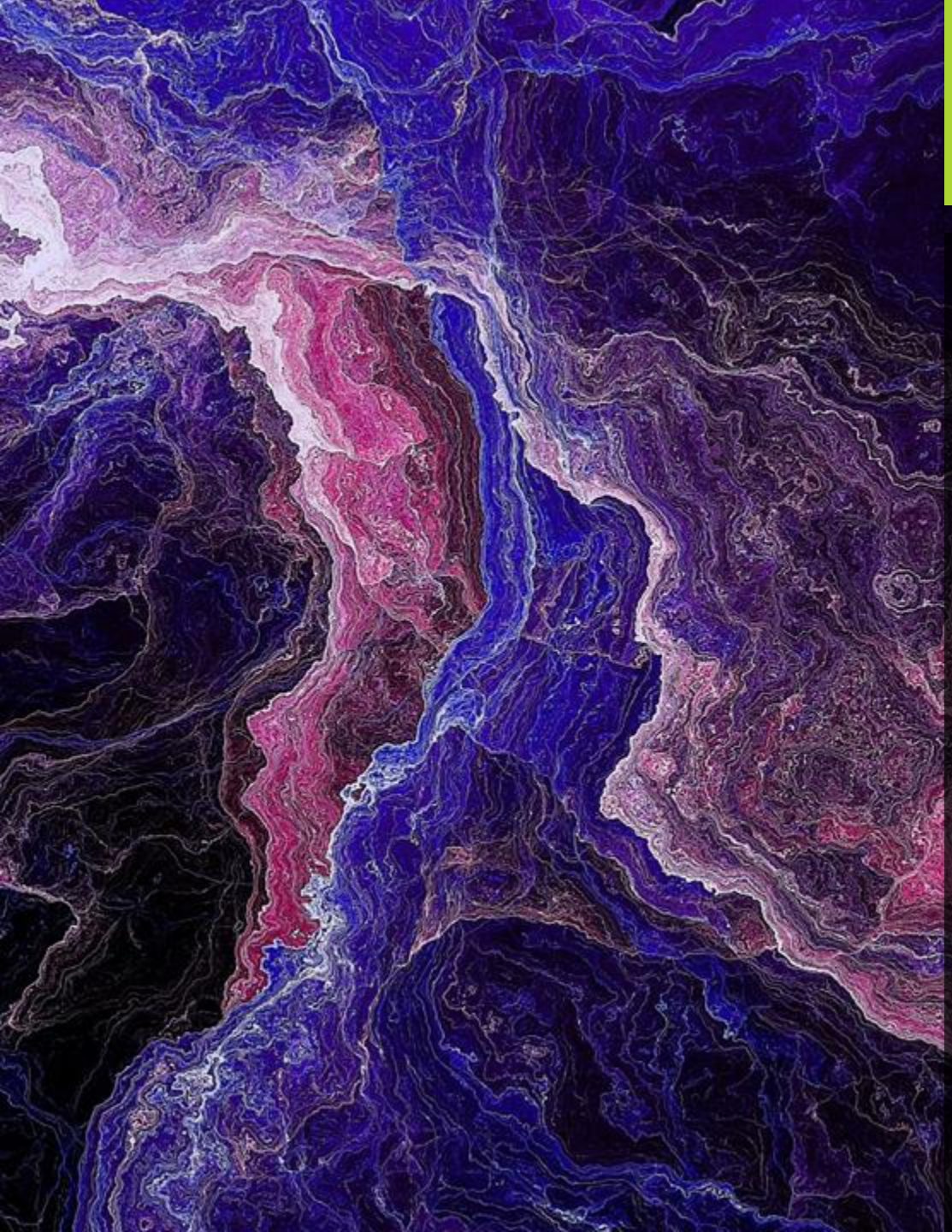
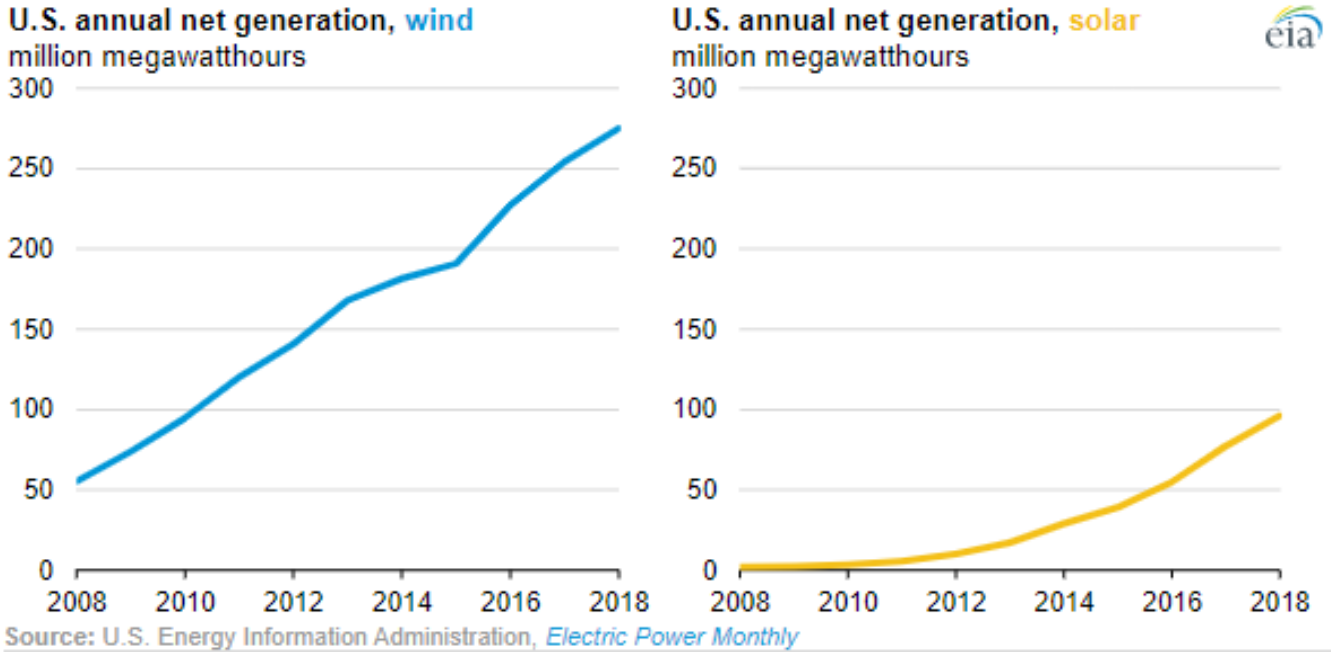


