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Distributed Energy Resources

UVIG ERS Tutorial

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RELIABILITY | ACCOUNTABILITY




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Why Are We Concerned About DER?

- Concern about changing generation fleet
  - Large coal fired power plants are being retired
  - Natural gas, renewables and variable generation are increasing
  - How does this change Essential Reliability Services?
- Essential Reliability Services
  - Generation Ramping – ability to adjust to meet changing loads
  - Frequency Control
    - Inertia – object in motion tends to stay in motion
    - Primary frequency response – automatic counter response compensating for the loss of a large generator
  - Voltage Control – maintain within limits
- Reliability Effects
  - How does reliability change with newer resources?

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What does this have to do with rooftop solar?

- DER penetration is growing in the west - California
- DER generation is approaching 6000 MW each day
  - This is equivalent to six nuclear or large coal plants
- How does this affect operation of the high voltage transmission system?
  - This is connected directly to distribution load – houses, businesses, etc.
  - Offsets load – utility generates less due to less system load
  - Changes load patterns
    - Much less load during mid-day
    - Large changes at sunrise and sunset – ramping issue startup and shutdown
- Is there a reliability issue to the high voltage system?
  - We don't know but we need to know

Initial DER Concerns

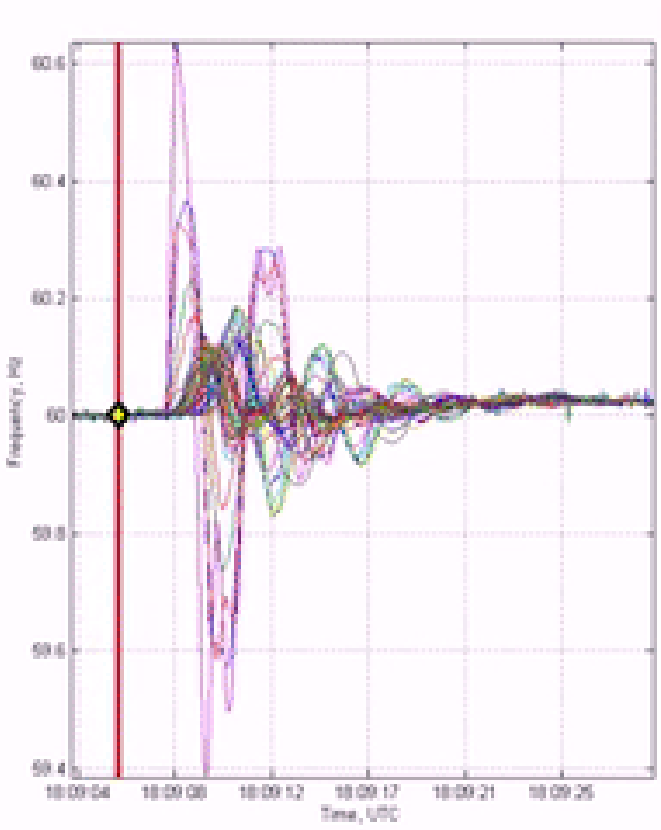
- Largest credible contingencies in WECC
  - 2 Palo Verde Units 2740 MW – 59.70 Hz nadir
    - Limiting outage for COI rating
  - Pacific DC RAS 3000 MW – 59.65Hz nadir
- How do the DER's perform under these conditions?
- DER dropping off will significantly increase load exacerbating a frequency excursion
- How do DER's coordinate with UFLS schemes?

