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DER Modeling Challenges

Updates and Forward-Looking Perspectives

Ryan Quint, Advanced Analytics and Modeling, NERC
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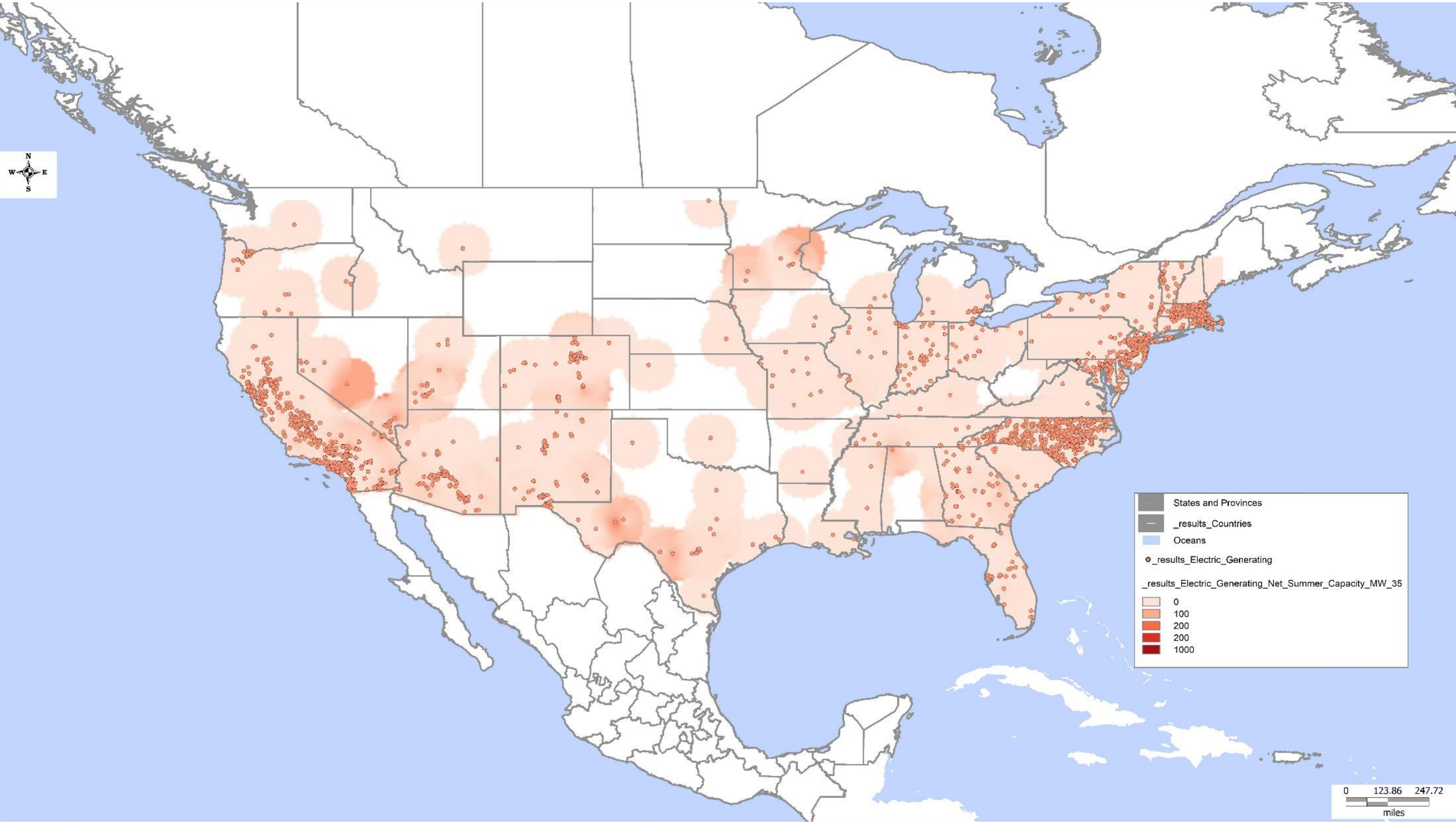
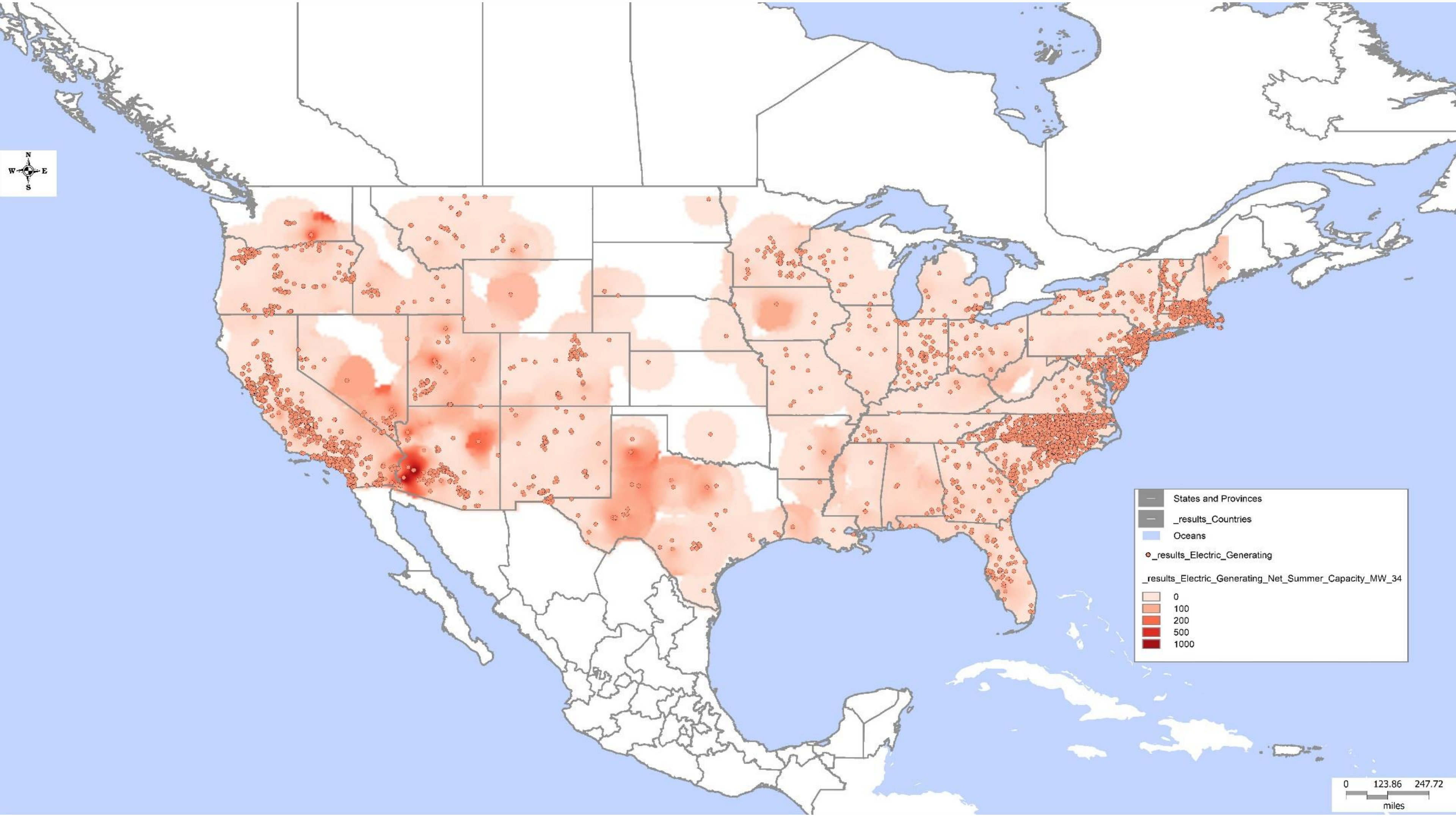
RELIABILITY | ACCOUNTABILITY