# System Inertia Impact Due to High-Renewable Penetration - Texas Interconnection

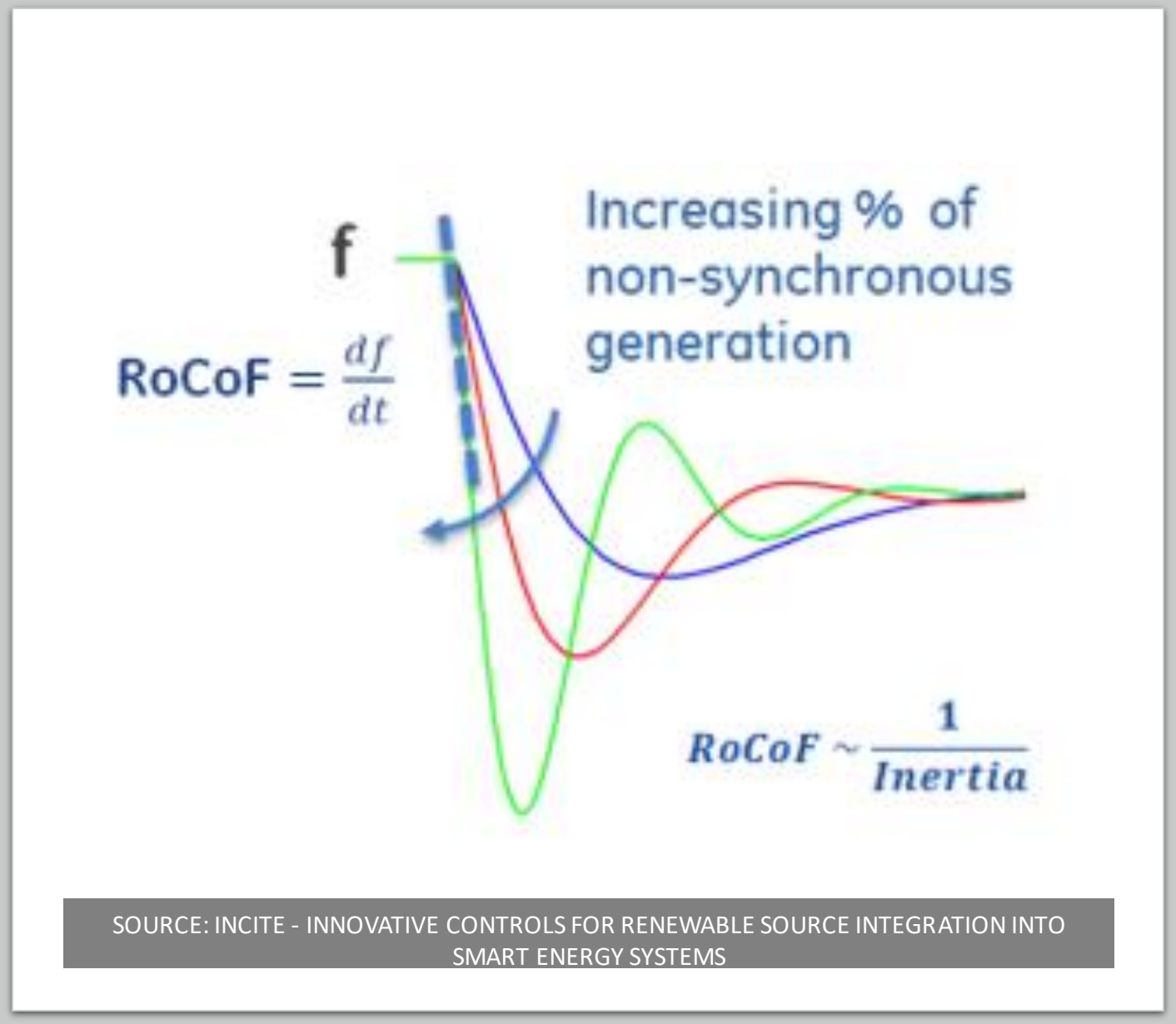
FACULTY ADVISOR: AYMAN SAMAAN

PRESENTED BY SALVADOR ZAMBRANO, JUSTIN VERGARA, GONZALO URIAS, ARNUVIO HERNANDEZ, AND JEREMIAH RODRIGUEZ

- Wind and Solar energy generation is growing rapidly in the US

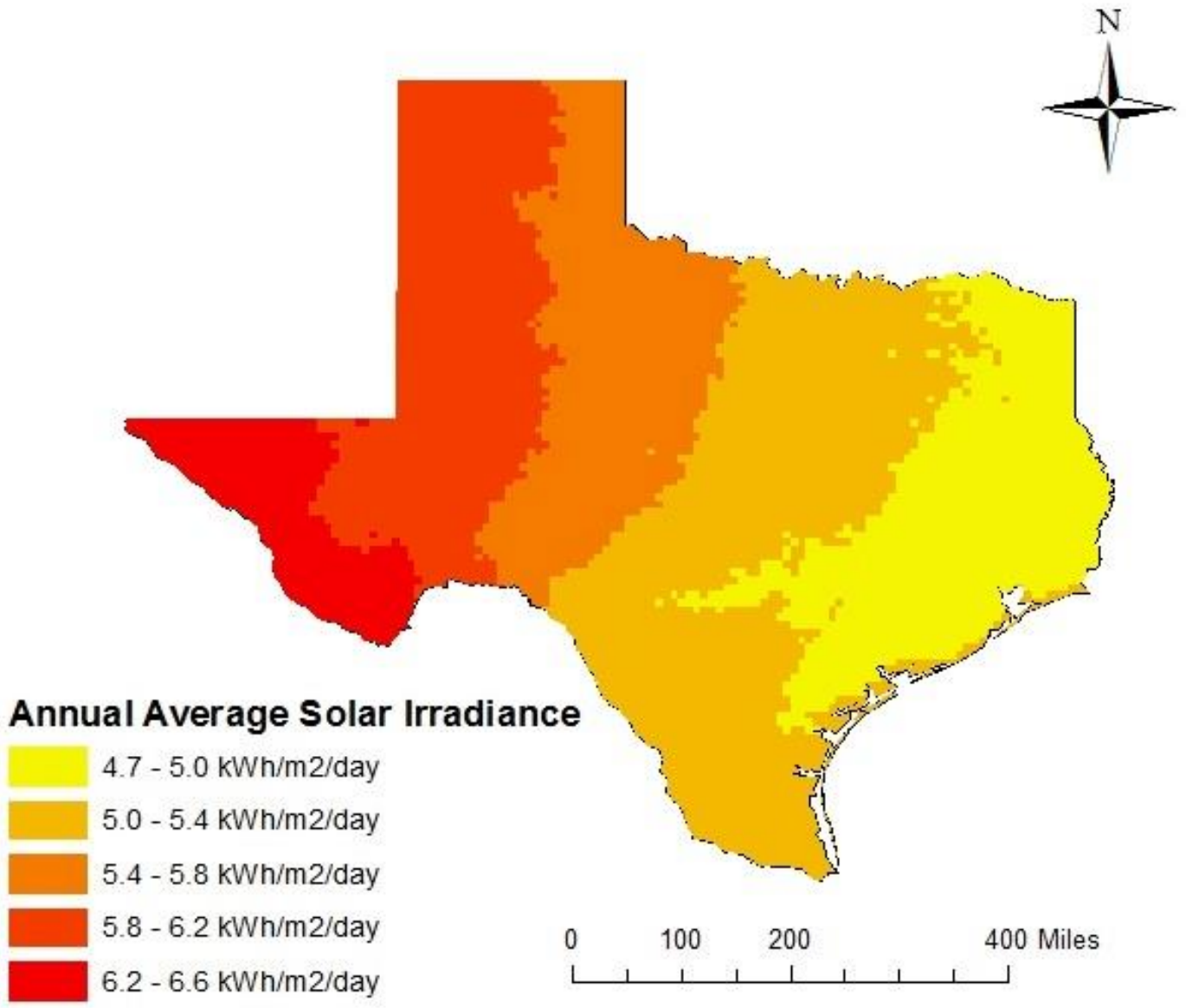


- **Blue Line** – system frequency with traditional synchronous machines (HIGH INERTIA)
- **Red Line** – Some renewable energy penetration (MEDIUM INERTIA)
- **Green Line** – High renewable energy penetration (LOW INERTIA)