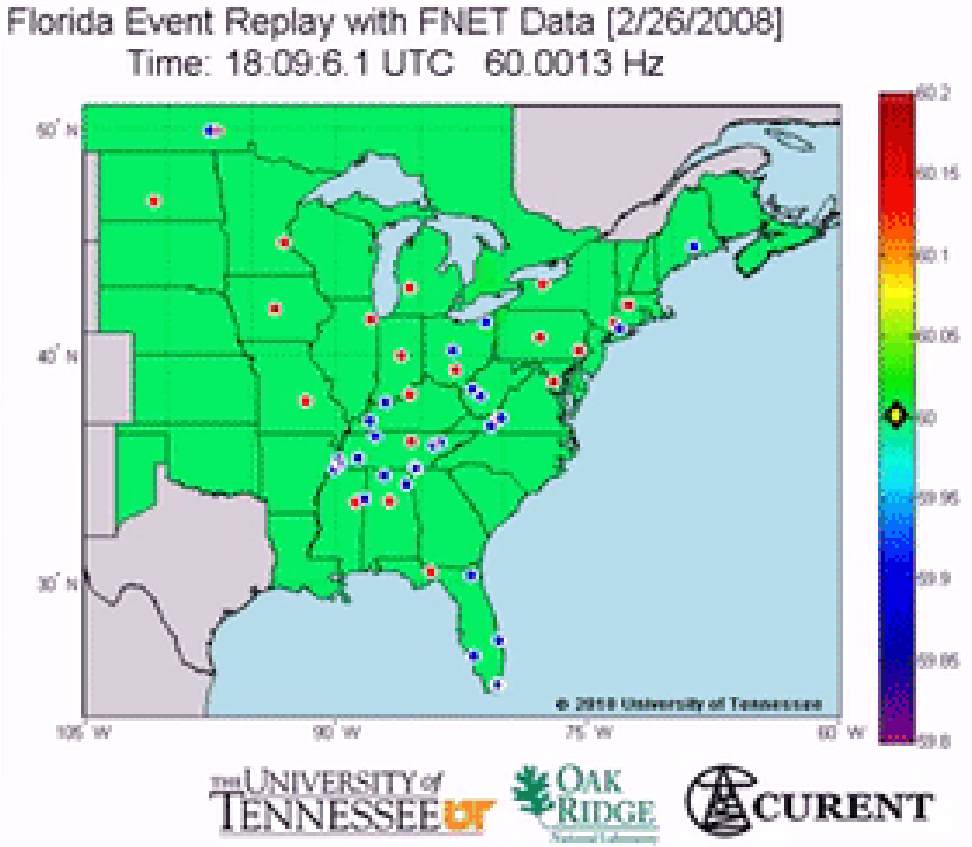
IEEE 1547 Frequency Separation Points

- WECC UFLS begins at 59.5 Hz ends at 58.3 Hz
- IEEE 1547 is designed to protect equipment and prevent islanding
  - Sensitive tripping
- BPS needs to be resilient and ride-through contingencies
  - Secure operation

DER Size	Frequency Range (Hz)	Clearing Times (sec)
=< 30 kW	> 60.5	0.16
	< 59.3	0.16
> 30 kW	> 60.5	0.16
	< 59.8 – 57.0 adjustable	0.16 – 300 adjustable
	< 57.0	0.16

Frequency Excursion – Interconnection-wide Phenomena





Distributed Energy Resources Defined

Distributed Energy Resource (DER) *is any resource on the distribution system that produces electricity and is not otherwise included in the formal NERC definition of the Bulk Electric System (BES).*

Types of DER :

- Distributed Generation
- Behind the Meter Generation
- Energy Storage Facility
- DER Aggregation
- Micro-Grid
- Cogeneration
- Emergency, Stand-By or Back-Up Generation

Some Problem Complexities:

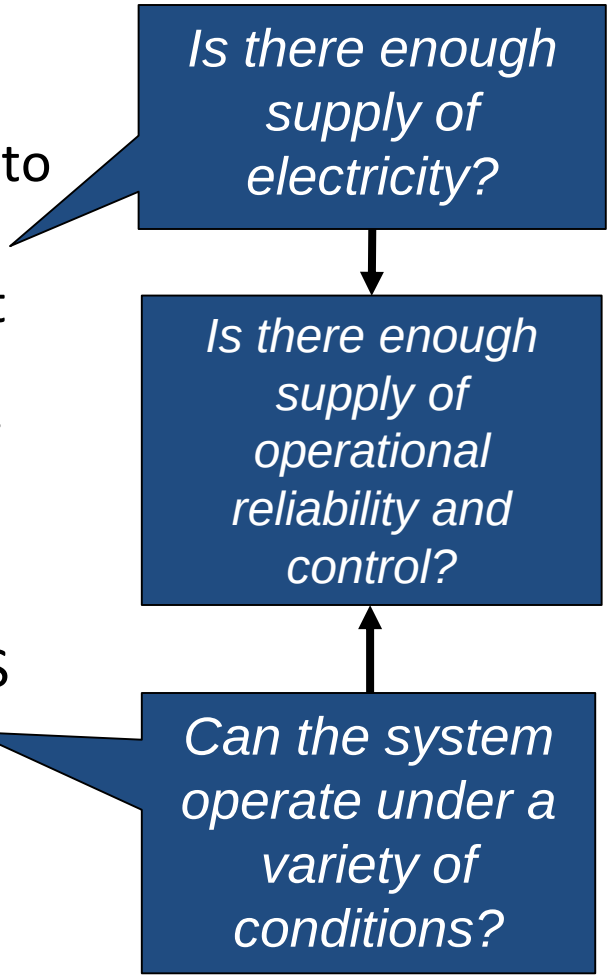
- Various technologies, unit sizes, ages, customer types
- Physical and Virtual Aggregation
- Variable output of units which can be dependent on weather (uncontrollable factor)

What is Bulk Power System (BPS) Reliability?

The ability of the BPS to meet the electricity needs of end-use customers at all times.

- **Resource Adequacy** — The ability of the BPS to supply the aggregate electrical demand and energy requirements of the customers at all times, taking into account scheduled and reasonably expected unscheduled outages of system elements.

- **Operating Reliability** — The ability of the BPS to withstand sudden disturbances such as electric short circuits or unanticipated loss of system elements from creditable contingencies.