Current Solar Production



Current and Planned Production (Based on 2-3 Year Commitments)



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The Control Shift (1 of 3)

10%

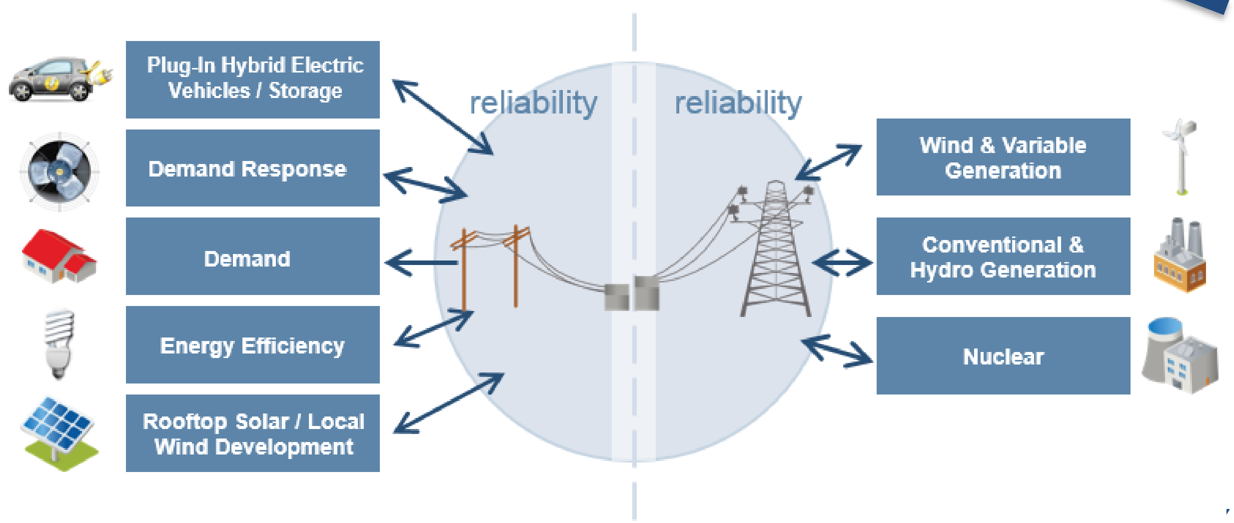
Distribution

- Variability absorbed by load variability
- Operational characteristics do not permeate to BPS

Bulk-Power System

- Supports system inertia and recovery modes
- Dispatchable based on demand
- Centralized to System Operator

90%



The Control Shift (2 of 3)