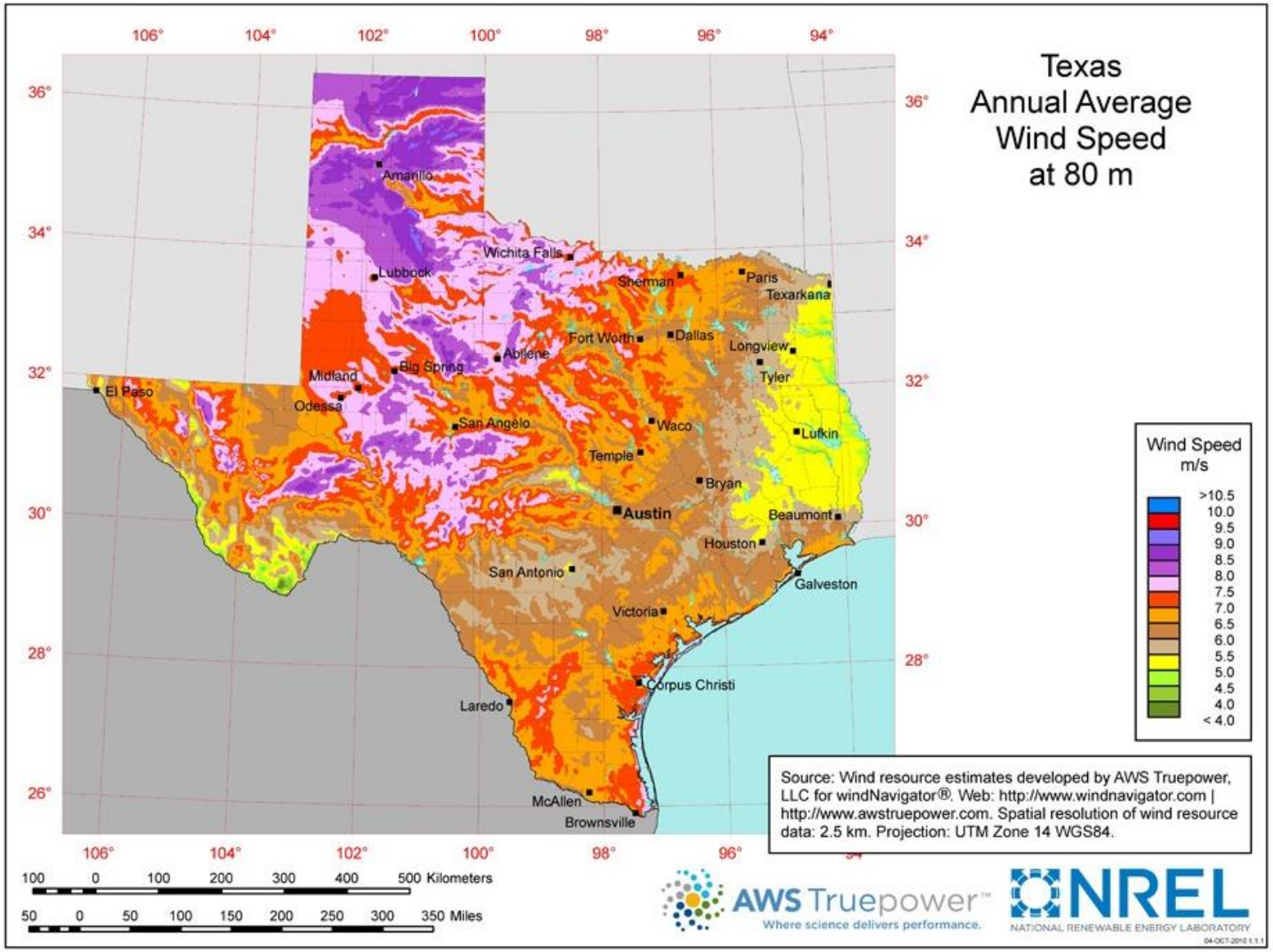



SOURCE: INCITE - INNOVATIVE CONTROLS FOR RENEWABLE SOURCE INTEGRATION INTO SMART ENERGY SYSTEMS

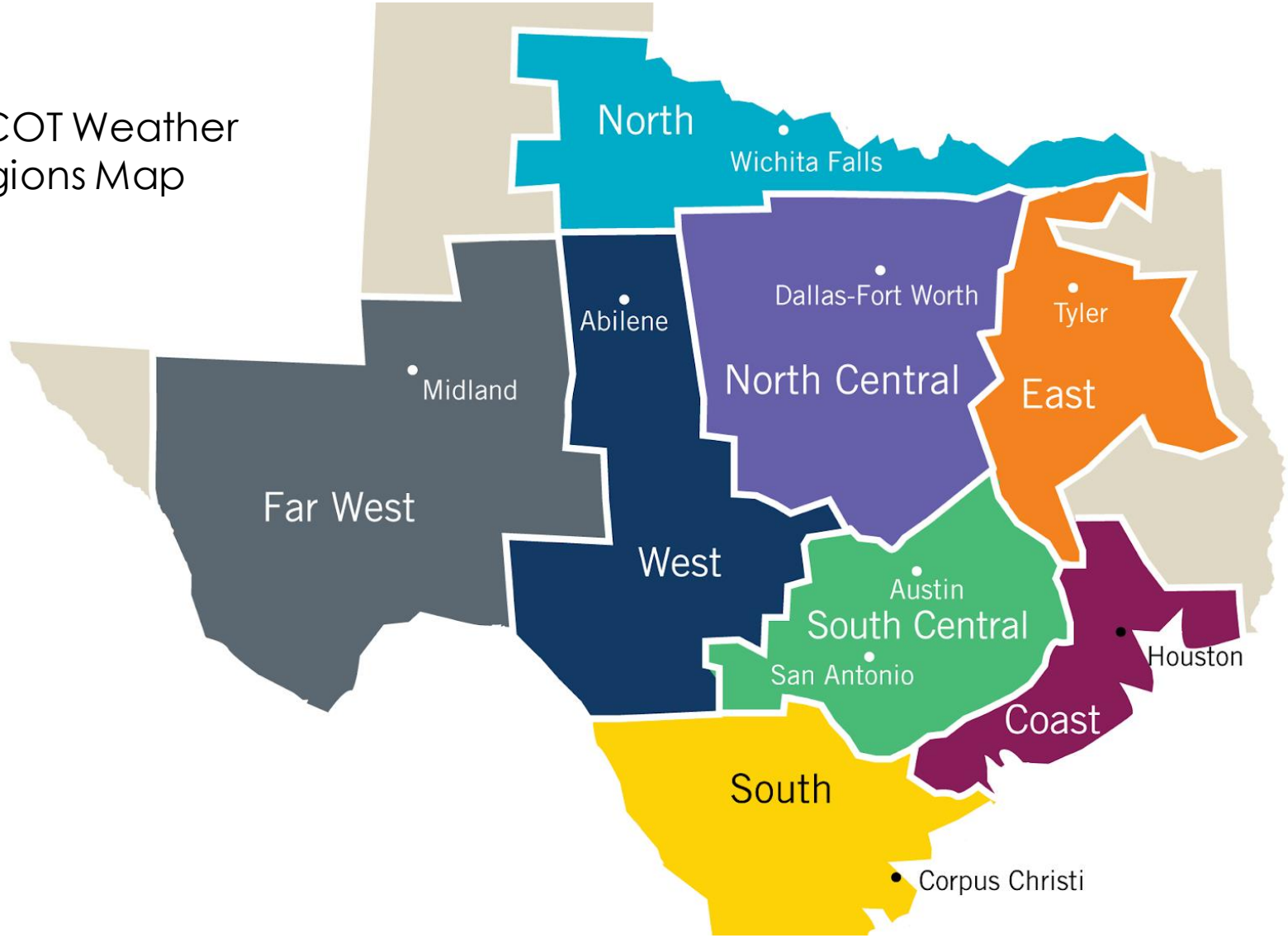
- Solar irradiance levels in Texas



- Wind speeds in Texas



- ERCOT Weather Regions Map



# 2017 Case Values

- Initial values by weather region

## Load

| Region | MW |
|---|---|
| Far West | 1306.74 |
| North | 1473.56 |
| West | 1675.54 |
| South | 6751.33 |
| North Central | 22261.69 |
| South Central | 12263.32 |
| Coast | 18189.51 |
| East | 3187.57 |
| Total | 67109.26 |

## Generation

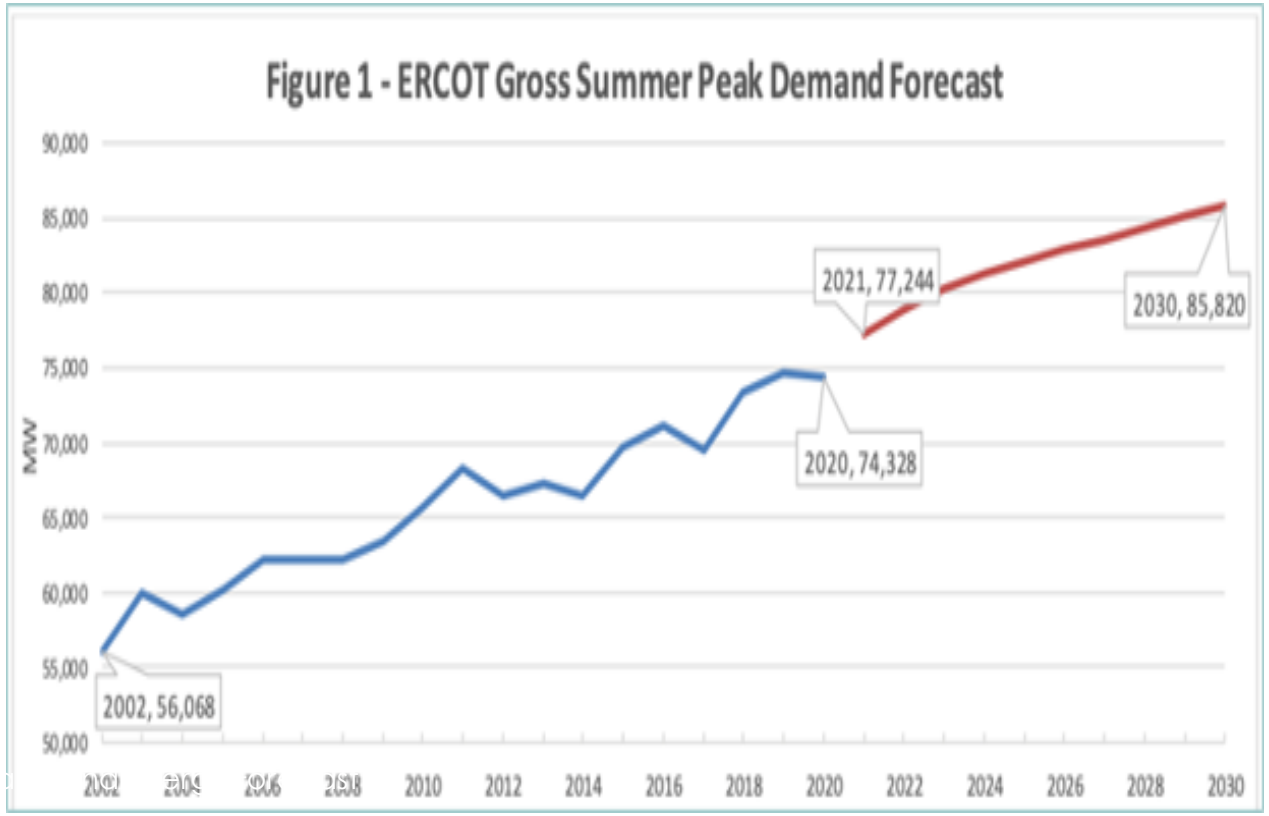
| Region | MW |
|---|---|
| Far West | 3007.34 |
| North | 1473.56 |
| West | 1675.58 |
| South | 6570.22 |
| North Central | 13,145.79 |
| South Central | 10372.81 |
| Coast | 22734.62 |
| East | 5765.64 |
| Total | 68,000 |
| Total Capacity | 84,622 MW |