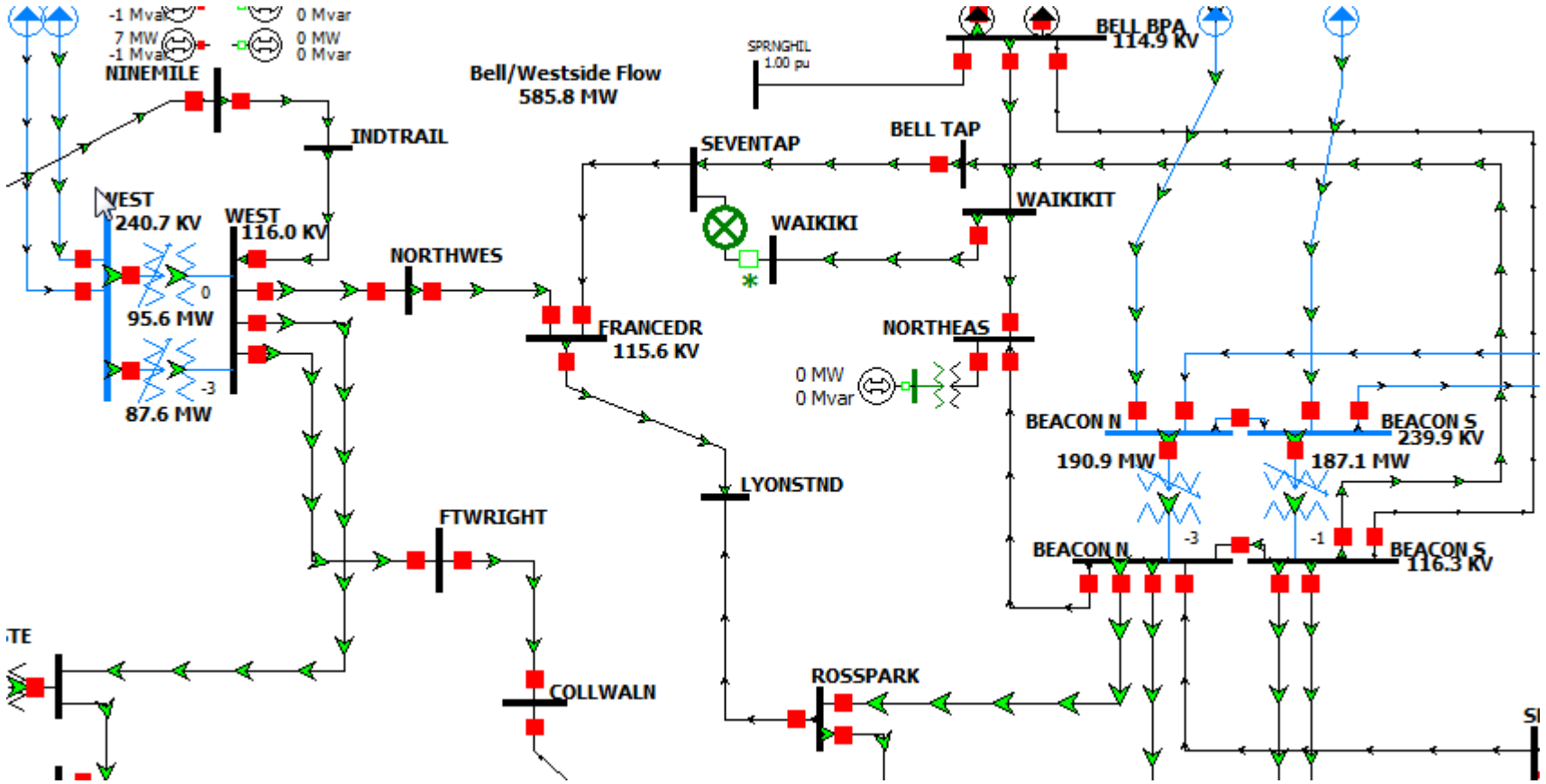


DER – Reliability Considerations

- At low penetration levels no real effect on BPS
  - What is “low” penetration?
- At higher penetration levels effects begin to manifest
  - Modeling – DER is netted with distribution loads today
  - Ramping and Variability – DER (solar) changes BPS load characteristics
  - Reactive Power – DER is generally providing WATTS only
  - Frequency Ride-Through – Not coordinated with UFLS schemes
  - System Protection – Distribution protection is designed for a single source (BPS)
  - Visibility and Control – Most DER is passive and not visible to BPS operator
  - Load and Generation Forecasting – Adds another variable
  - Interconnection Requirements – Interconnecting utilities will have a variety of resources to contend with and model correctly