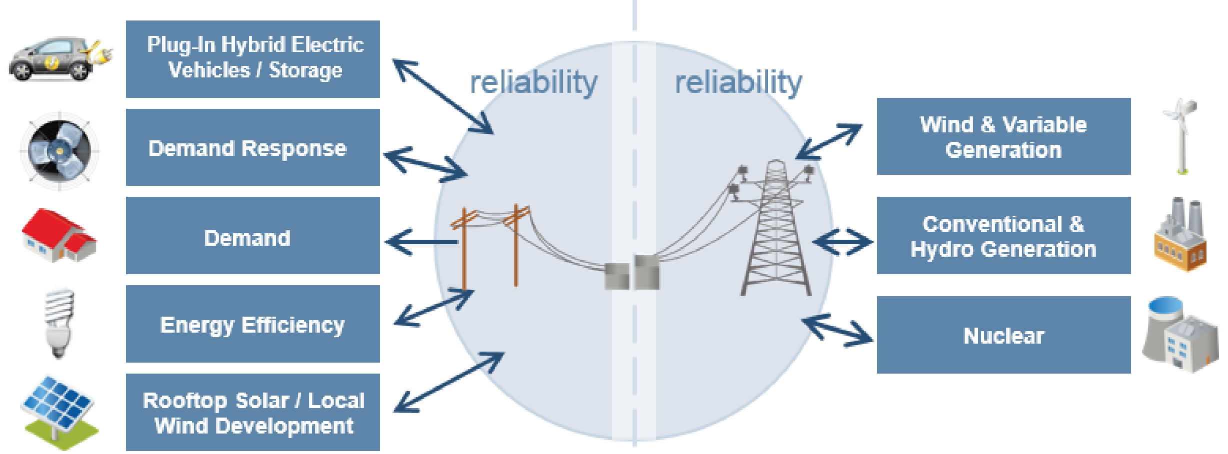
Bulk-Power System

- More rigorous generator control and dispatch ability
- Increased reliance on BPS generation
- Additional equipment to control local voltages

70%

Distribution 30%

- Disturbances permeate to BPS (common-mode)
- Dynamic and fast demand response
- Potential for over generation



The Control Shift (3 of 3)

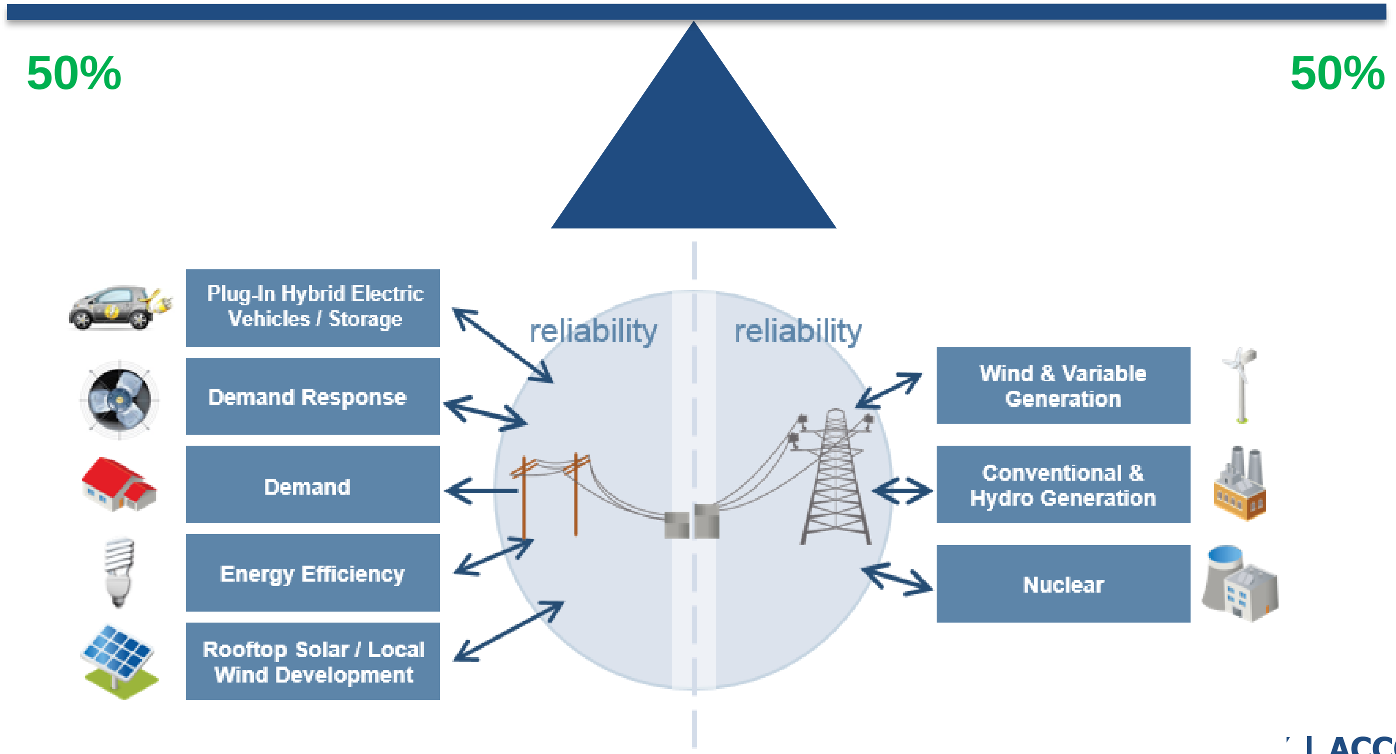
Integrated Power System

Distribution

- DER must act as a system resource
- Storage, curtailment, coordination, grid support, and control
- Operator or aggregator function is needed

Bulk-Power System

- Supports electricity services
- Long-haul power transfers provider
- Reliability backbone



Modeling Discussion Outline

#1: “How do I model DER in planning studies?”