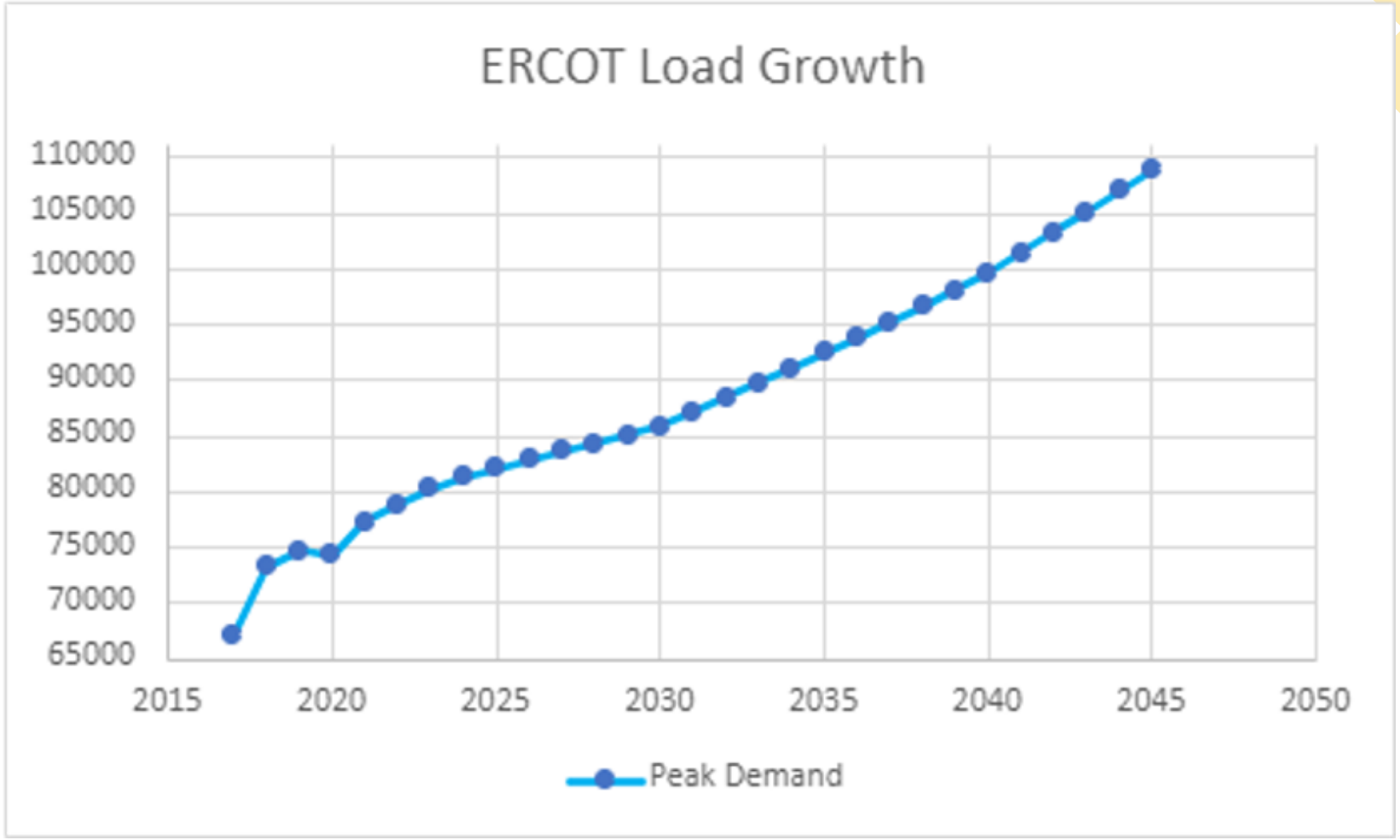
# 2045 Load Projection

AAGR of 0.9% for peak demand 2011-2020

forecasted AAGR of 1.2% from 2021-2030

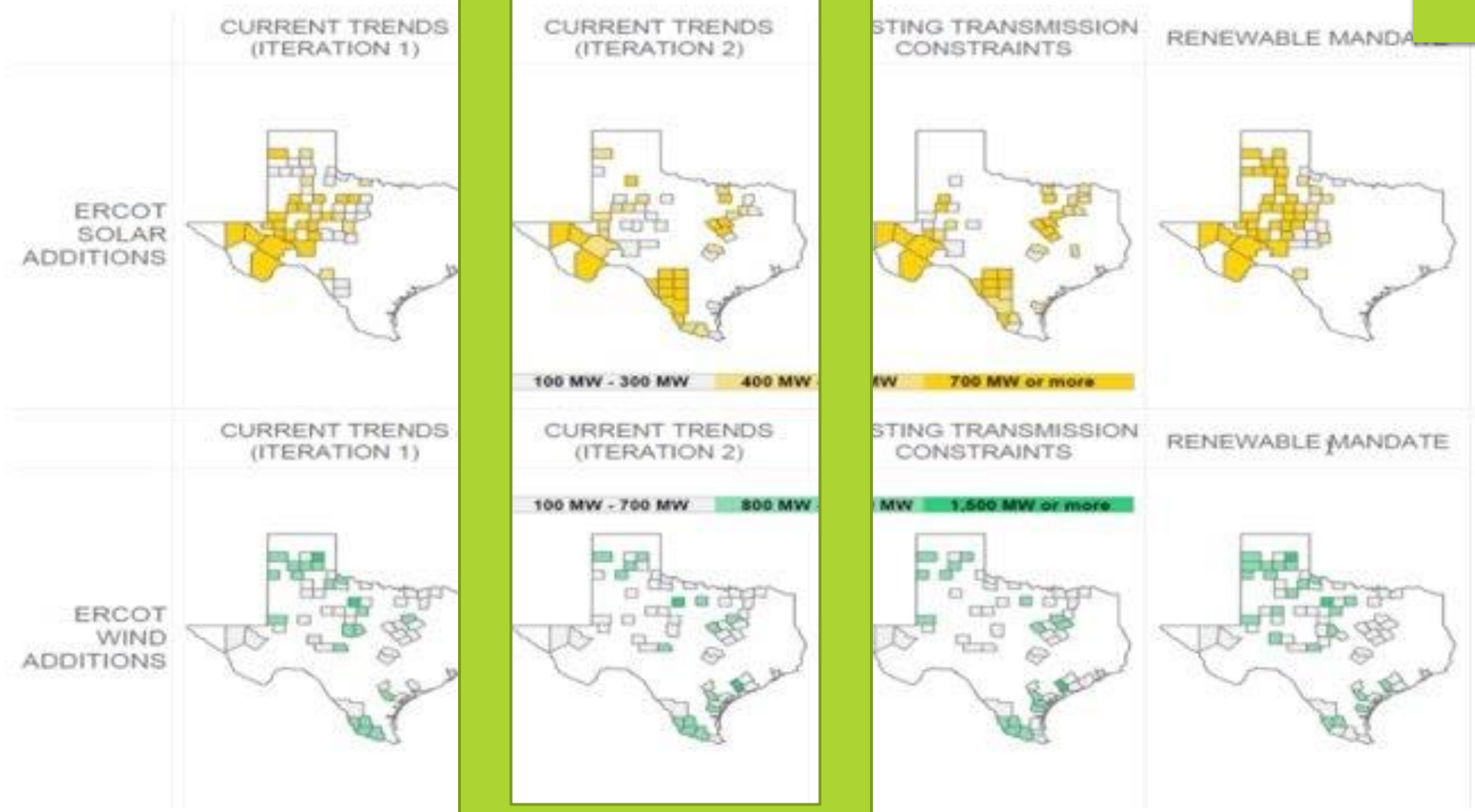
AAGR = Average Annual Growth Rate





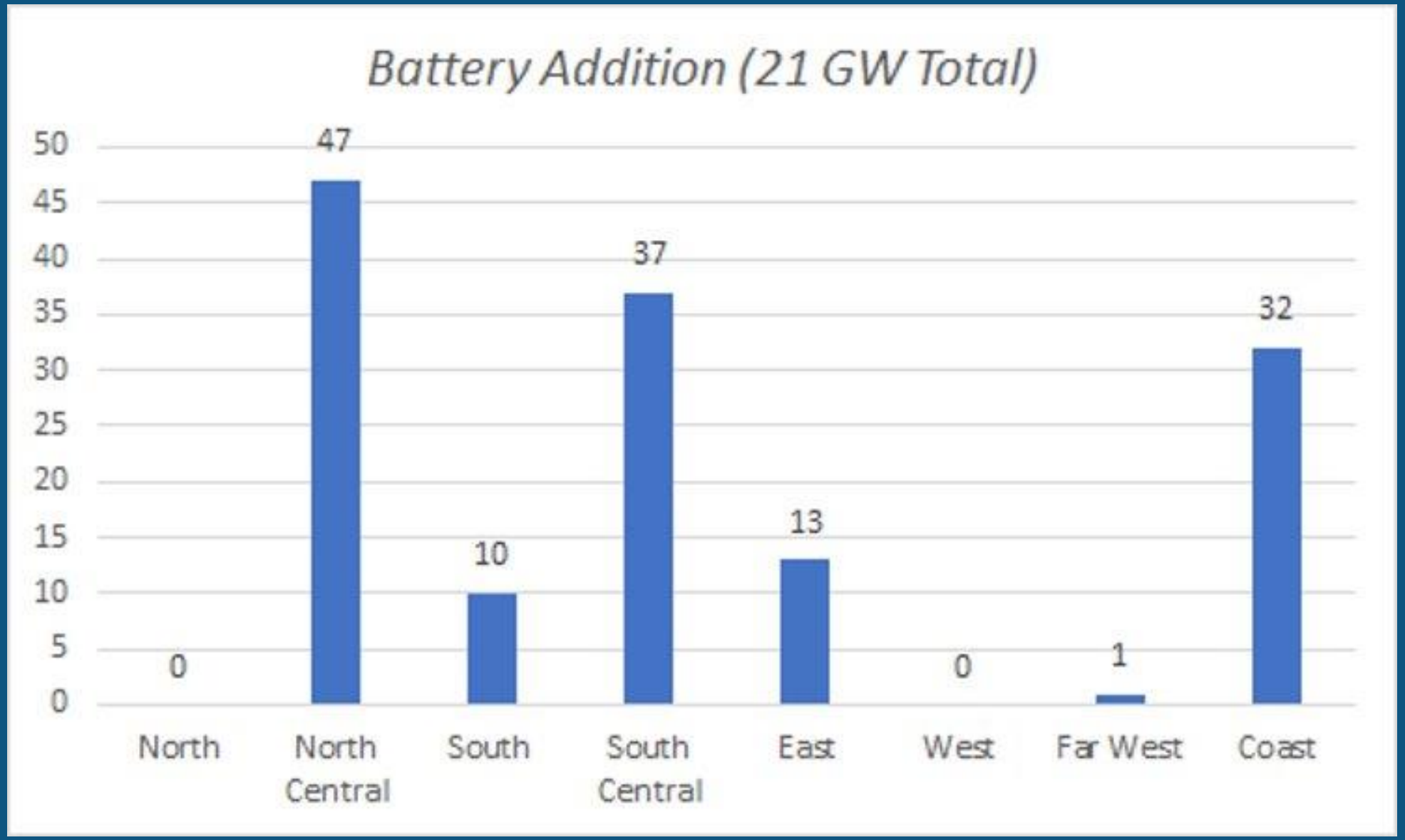

Peak Demand Growth (2017-2045)