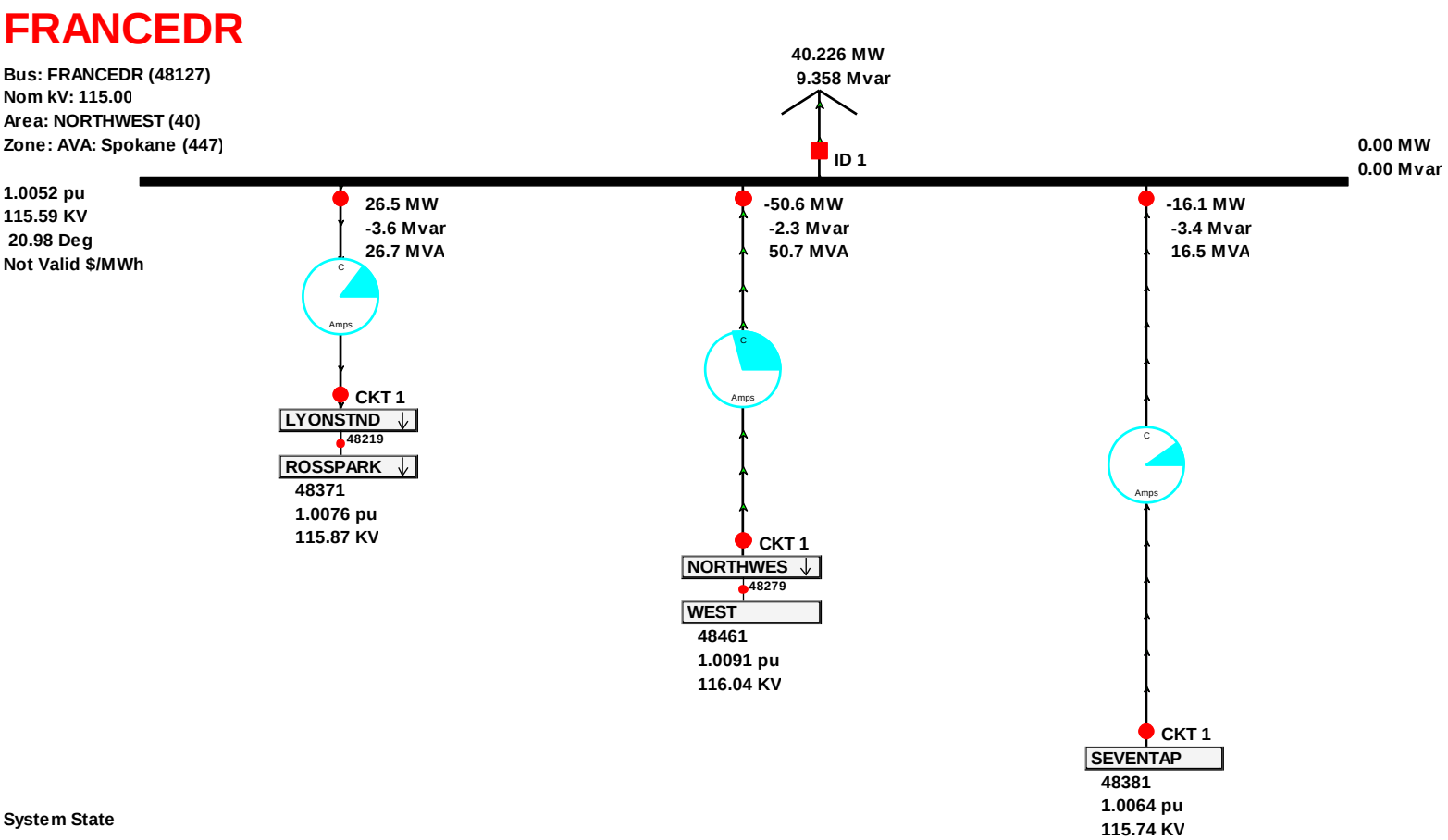
DER – Data and Modeling

- Typical Transmission One Line of steady state powerflow



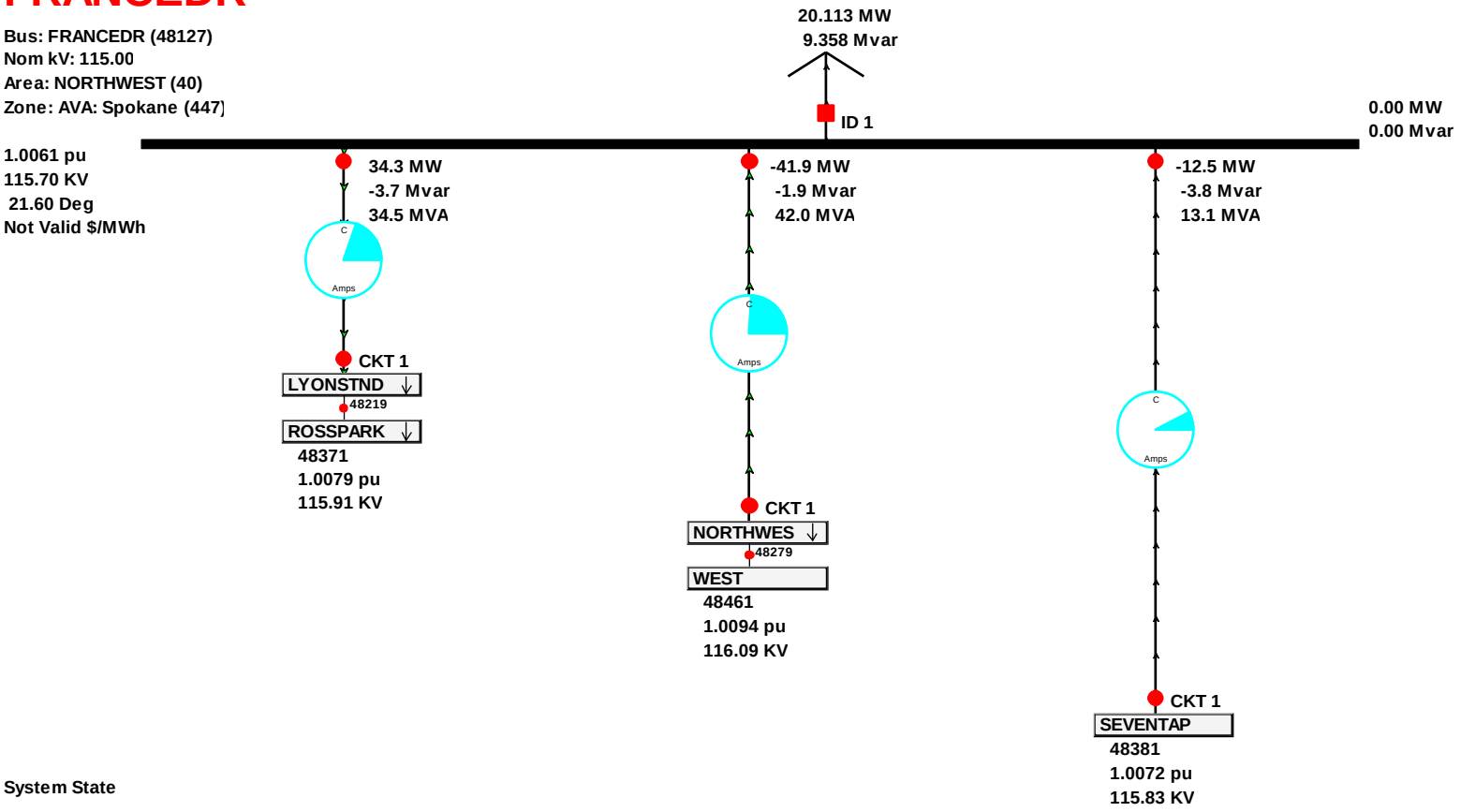
DER – Data and Modeling

- Typical Load Bus in steady state powerflow



DER – Data and Modeling

- Typical Load Bus in steady state powerflow with 50% DER

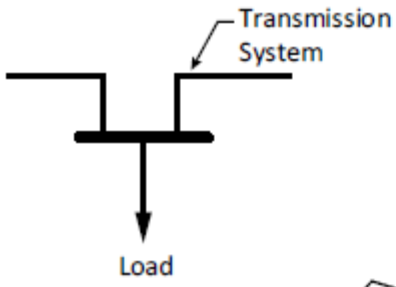


DER – Data and Modeling

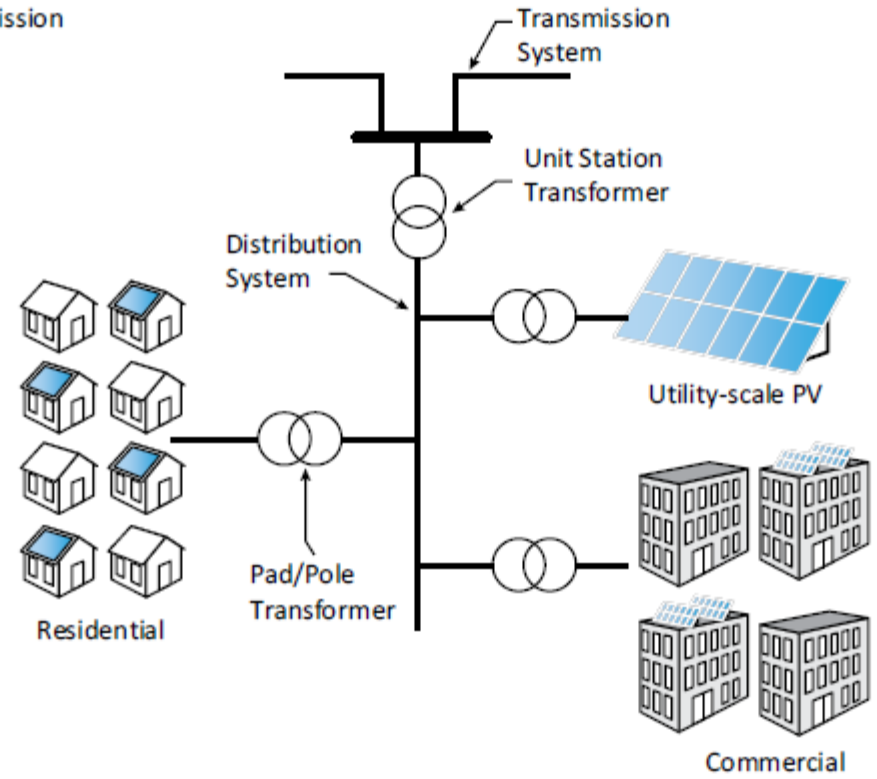
- Can you find DER in previous slides?
- Typical System Analysis Studies
  - Steady State – Pre and post-contingency thermal and voltage
  - Transient Stability – Time domain response to a contingency
  - Voltage Stability – Post-contingency stable voltage (reactive margin)
- DER will have a response in each type of study
- DER Data Requirements
  - KW, KVAR
  - Voltage regulation?
  - Frequency regulation?
  - Under / Over voltage tripping?
  - Under / Over frequency tripping?