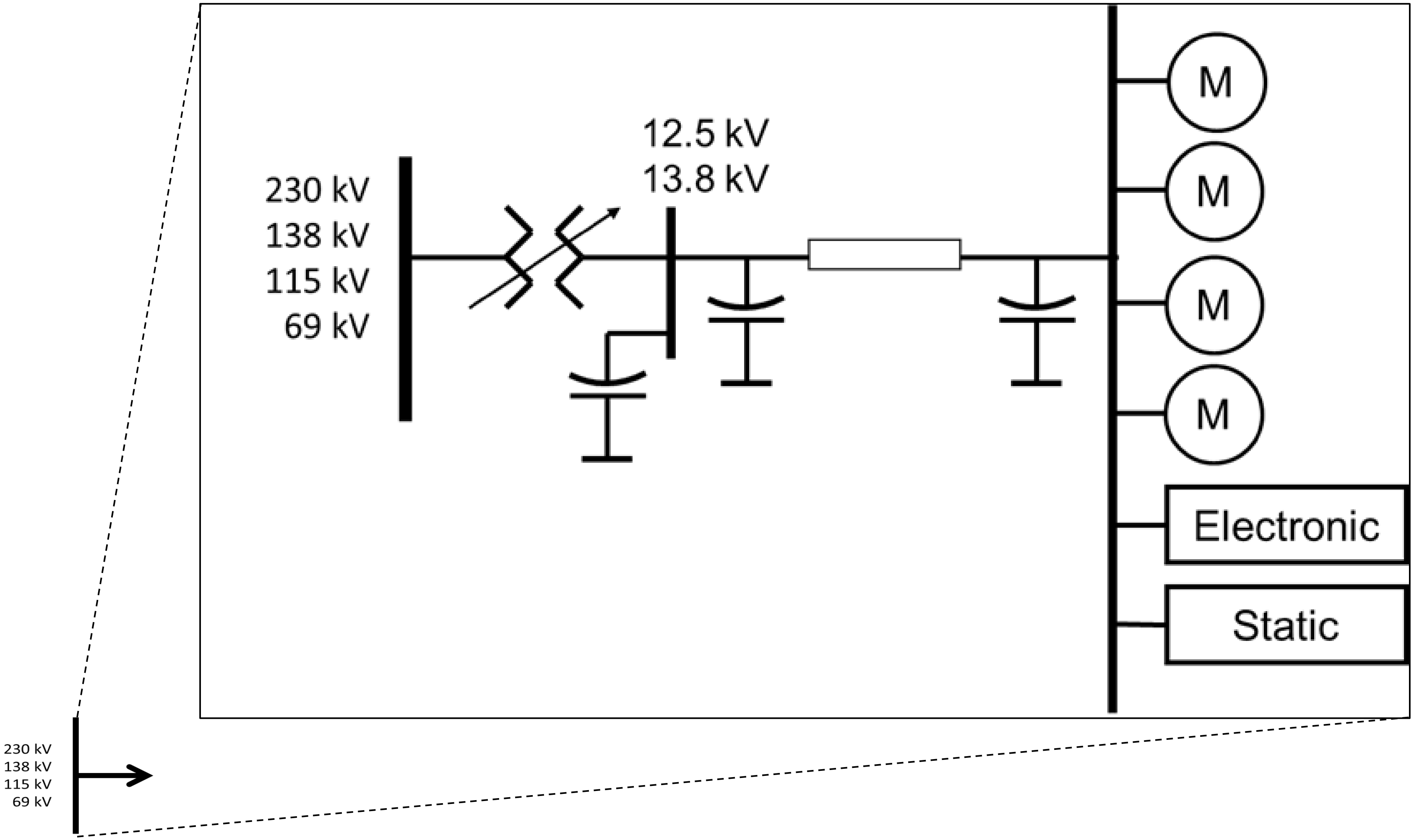
#2: “But what models do I use?”

#3: “What about the future?”

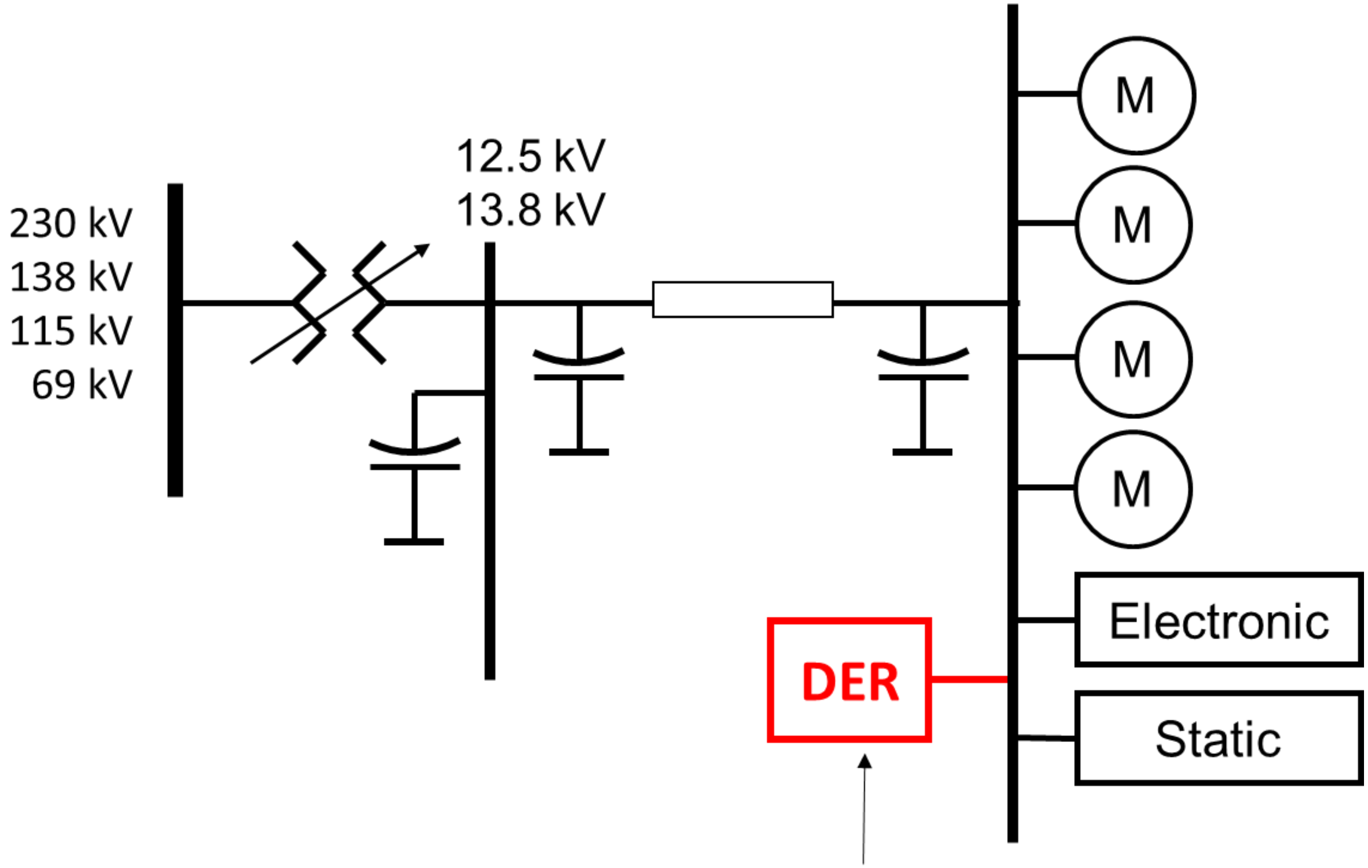
"How Do I Model DER in Planning Studies?"