# Projected Renewable Energy Development (ERCOT LTSA)



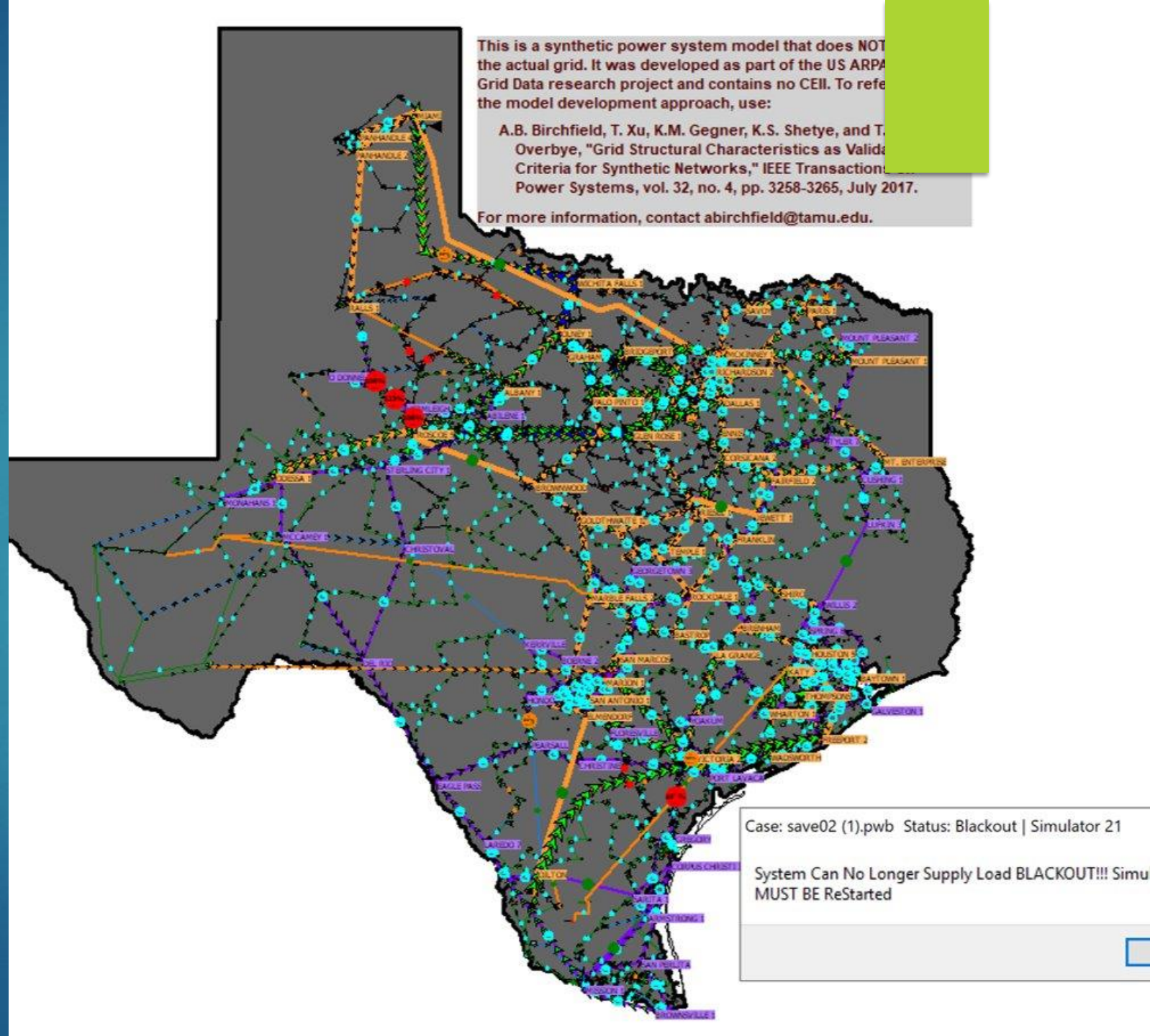
| Region | Wind Addition | Solar Addition |
|---|---|---|
| North | 34 Units | 20 Units |
| North Central | 12 Units | 19 Units |
| South | 43 Units | 17 Units |
| South Central | 5 Units | 14 Units |
| East | 1 Units | 5 Units |
| West | 0 Units | 7 Units |
| Far West | 0 Units | 38 Units |
| Coast | 19 Units | 0 Units |
| Total | 114 Units | 120 Units |

