Study Committee C6

Active Distribution Systems and Distributed Energy Resources

Paper ID 10525

Distributed Energy Resource Benchmark Models for Distribution Impact Assessment Developed by CIGRE Working Group C6.36

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Motivation

- DER model requirements increasing to effectively assess and plan active distribution systems
- DER models must sufficiently capture the DER *temporal characteristics* and *system interactions*
- Lack of DER benchmark models that can serve as a common reference

CIGRE WG C6.36 - DER Models for Impact Assessment

- Objective to develop:
  - *DER benchmark model framework*, and
  - Set of *benchmark DER models* for QSTS simulations

QSTS Simulations

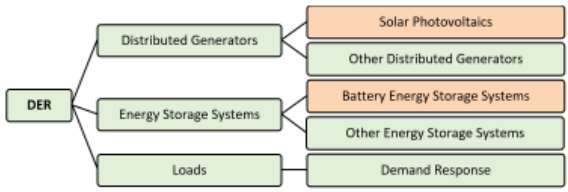
- Middle ground between static power flow and dynamic/electromagnetic transient (EMT) simulations
- Sequence of static power flows
- Captures discrete controls and time-dependencies
- Increasingly used at the distribution level
- Example applications:
  - Assess the impact of DER variability and controls on distribution system volt-var controls
  - Evaluate energy storage, demand response, and energy-constrained resources
  - Determine DER curtailment losses

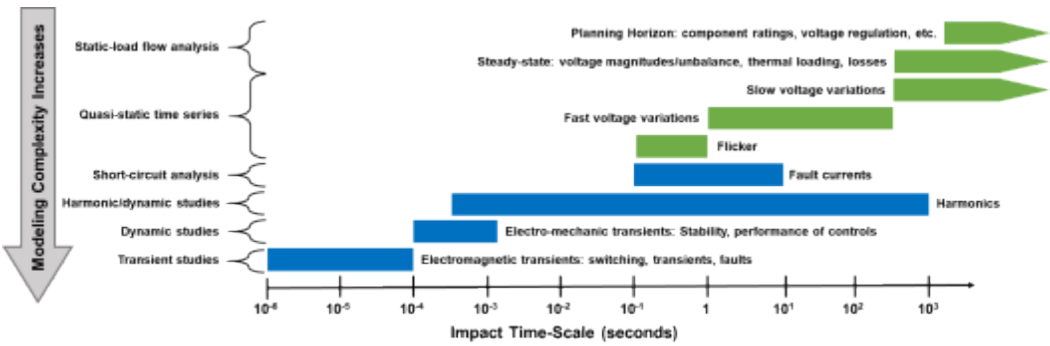
DER Benchmark Model Framework

- Two key components:
  - *DER benchmark model structure*
  - *DER benchmark model specification requirements*

DER Benchmark Model Structure

- *Mutually exclusive*: minimal overlap between individual benchmark models
- *Collectively exhaustive*: all relevant DER types included
- Specific for QSTS simulations
- Other structures possible
- Focuses on individual DER
- DER aggregations can be represented by a collection of benchmark models





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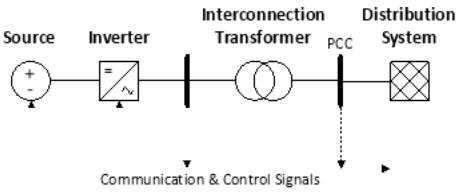
DER Benchmark Model Specification Requirements

- To provide *uniformity* across the benchmark models
- To establish a *structure* for the future derivation of benchmark models for other DER
- Key components: introduction, benchmark model, and application considerations
- **Introduction:**
  - Background
  - Principles of operation
  - Technology types
  - Etc.
- **Benchmark model:**
  - DER components relevant for QSTS simulations
  - DER operation dependent on distribution system
  - Input/output variables, internal parameters, and their relationships
  - Assumptions and simplifications employed
- **Application considerations:**
  - Aspects to consider when applying or implementing the DER benchmark model
  - Variations of the benchmark model
  - QSTS time step
  - Study usage
  - Data requirements for the model usage
  - Industry application of the DER
  - Comparison of models currently available
  - Etc.