DER Modeling Framework

Composite Load Model



Composite Load Model + DER



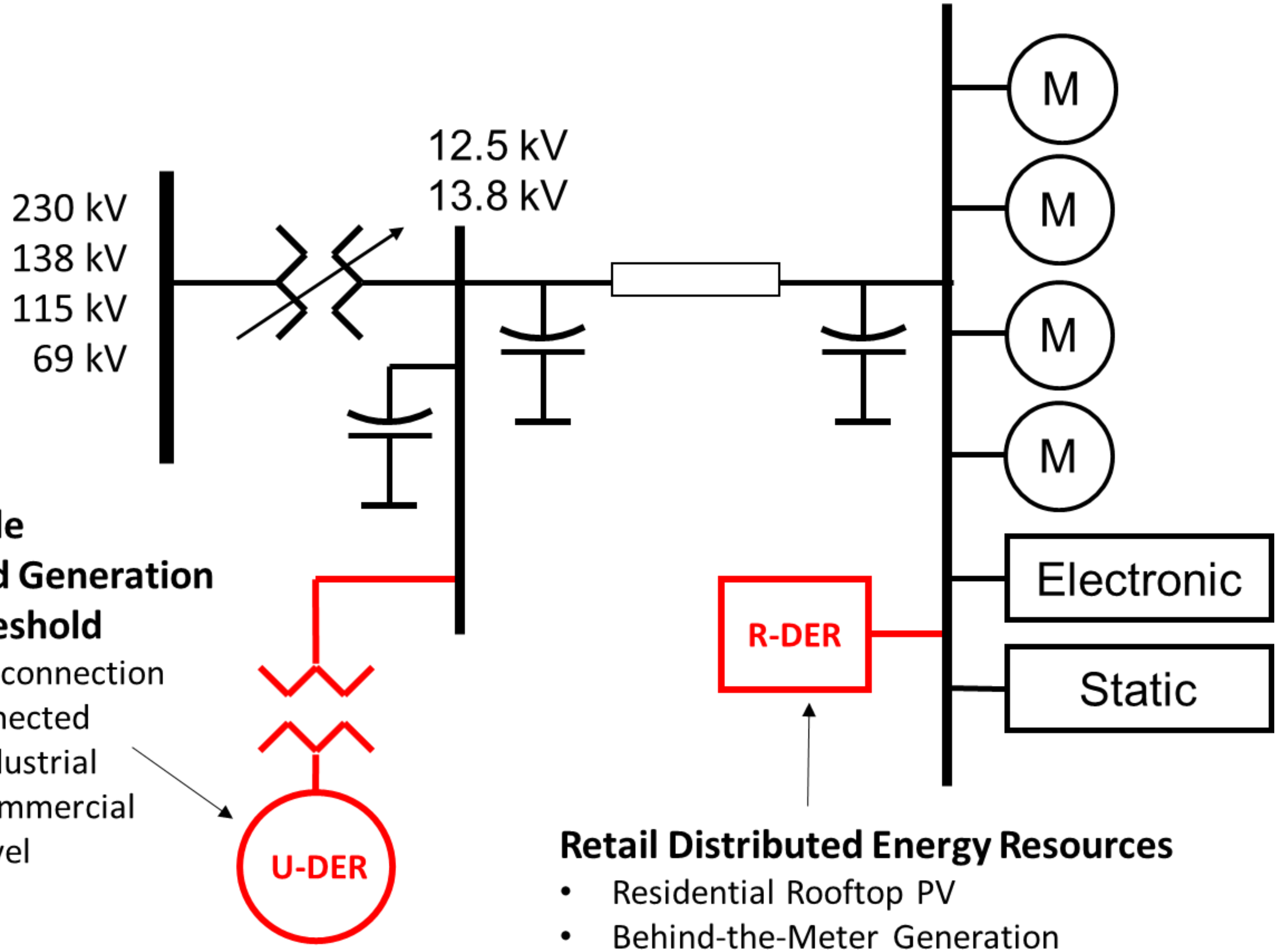
Distributed Energy Resources
- Residential Rooftop PV
- Behind-the-Meter Generation

U-DER and R-DER

- **Utility-Scale Distributed Energy Resources (U-DER):** distributed energy resources directly connected to the distribution bus or connected to the distribution bus through a dedicated, non-load serving feeder.
  - Three-phase interconnections;
  - Can range in capacity (e.g., 0.5 to 20 MW), although facility ratings can differ.

