EMT Input Data Structures & Models
A Utility Engineer's Perspective

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Dominion Energy

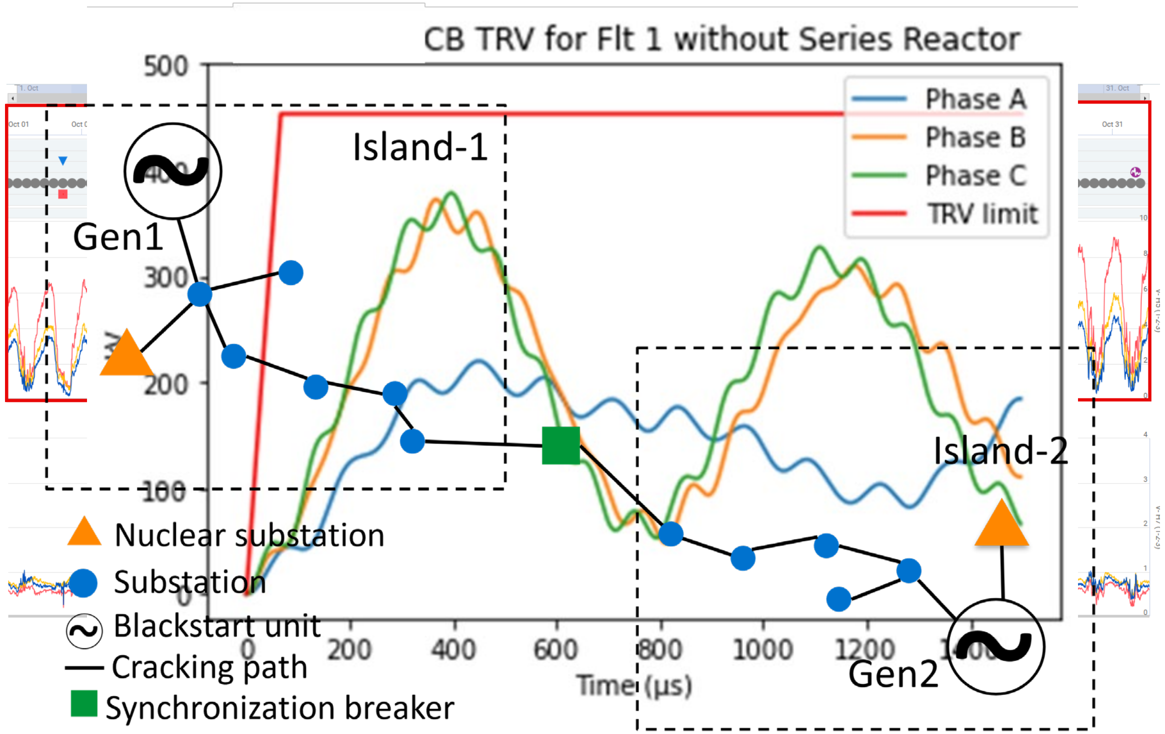
Dominion Energy Electric Transmission

- Operates in Virginia, North Carolina and West Virginia
- ~6,800 miles of transmission lines from 69 kV up to 500 kV
- More than 900 substations and 50,000 transmission structures
- **Electric Transmission Special Studies** provides domain expertise and root cause analysis for operational challenges across Dominion Energy.
- To address emerging issues, Special Studies leverages modeling and simulation capabilities at the **DETECT Laboratory** and collaborates with internal departments, industry groups, and academia.

Dominion **E**lectric **T**ransmission **E**nergy **C**enter for grid **T**ransformation

Use Cases for EMT Simulation at Dominion Energy

- Harmonics and resonance studies
- Transient recovery voltage studies
- Blackstart studies
- Switching transient studies
- Transformer inrush and saturation studies
- Sub-synchronous oscillation studies
- Fault analysis and protection system testing (HIL)
- Etc.