DER – Data and Modeling

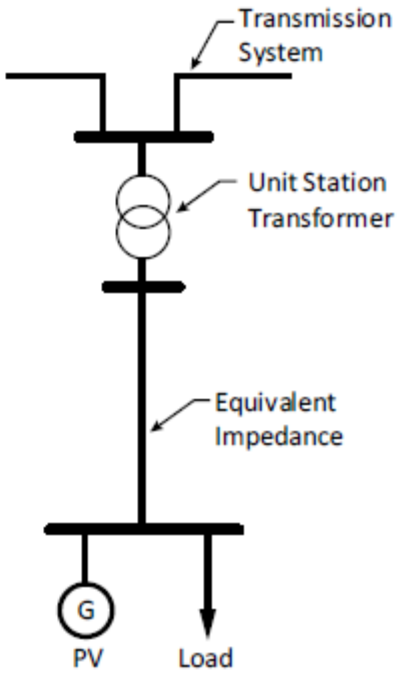
Typical Load Flow Model



High Penetration PV on Distribution System



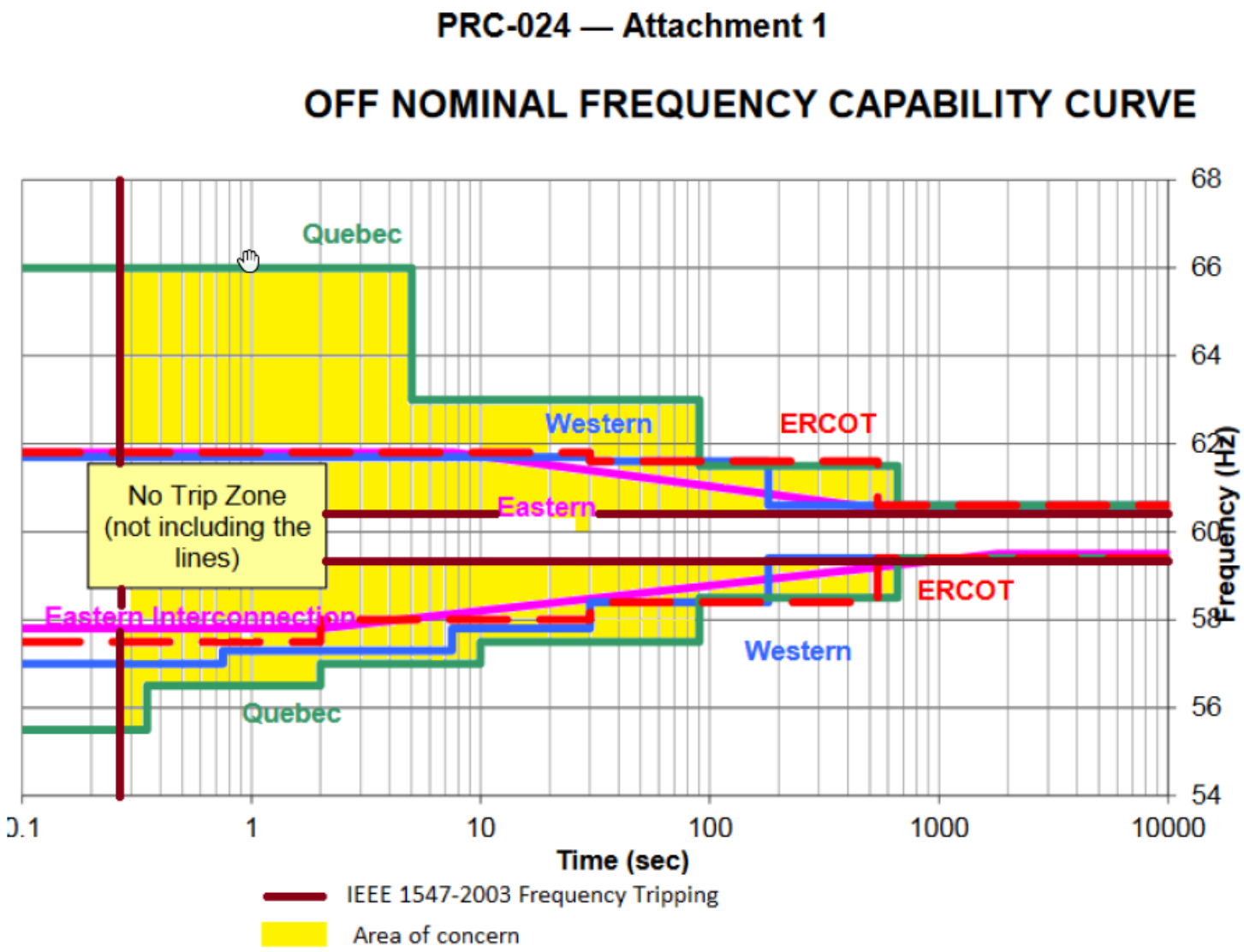
Recommended Load Flow Model



Characteristics of Non-Synchronous DER

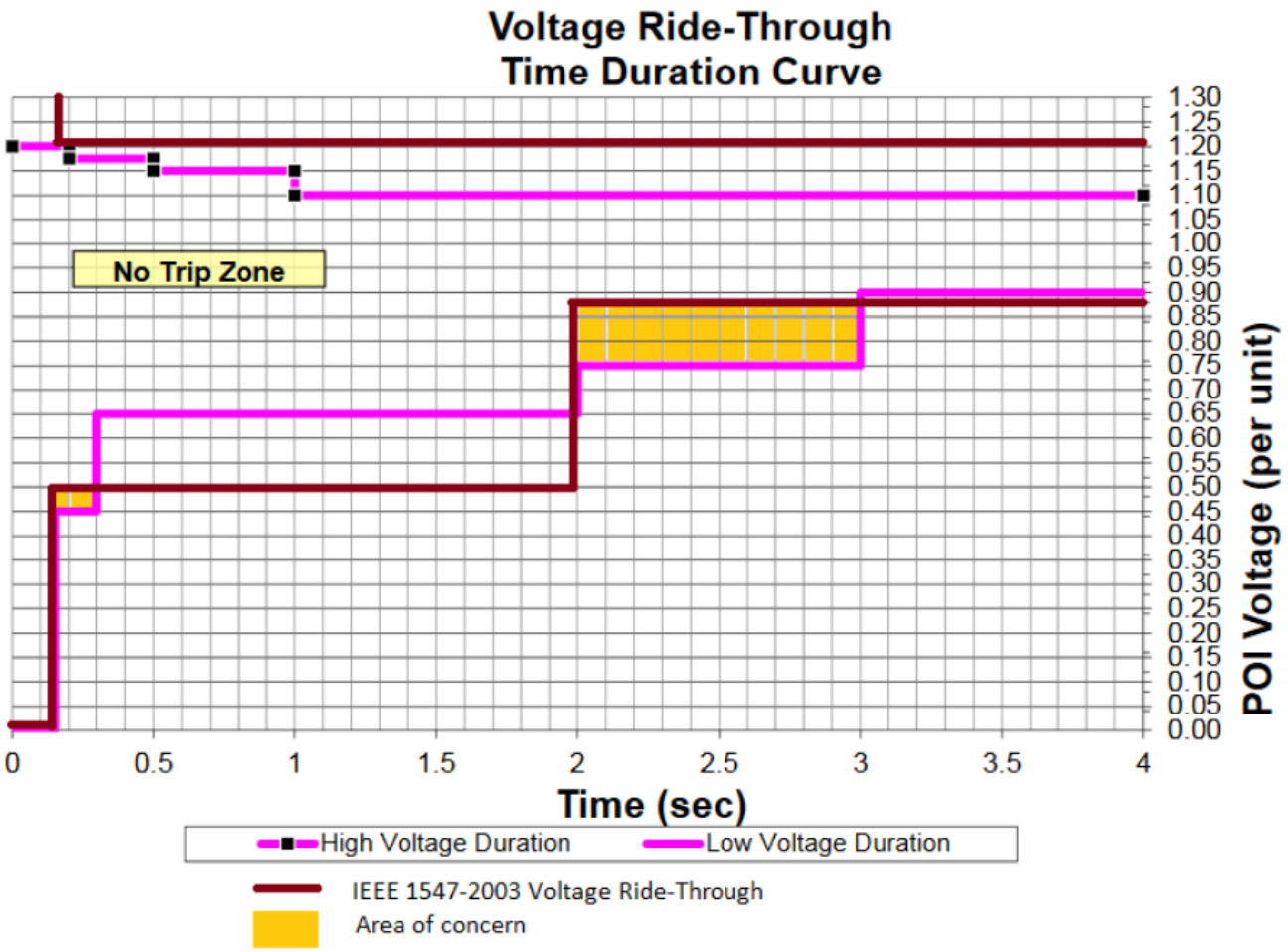
- DC to AC Inverters
- Performance requirements are designed to
  - Protect the public
  - Protect the equipment
  - Abnormal conditions – Shut Down!
  - IEEE 1547
  - UL1741
- BPS requirements are designed to provide reliability
  - PRC-024-2
  - Abnormal conditions – Stay Connected!
- Sensitivity vs Security
  - Blue Cut Fire illustrates this (August 2016 – 1175 MW BPS Gen Drop)

Characteristics of Non-Synchronous DER



Characteristics of Non-Synchronous DER

PRC-024— Attachment 2



Characteristics of Non-Synchronous DER

- Changes are underway
  - IEEE 1547-2018 standard changes
  - California Rule 21
    - Recognizes DER effects on BPS
  - NERC Inverter Task Force Report (BPS connected inverters)
  - NERC Alert (BPS connected inverters)
    - Loss of Solar Resources During Transmission Disturbances Due to Inverter Settings – 06/20/2017
    - No indication that DER tripped during this event
  - NERC Inverter Based Resources Performance Task Force