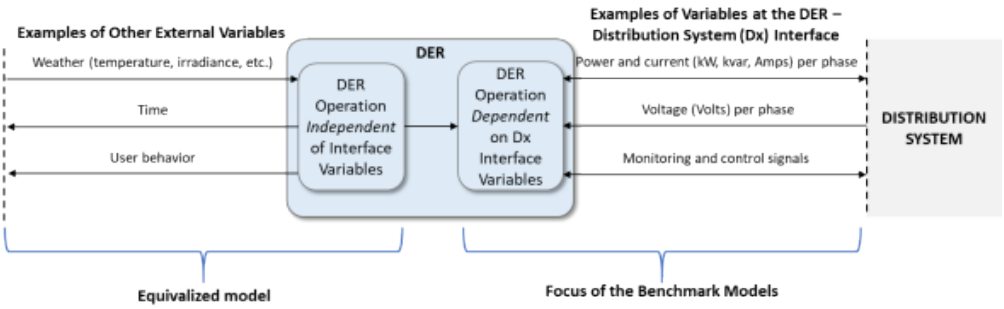
DER Benchmark Model Components

- **Source:**
  - E.g., PV panels, or battery
  - Important but simple equivalents may suffice
- **Inverter:**
  - Active & reactive power capabilities
  - Smart inverter functions and other controls
- **Interconnection transformer:**
  - Separate from the benchmark models
- **Monitoring & controls:**
  - Monitoring & controls interfacing DER and the distribution system



DER Benchmark Model Scope

- *Aggregate* DER behavior
- Focus on representing DER operation that
  - Impacts the distribution system state and/or
  - Is impacted by the distribution system state
- Not necessary (but permissible) to represent aspects independent distribution system state



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PV System Benchmark

Important Factors Impacting PV System Operation	
External	**Internal**
• Solar irradiance • Temperature • Other weather parameters • Shading and soiling of PV panels • PV panel age	• PV system configuration (centralized, string, microinverters, etc.) • Number, rating, and type of the panels and inverters • Panel orientation and tracking (fixed, single-axis, dual-axis) • Inverter controls (incl. maximum power point tracking (MPPT) scheme and smart inverter functions) • Plant-level controls (if any)

PV Benchmark – Components

- **PV panel model:**
  - Aggregated dc (kW) ratings and dc (kW) power generation
  - Many ways to represent the dc generation
  - PV dc generation largely independent of the distribution system state
  - Hence, not necessary to perform PV resource modeling as a part of the QSTS simulation
- **PV inverter model**
  - A separate benchmark model developed by the WG C6.36
  - Aggregated ac (kW and kVA) ratings
  - Reactive power capability
  - Efficiency
  - Smart inverter controls

PV Benchmark – Assumptions

- Aggregate operation
- Quasi-static steady-state model
- Voltage-insensitive model
- Normal distribution system operating conditions
- Balanced phase powers

Conclusion & Future Work

- DER model requirements are increasing, but there is a lack of DER benchmark models to serve as a reference
- To address these needs, CIGRE WG C6.36 has developed:
  - *DER benchmark model framework*, and
  - Set of *benchmark DER models for QSTS simulations*
- **C6.36 Next steps:**
  - Publish the work in CIGRE technical brochure in 2022
  - Organize a tutorial in 2023
- **Future work beyond WG C6.36:**
  - DER benchmark models for *other DER*
  - DER benchmark models for *aggregated DER*
  - Expand DER benchmark models from autonomous controls to *centralized controls* by (ADMS) and/or DERMS
  - DER benchmark models for *other study types*
  - Validate DER benchmark models against *laboratory and field testing* of DER