Current EMT Tools & Practices at Dominion Energy

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- System-wide models exist for short-circuit, load flow and transient stability studies
- These models form the foundation for EMT model development
- Model creation/conversion involves:
  - Manual process
    - Only practical for modeling small areas
    - No real input data structures
    - Arduous and error prone process
    - Modeling choices and details rely on engineering judgement/experience for specific studies.

TRV for remote fault using different line models

COMPARISON OF PSCAD TRANSMISSION LINE MODELS

Issue	Minimum Recommended Cable Model	Importance of Detailed Models (Segments, Bonding, Grounding Frequency-Dependent (FD))
Phase unbalance and transposition	Bergeron (Unbalanced) Equivalent PI	Segments are important. FD is not important.
Harmonic frequency scans	Bergeron Equivalent PI	Segments are not important. FD is moderately important; cable parameters may be re-calculated for each frequency of interest if necessary.
TOV – Ground faults and clearing	Bergeron	Minimal; damping from other system components is more important.
TOV – Resonance	Bergeron	Minimal; damping from other system components is more important.
TOV – System islanding and load rejection	Bergeron	Minimal; damping from other system components is more important.
Ferroresonance	Bergeron	Minimal; damping from other system components is more important.
Harmonic sources and flows	Bergeron Equivalent PI	Segments are not important. FD is moderately important; cable parameters may be re-calculated for each frequency of interest.
Cable energization	Bergeron (at Target Frequency)	Segments are not important. FD is moderately important; this is usually the first case in which to apply an FD model.
Auto-reclosing overvoltages	Bergeron	Segments are not important. FD is moderately important, but power-frequency solution should not be compromised.
Discharge of the cable	Bergeron	Minimal.
Sheath overvoltages and protection	Bergeron (Unbalanced)	Segments are important. FD is moderately important.
DC offset / zero-miss effect	Bergeron	Minimal.
Current transformer (CT) saturation	Bergeron	Minimal.
Capacitive current interruption	Bergeron	Minimal.
Lightning overvoltage	Bergeron (Unbalanced, at Target Frequency)	Segments are important. FD is moderately important.
Shunt reactor restrike	Bergeron	Segments are not important. FD is moderately important.
Inductive coordination and EMI	Bergeron (Unbalanced) Equivalent PI	Segments are important. FD is not important.

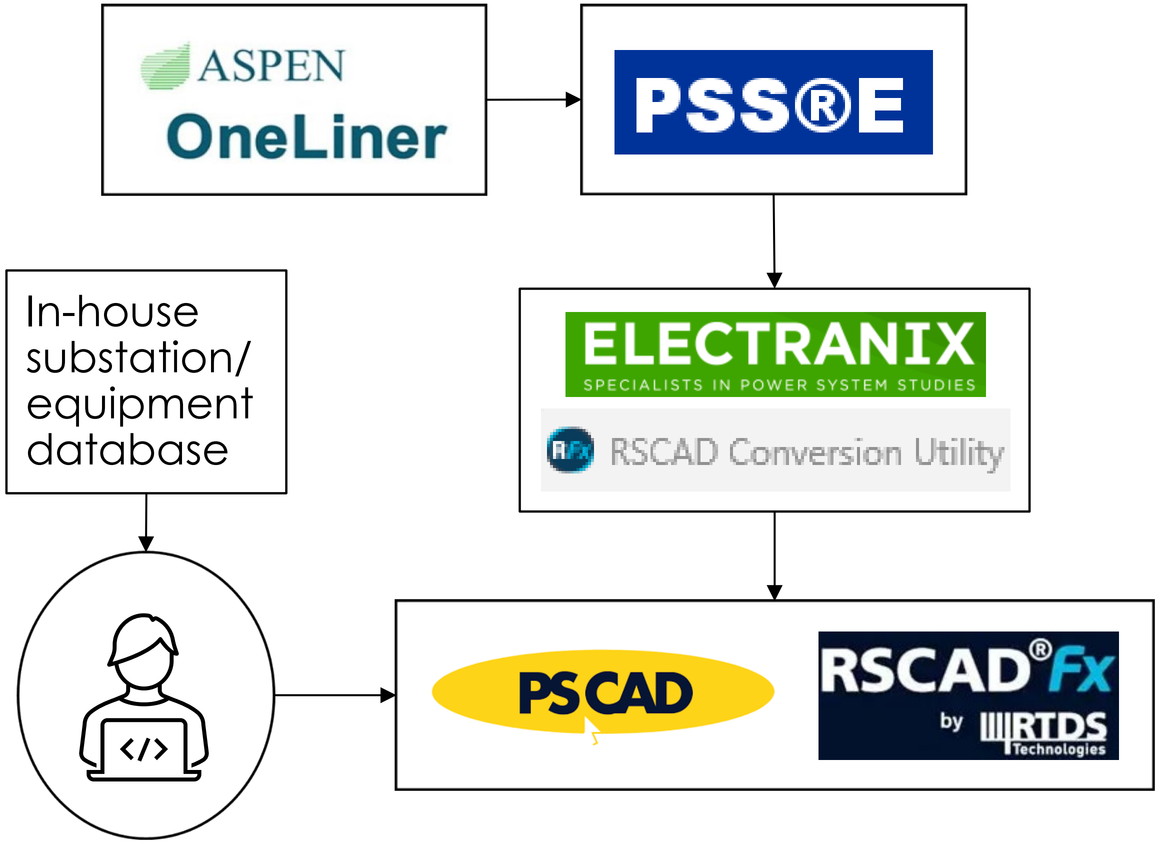
Source: CIGRE WG C4.502 Power System technical performance issues related to the application of long HVAC cable