- **2045 Generation Additions**

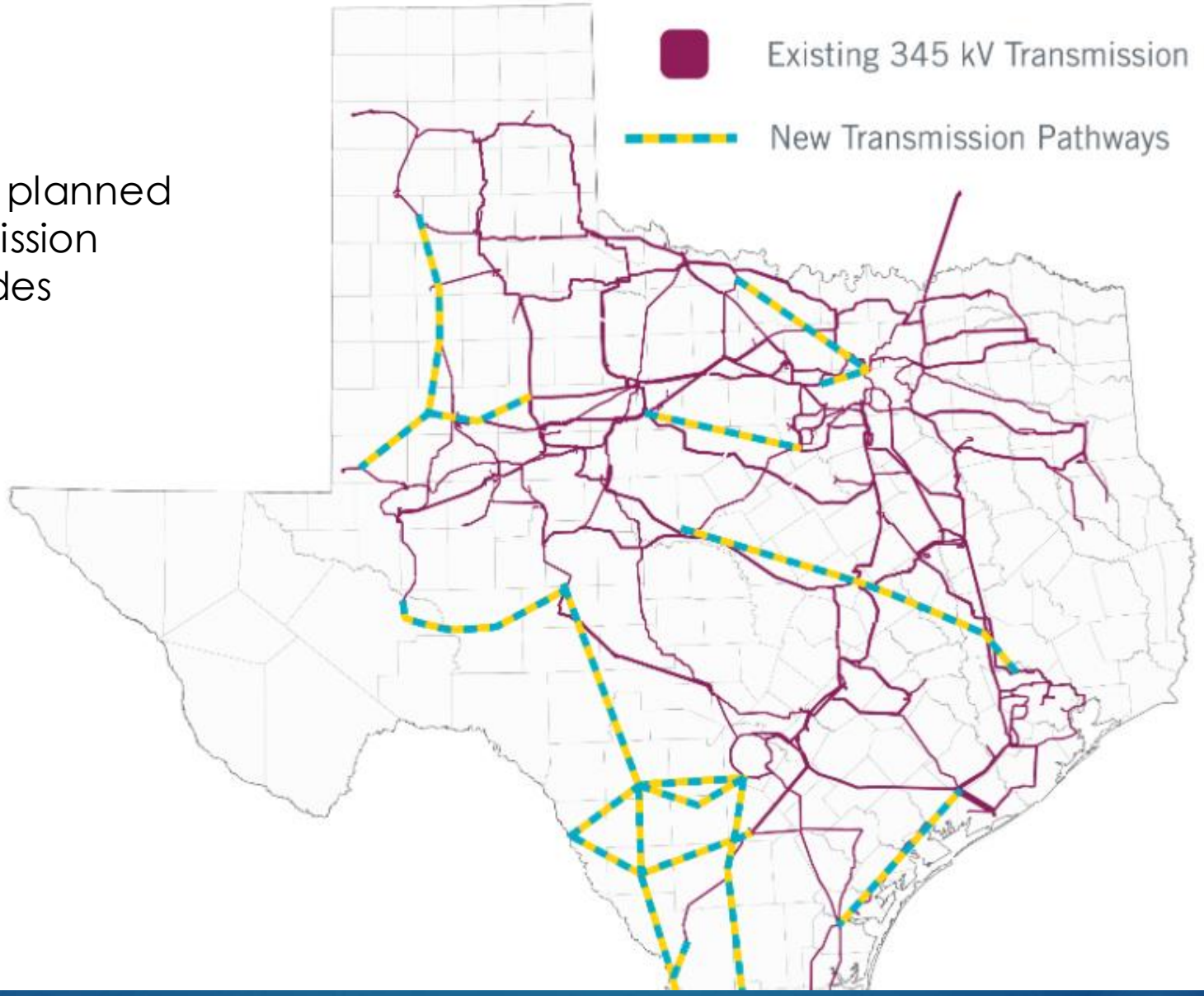



- **2045 Battery Additions**

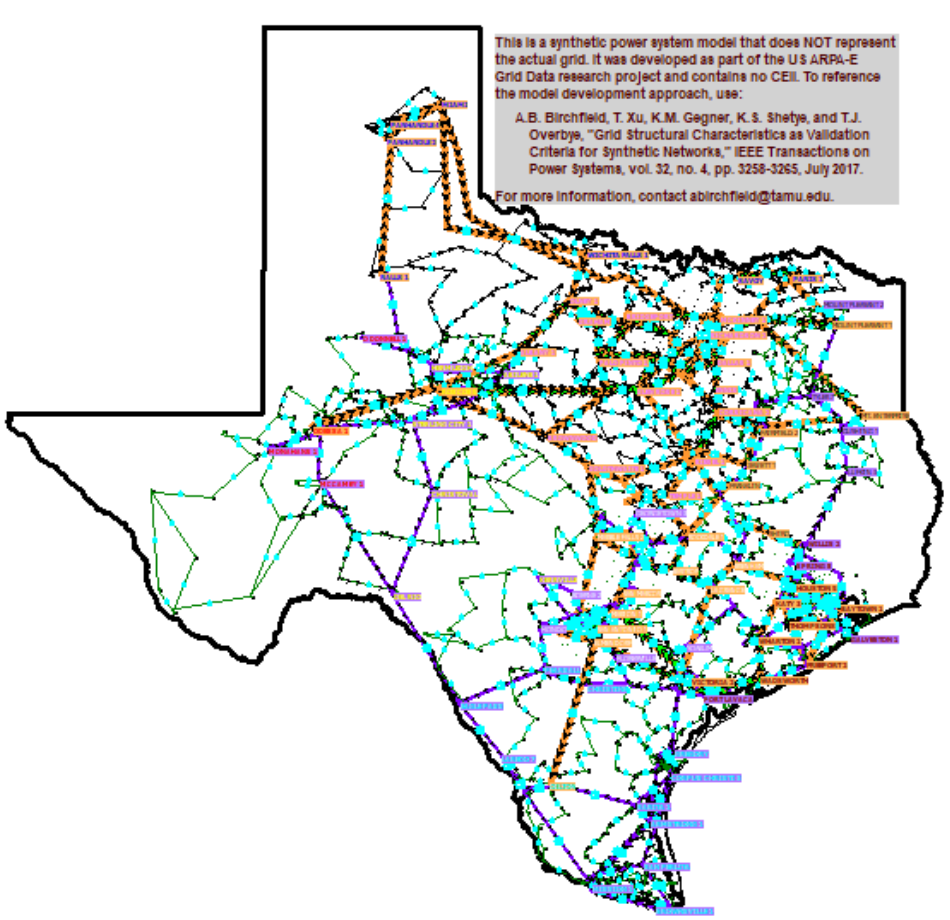
- Thermal Overloads in Steady-State (Lines with Red Bubbles)



