Modeling Distribution Feeders with Distributed Generation (DG) in ASPEN

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System Protection Engineering
Dominion Energy

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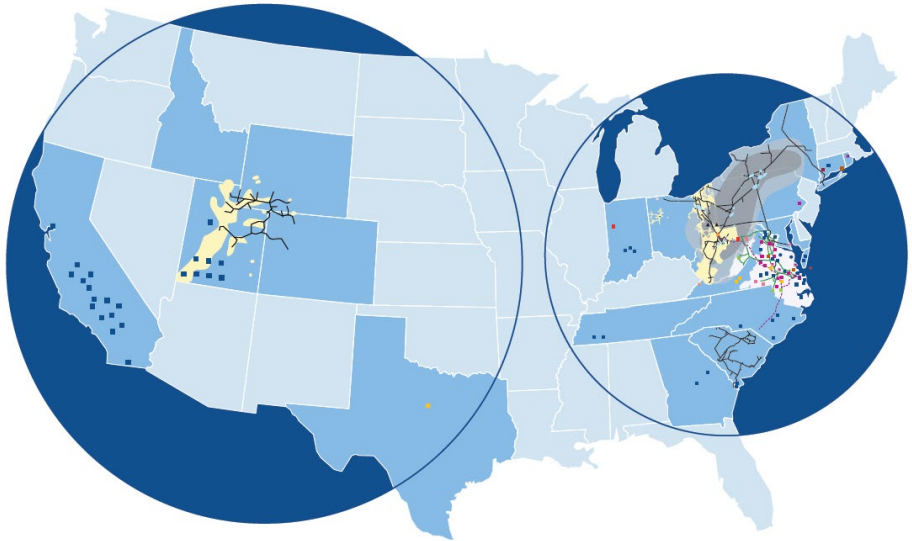
Dominion Energy Footprint

- 26 GW of electric generation
- 6,600 miles of electric transmission lines
- 57,900 miles of electric distribution lines



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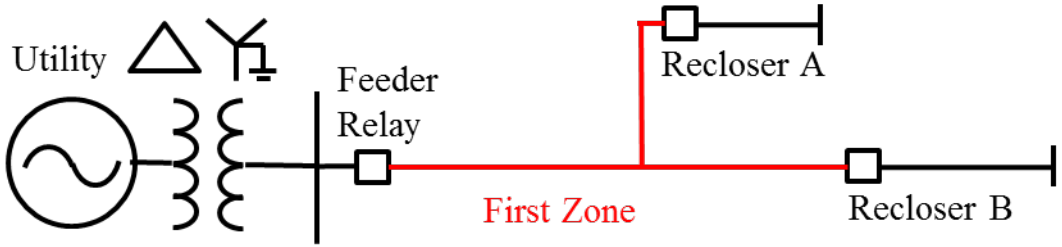
Distribution Protection Challenges with DGs

- DG short circuit modeling and validation
- Relay settings for both DG on and off scenarios
- Arc flash calculation
- **Distribution feeder modeling**

Distribution Feeder Topology

- Feeder relays protect the first zone
- Radial systems
- Need to coordinate with down-line protective devices, i.e. reclosers and fuses



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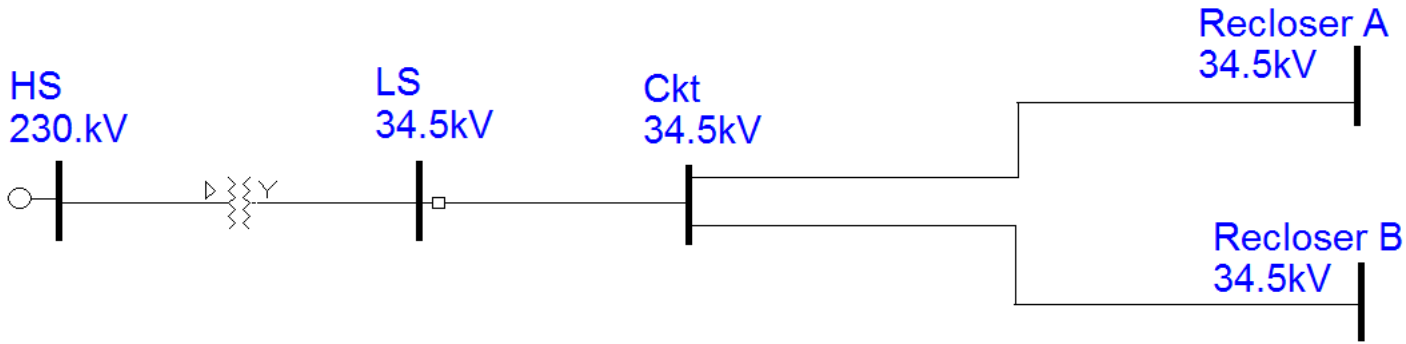
Single-bus Model