- Are these guides still relevant for today's electric system?
- How can we create similar guides for modeling other network assets?

Sensitivity Studies

Current EMT Tools & Practices at Dominion Energy

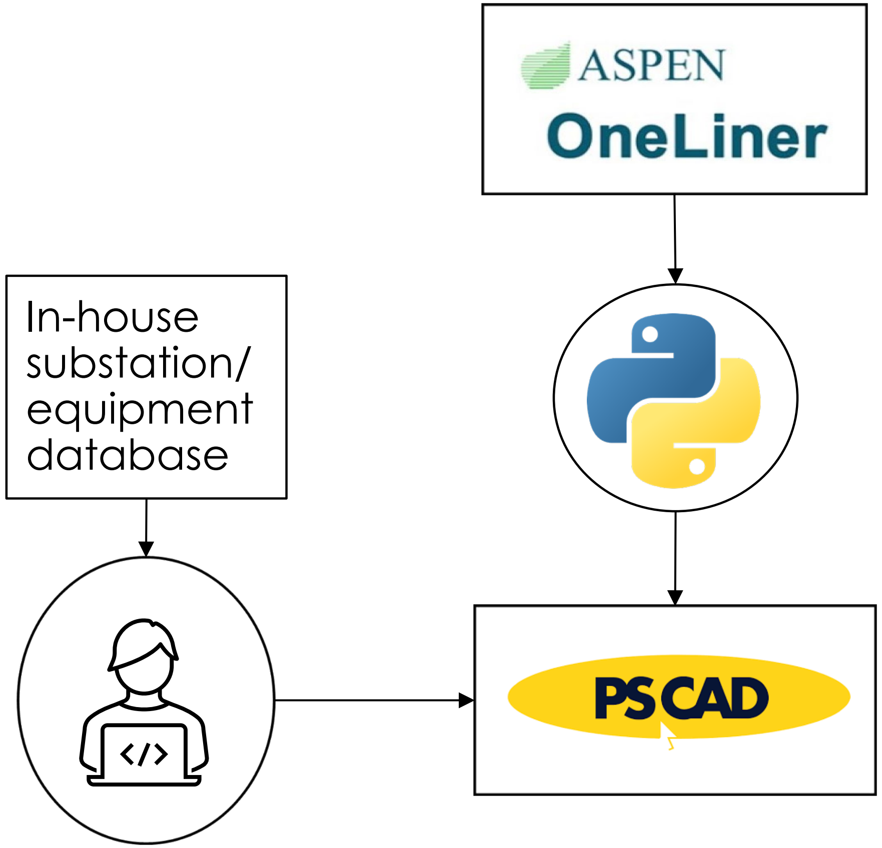
- System-wide models exist for short-circuit, load flow and transient stability studies
- These models form the foundation for EMT model development
- Model creation/conversion involve:
  - Manual process
  - Commercial tools
    - Enables wider-area modeling
    - Uses common input formats (raw, seq, & dyr)
    - No input data structures outside of the conversion software
    - Modeling choices limited to conversion software options
    - High number of errors/warning can make conversion tedious