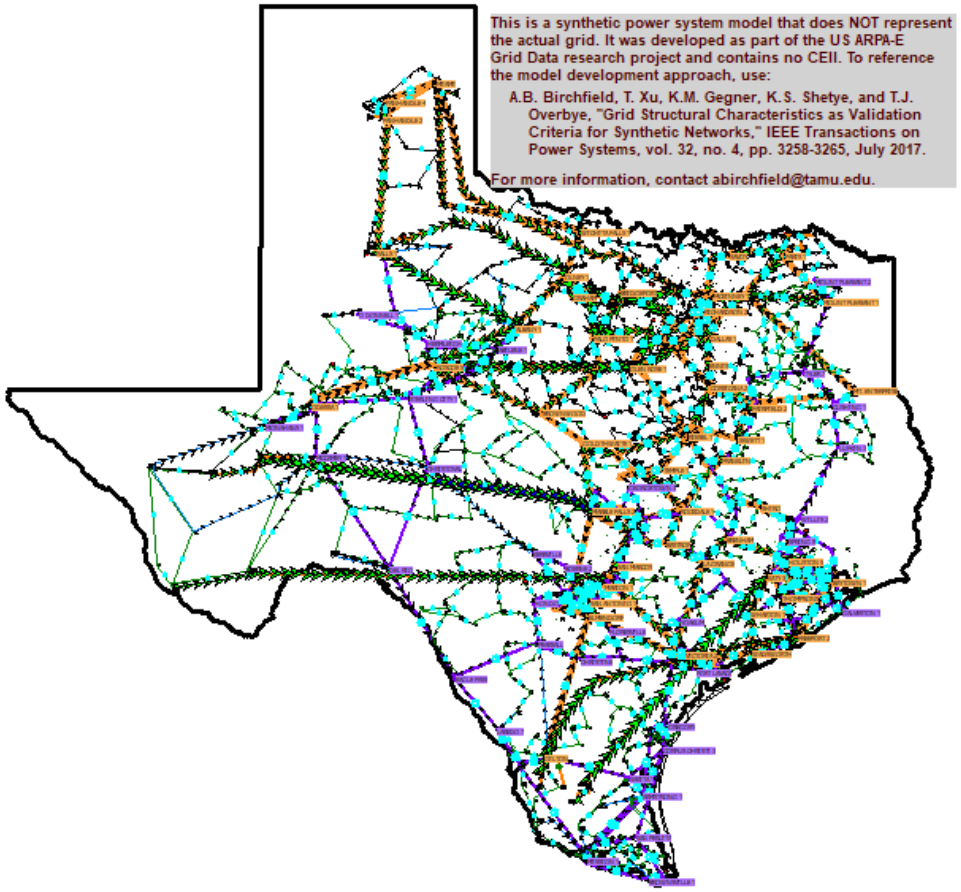
- ERCOT planned transmission upgrades



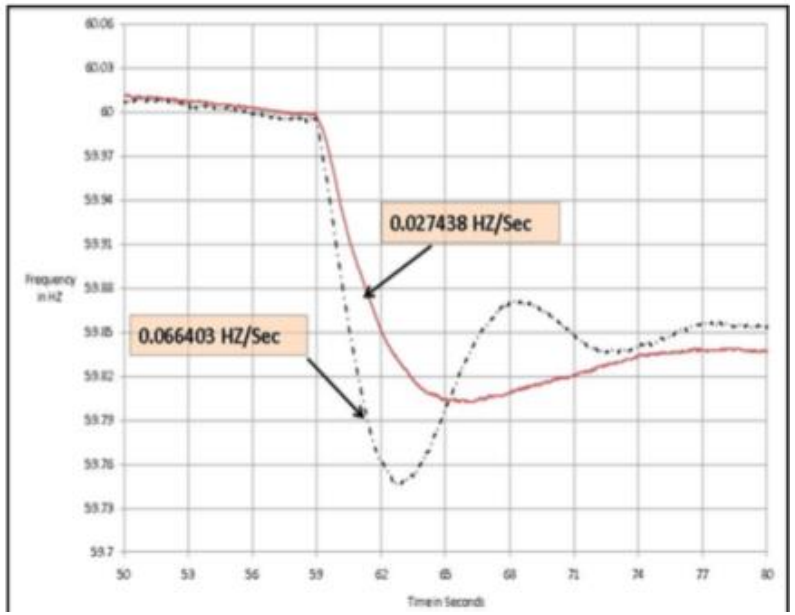
## 2017 Case Transmission System




## 2045 Case Transmission System

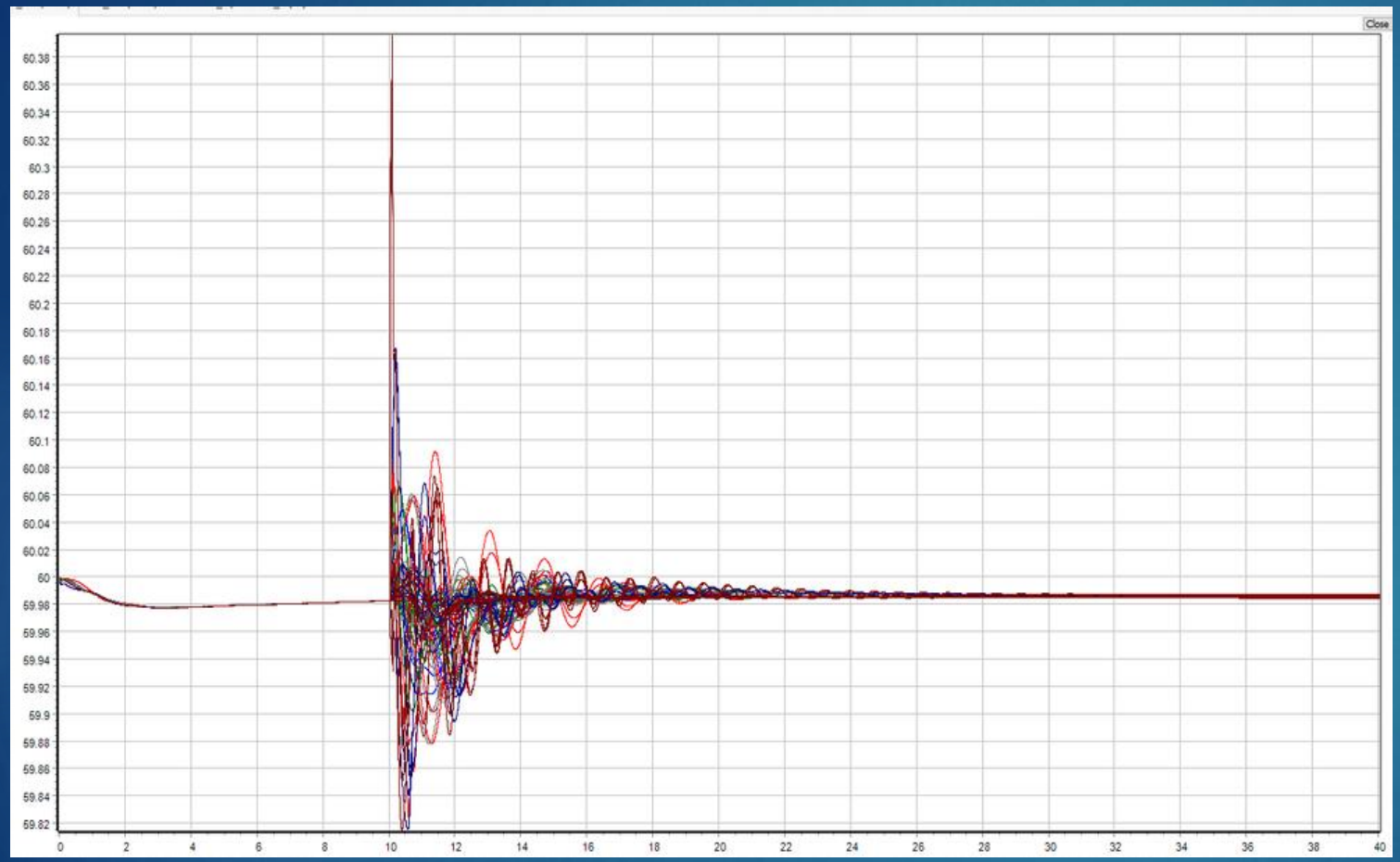


# Basics on Transient Stability




- Underfrequency Load Shedding (forced blackouts) occur at **59.3Hz**
- **Critical busses –** faults applied where there is high generation
- **Monitoring busses –** used to represent the case