- Models impedance from substation to down-line devices
- Each down-line device is on an individual branch
- Does not reflect true topology
- Simplicity



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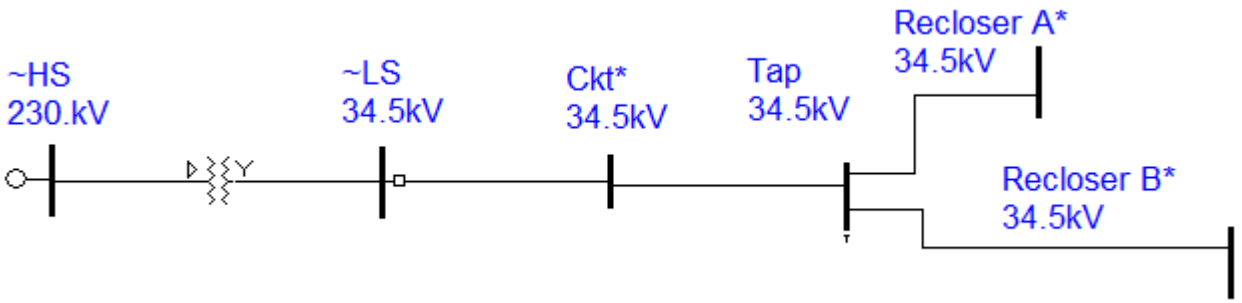
Mainline & Branch Model

- Reflects true topology
- Down-line devices are tapped from the “mainline”
- Complexity



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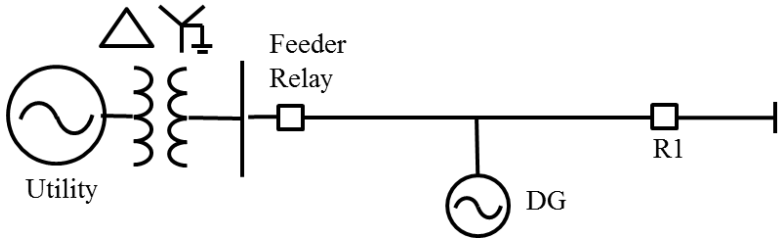
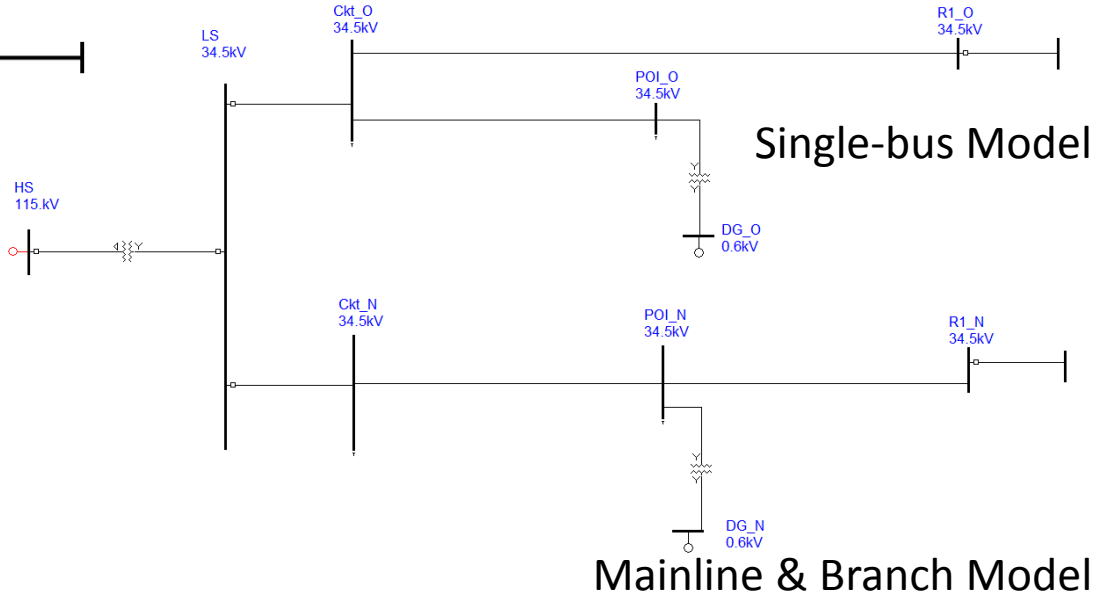
Model Comparison