Current EMT Tools & Practices at Dominion Energy

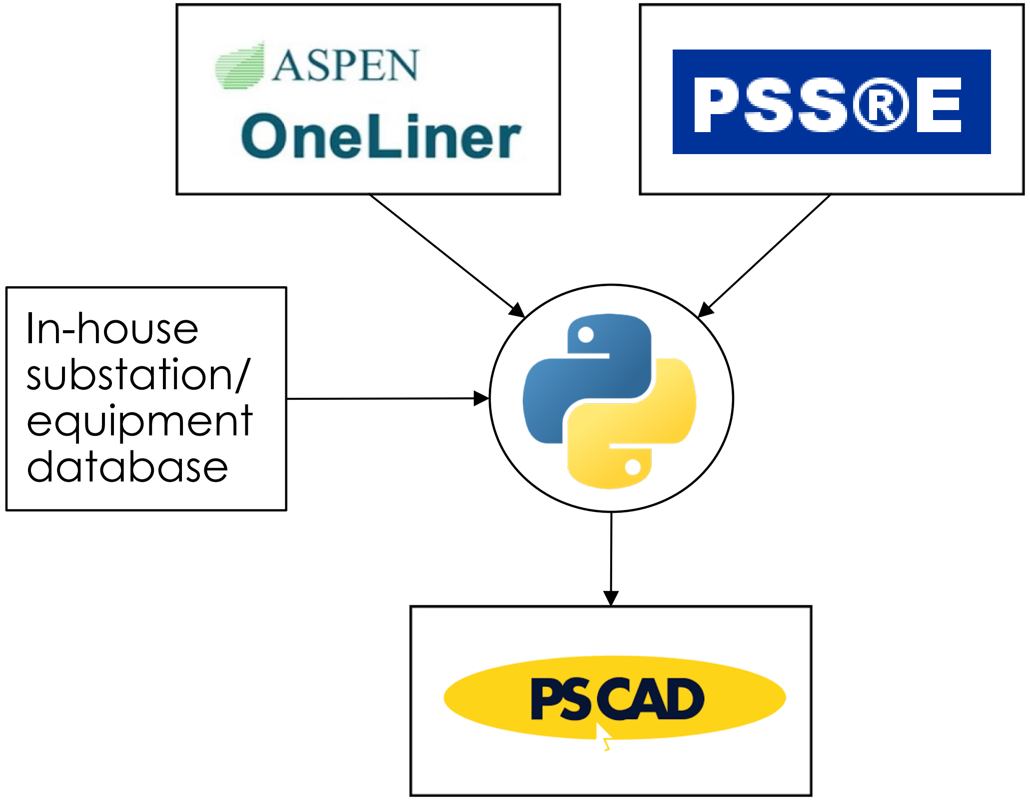
Dominion Energy

- System-wide models exist for short-circuit, load flow and transient stability studies
- These models form the foundation for EMT model development
- Model creation/conversion involve:
  - Manual process
  - Commercial tools
  - In-house conversion algorithm
    - Enables wider-area modeling
    - Potential to read any text-based format
    - Flexible modeling choices
    - Substantial initial efforts required



Ongoing Actions and Potential Next Steps

- Collaborate with commercial tool developers to flag issues and provide feedback
- Maintain partnerships with industry and academia to inform modeling decisions
- Continue improving the capabilities of the in-house conversion algorithm



Thank you