▶SOURCE: INCITE - INNOVATIVE CONTROLS FOR RENEWABLE SOURCE INTEGRATION INTO SMART ENERGY SYSTEMS

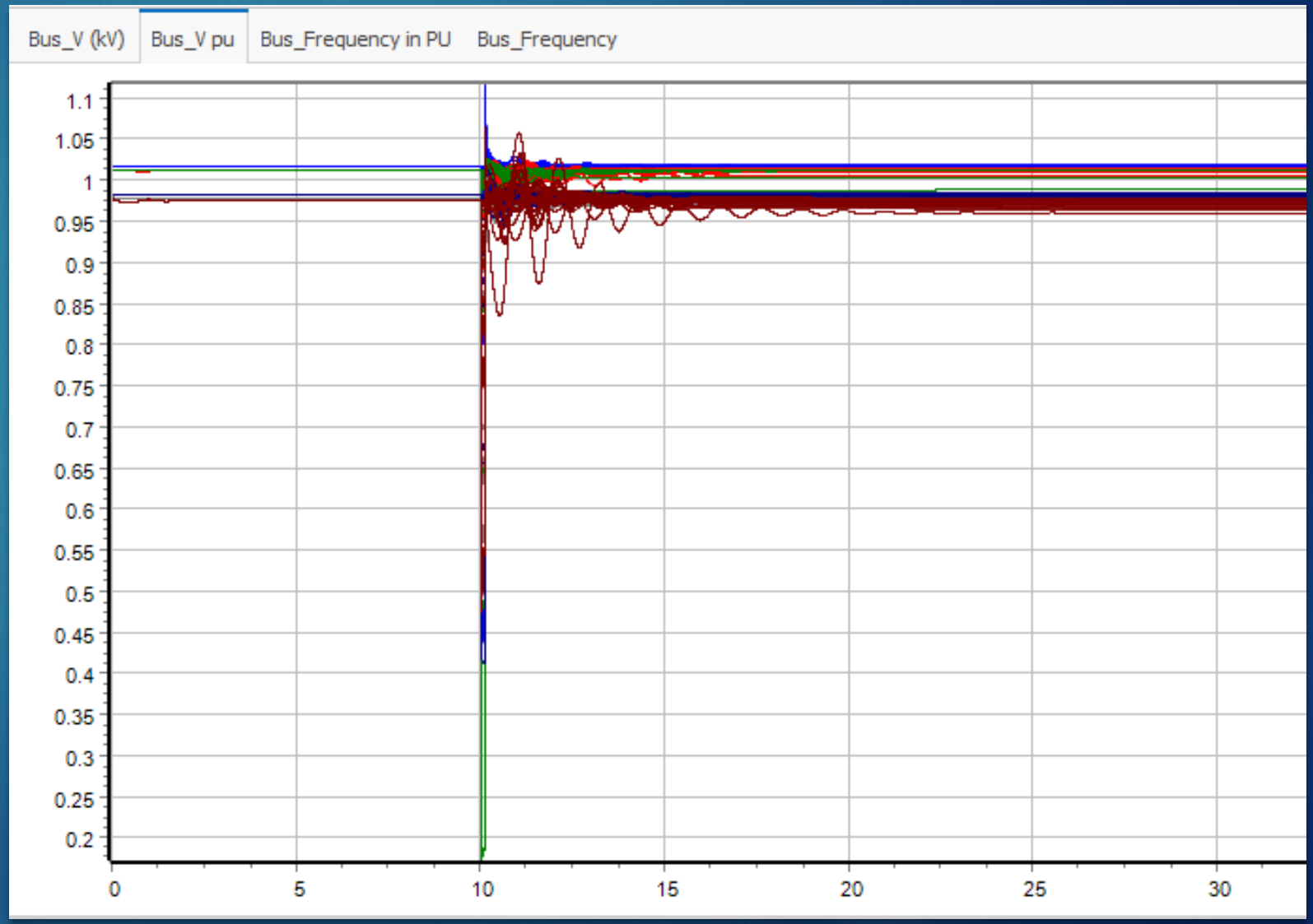



# Max Penetration Threshold – 71%

- Frequency
- No UFLS
- 0.1 Hz Reliability Margin

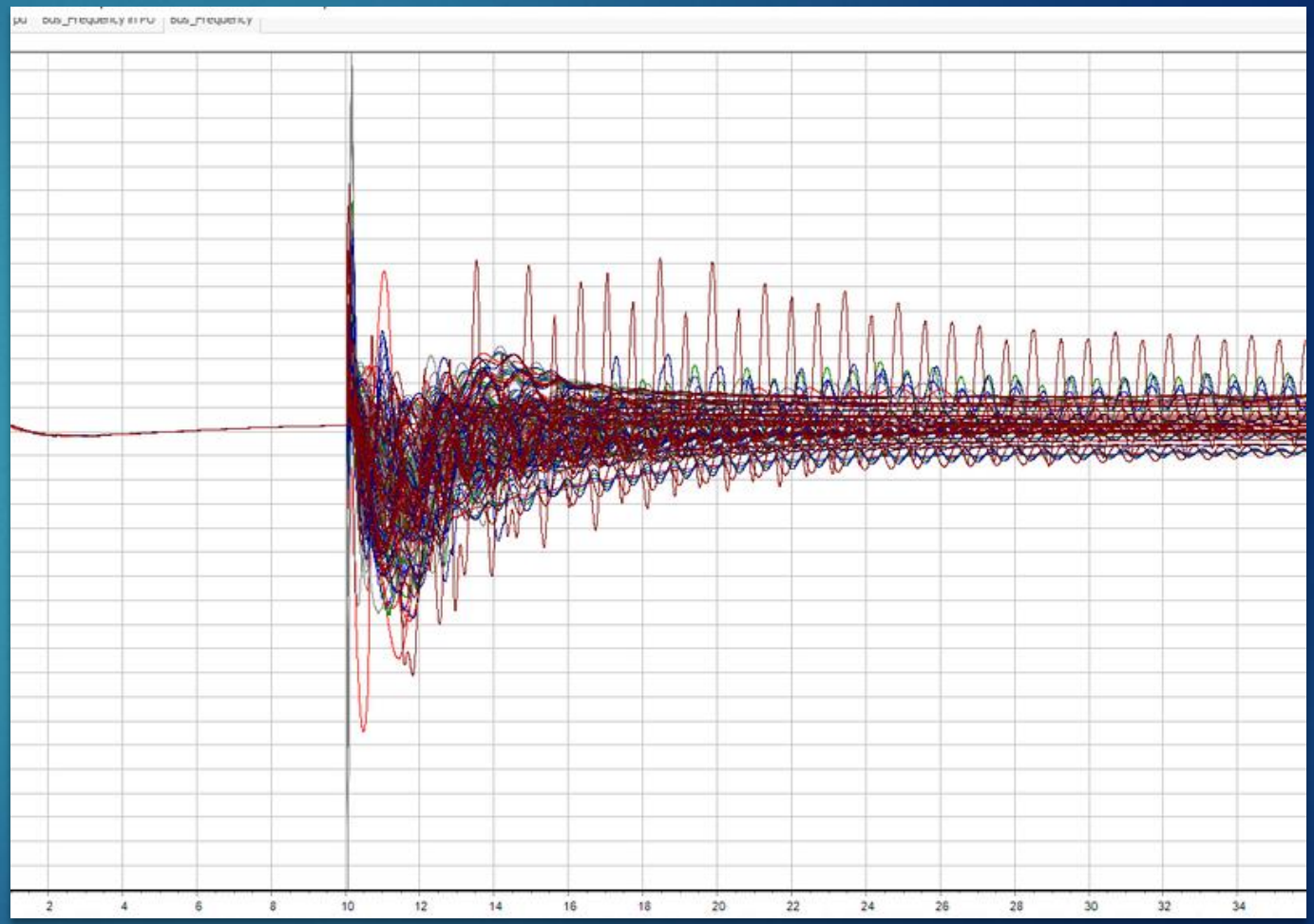
# Voltage - 71% Penetration

- The system converges



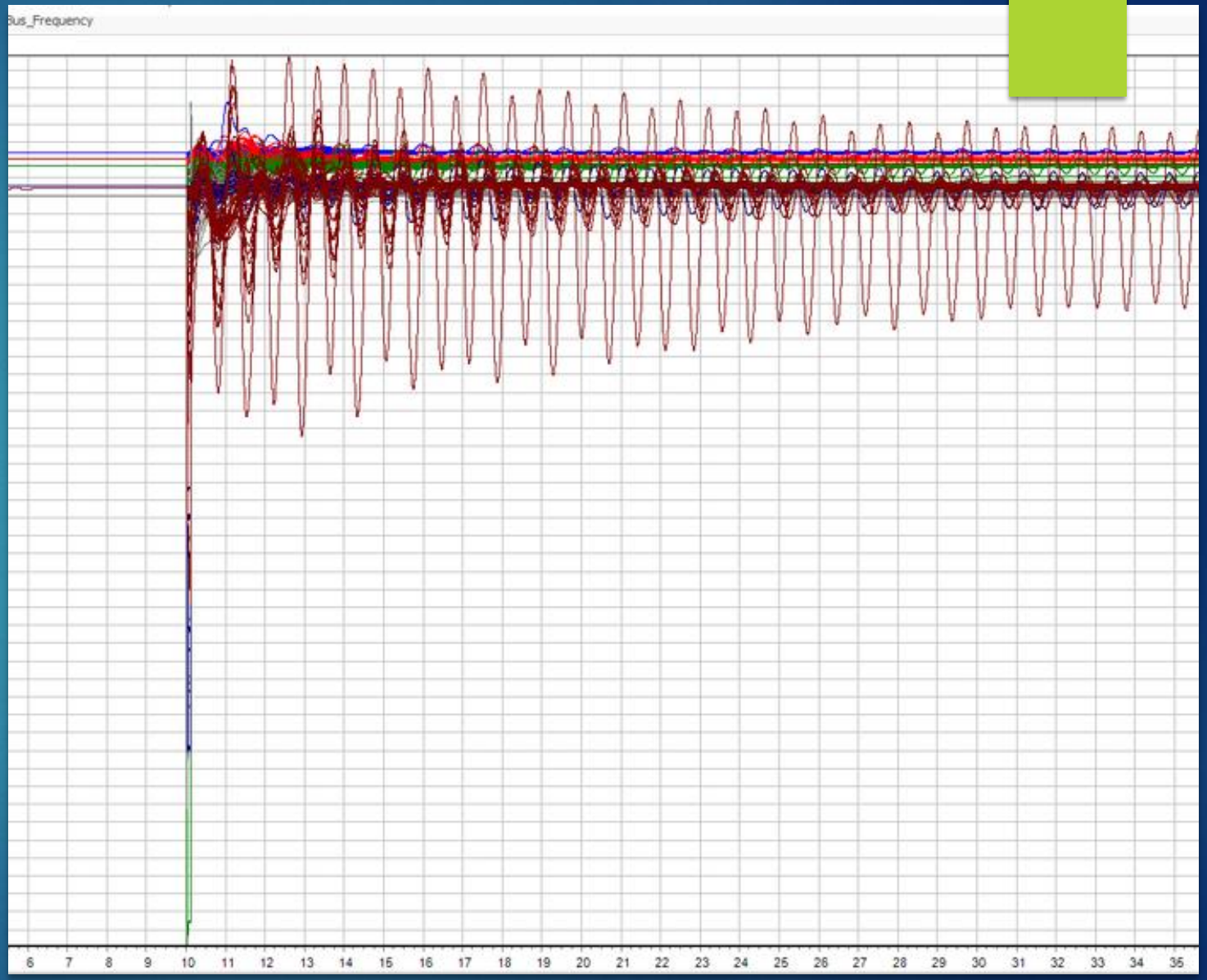
# 76% Threshold - Frequency

- UFLS
- Oscillation



# 76% Threshold - Voltage

- Oscillations do not show any sign of converging



# Off-Peak Load and Resource Balance (Steady-State)

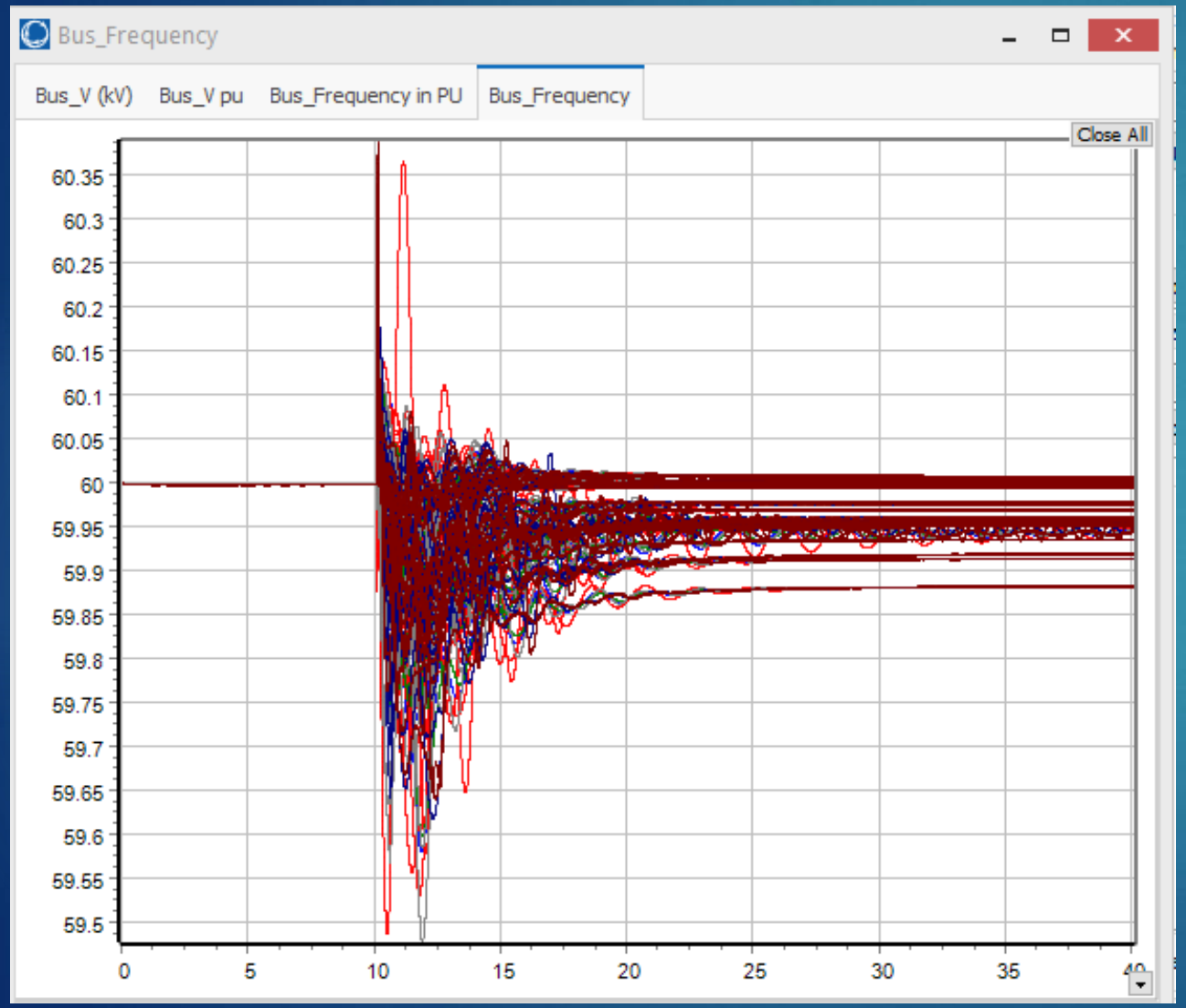
| Fuel Type | GW |
|---|---|
| WND (Wind) | 33 |
| SUN (Solar) | 0 |
| NG (Natural Gas) | 30 |
| BIT (Bituminous Coal) | 7 |
| WAT (Water) | 3 |
| NUC (Nuclear) | 5 |

TotalGeneration Capacity: 78 GW

| Load | GW |
|---|---|
| 40% Demand | 44 |
| Battery Load | 39 |

Total Demand: 83 GW

# Frequency – Off Peak




Staggered Charging Scheme




# Voltage – Off Peak

VOLTAGE STABILIZES

# Short Circuit Duty

- Significant decrease in short circuit current in some areas
- May need to change/update protection elements
- May need to watch inverter parameters for weak fault current