- **Retail-Scale Distributed Energy Resources (R-DER):** distributed energy resources that offset customer load. These DER include residential, commercial, and industrial customers.
  - Typically, the residential units are single-phase
  - Commercial and industrial units can be single- or three-phase facilities.

Composite Load Model + DER



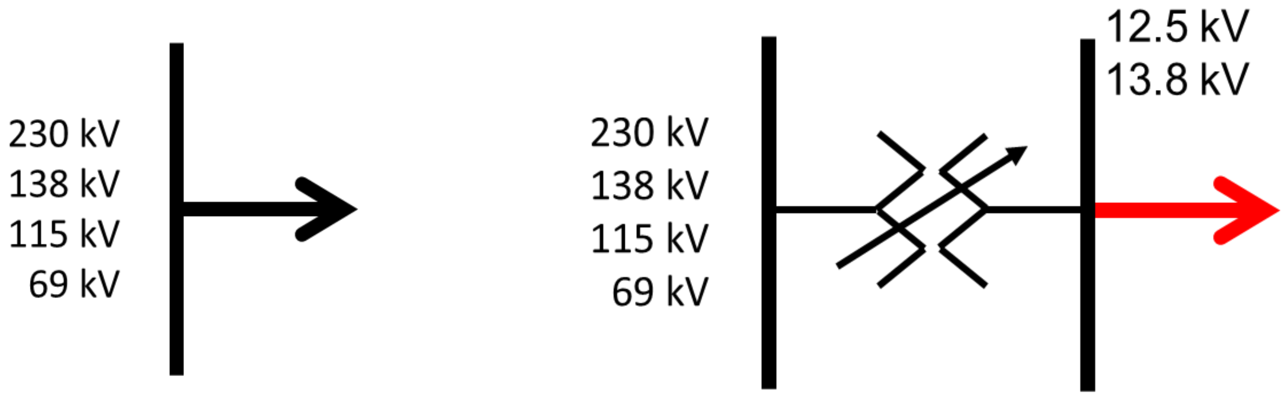
Utility-Scale Distributed Generation ≥ MW Threshold

- 3-ϕ Interconnection
- Bus-Connected
- Large Industrial
- Large Commercial
- Plant-Level

Retail Distributed Energy Resources

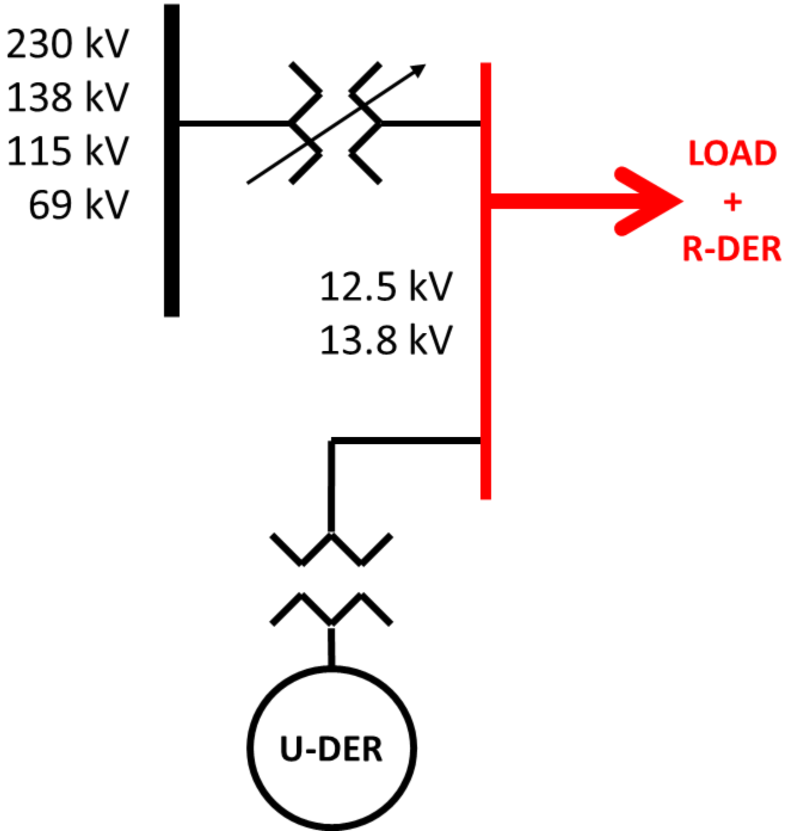
- Residential Rooftop PV
- Behind-the-Meter Generation