Single-bus Model

Mainline & Branch Model

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Traditional Model Format Underestimate Fault Current

- 40 MVA DG located at the mid point
- Apply fault on down-line Recloser R1
- Compare fault seen by the feeder relay

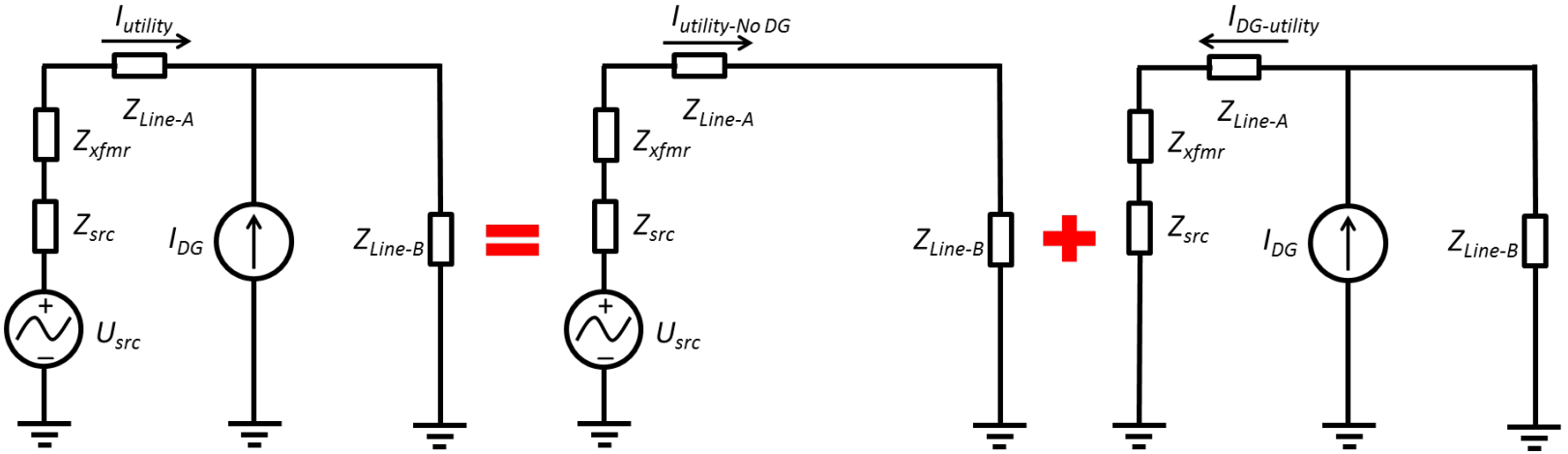
	3 phase fault (Ip)	1 phase ground fault (3*I0)
Single-Bus Format	2305 A	2591A
Mainline & Branch Format	2422 A	2774A
Mismatch	117 A	183 A

Traditional Model Format Underestimate Fault Current – Cont.

- As the DG tap point moves toward the reach point, the model mismatch increases

	3 phase fault (Ip)	1 phase ground fault (3*I0)
Single-Bus Format	2305 A	2568A
Mainline & Branch Format	2480 A	2842A
Mismatch	175 A	274 A

The Single-bus Model Mis-represents DG Fault Impedance



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Limitations of the Single-bus Format: Mis-coordination with Down-line Devices

- Adequate time separation between feeder relays and down-line devices is needed
- Single-bus models over-estimate time separation

	Fault current seen by feeder relay (A)	Feeder relay clearing time (s)	Fault current seen by Recloser R1 (A)	Recloser clearing time (s)	Time separation (s)
Single-Bus Format	2305	0.731	3106	0.331	0.400
Mainline & Branch Format	2480	0.657	3282	0.300	0.357

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Limitations of the Single-bus Format: Instantaneous Protection Overreaching Down-line Devices

- Instantaneous tripping is set to provide high-speed protection
- The setting value is based on the fault current magnitude at the closest first zone device
- Instantaneous values set based on single-bus models could over-reach beyond first zone devices

	3 phase fault (Ip)	Phase INST setting
Single-Bus Format	2305 A	2766 A
Mainline & Branch Format	2480 A	2976 A
Percentage		93%

Conclusions

- The traditional radial feeder modeling approach underestimates fault current magnitude when DGs are present, which could lead to protective device mis-coordination
- The proposed new feeder modeling approach proves more accurate for DG circuits
- Embrace the change

Questions?