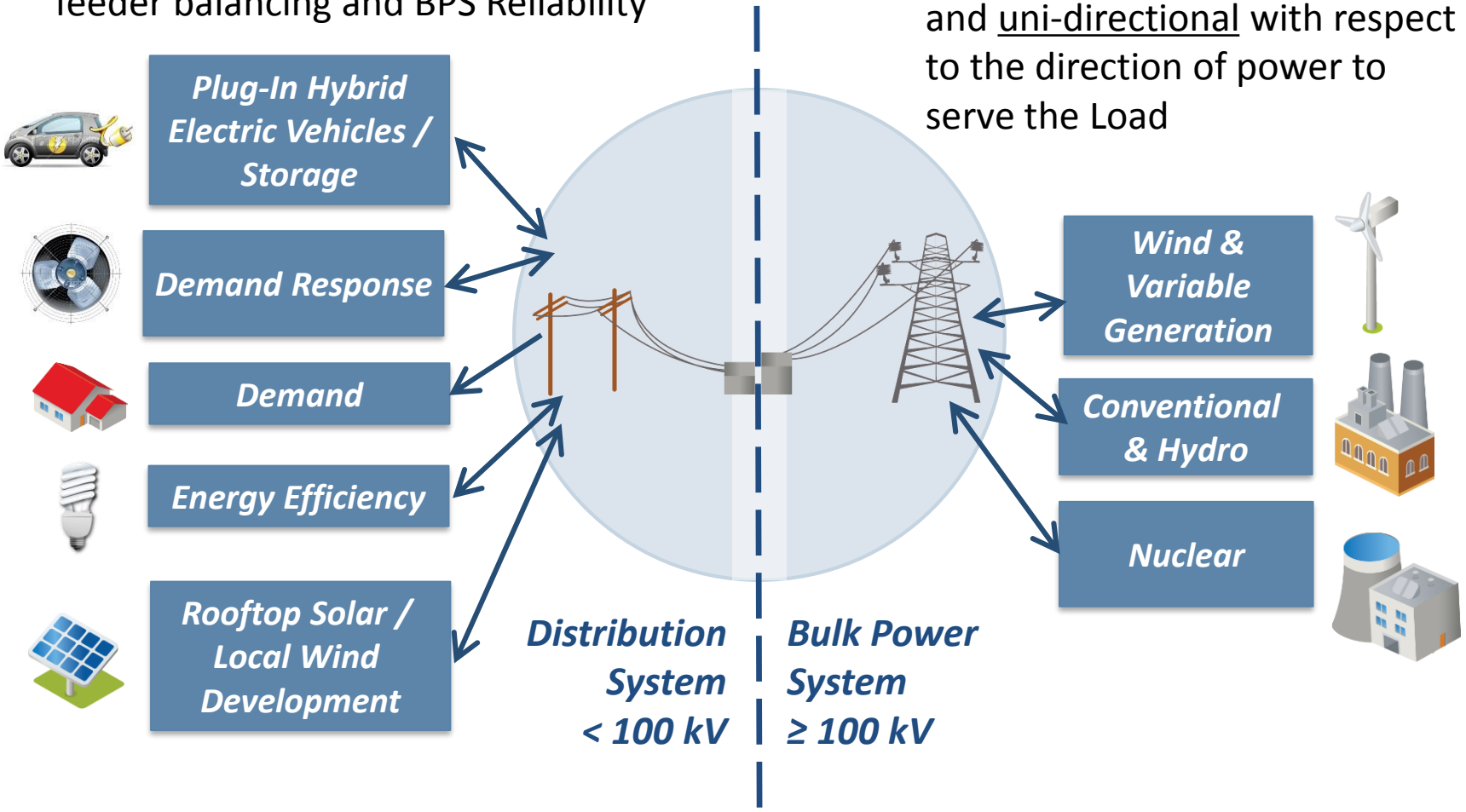
DER – Future System?

- Smart Inverters
  - Active Voltage Control
    - Provide dynamic voltage support
  - Active Frequency Control
    - Provide primary frequency response
- Aggregation of DER
  - Virtual Generators
  - Operate large amounts of DER as a single resource
- Energy Storage
  - Inject energy to meet fast change demand
  - Provide operating reserve
- Provide Essential Reliability Services to BPS

DER and BPS Power Flow Changes

- DER enable bi-directional power flows from the Distribution System which effects feeder balancing and BPS Reliability

- BPS previously considered the Distribution System as balanced and uni-directional with respect to the direction of power to serve the Load



Reference Links

- Essential Reliability Services Work Group
  - http://www.nerc.com/comm/Other/Pages/Essential-Reliability-Services-Task-Force-(ERSTF).aspx
- Distributed Energy Resources Report
  - http://www.nerc.com/comm/Other/essntlrlbltysrvcstskfrcDL/Distributed_Energy_Resources_Report.pdf
- ERS Concept Paper
  - http://www.nerc.com/comm/Other/essntlrlbltysrvcstskfrcDL/ERSTF%20Concept%20Paper.pdf
- 1200 MW Fault Induced Solar Photovoltaic Resource Interruption Disturbance Report
  - http://www.nerc.com/pa/rrm/ea/Pages/1200-MW-Fault-Induced-Solar-Photovoltaic-Resource-Interruption-Disturbance-Report.aspx
- ERS Videos
  - https://vimeopro.com/nerclearning/erstf-1

Questions and Answers