R-DER in Powerflow

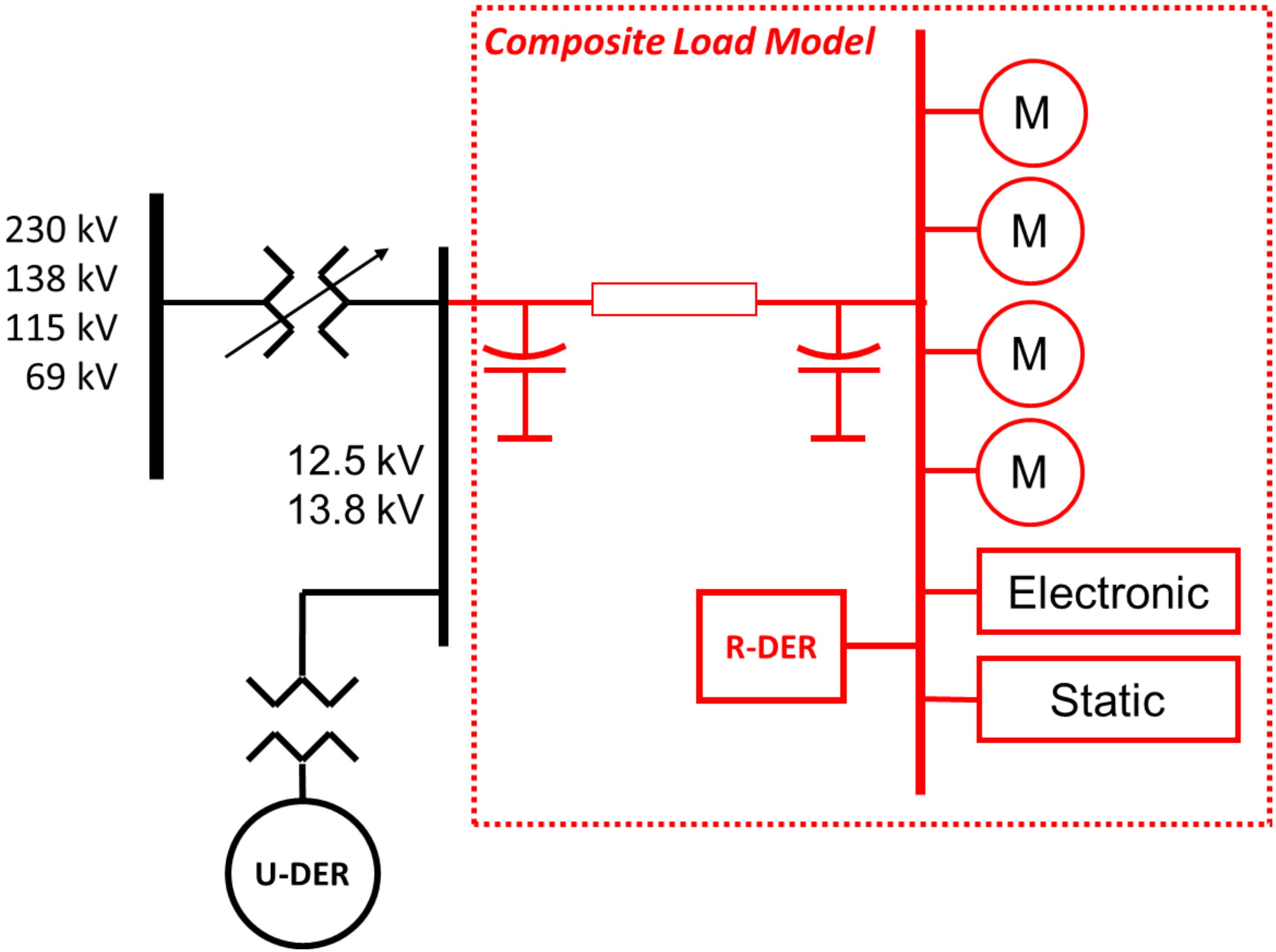


	Number of Bus	Name of Bus	Area Name of Load	Zone Name of Load	ID	Status	MW	Mvar	MVA	S MW	S Mvar	Dist Status	Dist MW Input	Dist Mvar Input	Dist MW	Dist Mvar	Net Mvar	Net MW
1	2	Two	Top	1	1	Closed	80.00	20.00	82.46	80.00	20.00	Closed	40.00	0.00	40.000	0.000	20.000	40.000
2	3	Three	Top	1	1	Closed	220.00	40.00	223.61	220.00	40.00	Open	110.00	0.00	0.000	0.000	40.000	220.000
3	4	Four	Top	1	1	Closed	160.00	30.00	162.79	160.00	30.00	Closed	80.00	0.00	80.000	0.000	30.000	80.000
4	5	Five	Top	1	1	Closed	260.00	40.00	263.06	260.00	40.00	Open	130.00	0.00	0.000	0.000	40.000	260.000
5	6	Six	Left	1	1	Closed	400.00	0.00	400.00	400.00	0.00	Closed	200.00	0.00	200.000	0.000	0.000	200.000
6	7	Seven	Right	1	1	Closed	400.00	0.00	400.00	400.00	0.00	Closed	200.00	0.00	200.000	0.000	0.000	200.000

U-DER + R-DER in Powerflow



U-DER + R-DER in Dynamics



Modeling Thresholds

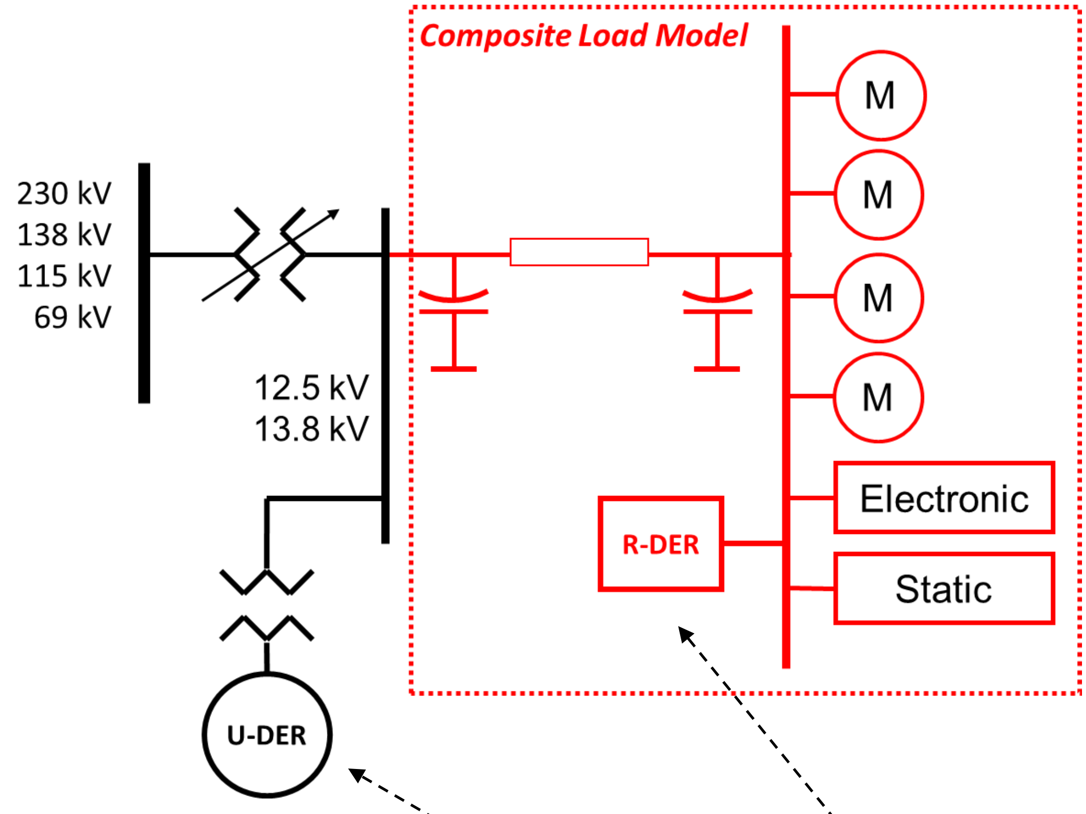
Table 1: Example of U-DER and R-DER Requirements		
Criteria	**Description**	**Threshold**
U-DER Modeling	Gross aggregate nameplate rating of an individual U-DER facility directly connected to the distribution bus or interconnected to the distribution bus through a dedicated, non-load serving feeder	___ MVA
R-DER Modeling	Gross aggregate nameplate rating of all connected R-DER resources that offset customer load including residential, commercial, and industrial customers	___ MVA

- NERC DERTF recommended R-DER threshold = 0 MVA
  - "don't load net the DER"
- U-DER modeling threshold may vary
  - Bright line threshold not recommended

"But What Models Do I Use for the DER?"

DER Models and Modeling Parameters

DER Model Selection



How do I model these?

Modeling Data Collection

- U-DER
    - Type of generating resource (e.g., recip engine, wind, solar PV, BESS)
    - Distribution bus nominal voltage where the U-DER is connected
    - Feeder characteristics for connecting U-DER, if applicable
    - Capacity of each U-DER resource (Pmax, Qmax)
    - Control modes – voltage, frequency, active-reactive power priority
- R-DER
    - Aggregate capacity (Pmax, Qmax) of R-DER for each feeder or load as represented in the powerflow base case
    - Vintage of IEEE 1547 (e.g., -2003) (or other relevant standard reqs.)
    - As available, aggregate information characterizing the distribution circuits where R-DER are connected

Synchronous DER Models

- Use gentpj model with *Kis* = 0
- If modeling information available, use that data
- Otherwise, use engineering judgment
- Examples provided in NERC guideline, for reference

Table 2.1: Synchronous DER Default Model Parameters

Parameter	Steam	Small Hydro	Gas
MVA	14	32	15
T′d0	6	6	6.5
T″d0	0.035	0.027	0.03
T′q0	1	0[22]	1
[illegible]	[illegible]	[illegible]	[illegible]

2nd Generation Renewable Energy System Models

- Most detailed models available
- Complex, often not necessary for interconnection-wide modeling.
- Other models may be more suitable and easier to use for representing DER
- May be useful for detailed interconnection studies, large capacity resources relative to local interconnecting network, high penetration systems, or other special studies
- Planners should determine appropriate situations where complex models useful for modeling DER

PV1 Model

- Interim solution for BPS-connected solar PV
- Developed prior to 2nd generation models being developed
- Not implemented consistently across software platforms.
- Use of the PV1 model is not recommended.
  - For detailed solar PV modeling – use 2nd generation renewable models
  - For aggregated DER – use PVD1 and future DER_A

PVD1 Model

- Most flexible and user-friendly model for R-DER solar PV
- Reasonable representation for U-DER, particularly when detailed information of equipment and controls not available
- May not be adequate for detailed system studies or high DER penetration DER systems

DER_A Model

- Currently being implemented and benchmark tested by software vendors
- Should be released in 2018
- Simplified version of 2^{nd} generation renewables model(s)
- Parameter list size similar to PVD1 (relatively small)
- Additional features to PVD1
  - Frequency controls
  - Voltage, power factor, and reactive power controls
  - Inverter cutouts for aggregated response
  - Fractional re-energization
  - Ramp rate limits
- Recommended model once implemented

U-DER Capabilities

Table 3.1: U-DER Modeling Options					
BPS Model Options					
Model	**PSLF**	**PSSE**	**PW**	**PT**	**V&R**
Synchronous Machine Models	X	X	X	X	X
2nd Generation Renewable Models	X	X	X	X	X
PV1	X	X	X	X[1]	-
PVD1	X	-	X	-	-
DER_A[2]	-	-	-	-	-

“What About the Future?”

Considerations Moving Forward

DER Modeling Perspectives

DER Modeling Aspects	Progress
DER Monitoring, Observability, and Forecasting	
DER Powerflow Modeling Capability	
DER Powerflow Modeling Practices	
DER Dynamic Model Availability	
DER Dynamic Modeling Practices	
DER Performance – IEEE Std. 1547	
DER Performance Modeling	

Relevant NERC DER Modeling Links

- Guidelines
  - Reliability Guideline: Modeling Distributed Energy Resources in Dynamic Load Models – HERE
  - Reliability Guideline: Distributed Energy Resource Modeling – HERE
- Technical Reports
  - Distributed Energy Resources Connection Modeling and Reliability Considerations – HERE

Questions and Answers

Ryan Quint, PhD, PE
Senior Manager, Advanced Analytics and Modeling
North American Electric Reliability Corporation
Office (202) 400-3015
Cell (202) 809-3079
ryan.quint@nerc.net