ERCOT PSCAD Model Submittal Guidelines

# Introduction

Unlike dynamic models that are needed to develop base cases to simulate dynamic events in the ERCOT system, electromagnetic transient (EMT) models are required for specific studies and concerns (SSR evaluations, grid assessments under low system strength, etc.) EMT studies historically have not been required in ERCOT. However, due to changes in the ERCOT system, including higher penetrations of inverter-base generation and the addition of series capacitors, there is a greater need to assess the ERCOT system with EMT studies. Therefore, EMT (PSCAD) models for many facilities connected to the ERCOT system are now required. All the PSCAD models provided to ERCOT by Resource Entities are customized models (typically) developed by manufacturers that have various modeling practices and limitations on the usage of the models. As a result, significant effort involving Resource Entities, manufacturers, TSPs, and ERCOT is often required to identify and implement model updates or adjustments necessary to perform simulations with the model. This guideline will help ensure that EMT model developers incorporate necessary equipment functions into submitted EMT models. Any deviations from this guideline should be documented and explained and are subject to review.

# PSCAD Model Requirement

**Model Accuracy Features**

In order to be sufficiently accurate, the model provided for each facility shall:

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| Item | Description | Check |
| 1 | Represent the full detailed inner control loop of the power electronics. The model cannot use the same approximations classically used in transient stability modeling, and should fully represent all fast inner controls, as implemented in the real equipment. It is preferred and recommended to create models which embed the actual hardware code into a PSCAD component whenever possible. If the model is assembled using standard blocks available in the PSCAD master library, approximations are usually introduced, and specific implementation details for important control blocks may be lost. In addition, there is a risk that errors will be introduced in the process of manually assembling the model. NOTE: For this type of manually assembled model, (not using a direct “real code” embedding process), validation is recommended. |  |
| 2 | Incorporate a full IGBT representation (preferred), or may use a voltage source interface that mimics IGBT switching (i.e. a firing pulse based model). A three phase sinusoidal source representation is not acceptable. Models manually translated from MATLAB (i.e. block-by-block) or control block diagrams are often unacceptable because the method used to model the electrical network and interface to the controls may not be accurate, or portions of the controls (such as protection) are omitted. Note, however, that Matlab may be used to generate C code which is used in the real control hardware, and if this approach is used by the developer, the same C code may be directly used to create an extremely accurate PSCAD model of the controls. The controller source code may be compiled into DLLs or binary if the source code is unavailable due to confidentiality restrictions. |  |
| 3 | Represent plant level controllers as they are implemented in the real controls, such as automatic voltage regulation. Parameters typically requiring site-specific adjustment should be made user-accessible. For example, the plant level controller should provide access to regulation gains and droop settings. |  |
| 4 | Represent all pertinent control features as they are implemented in the real controls (e.g. customized PLLs, ride-through controllers, etc.) |  |
| 5 | Represent SSO mitigation and/or protection including the ability to enable and disable SSO mitigation/protection, if applicable |  |
| 6 | Represent dynamic reactive devices including automatically controlled capacitor and reactor banks, if applicable. |  |
| 7 | Represent all pertinent electrical and mechanical configurations, such as filters and specialized transformers. Mechanical features (such as gearboxes, pitch controllers, etc.) should be included in the model if they impact electrical performance. |  |
| 8 | Have all pertinent protections modeled in detail. Typically this includes various over-voltage and under-voltage protections (individual phase and RMS), frequency protections, DC bus voltage protections, and overcurrent protection. There may be others. |  |
| 9 | Accurately reflect behavior throughout the valid (MW and MVAr) output range from minimum power through maximum power. |  |

**Model Usability Features**

In order to allow study engineers to perform system studies and analyze simulation results, the model provided for each facility shall:

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| 10 | Have pertinent control or hardware options accessible to the user (e.g. adjustable protection thresholds or real power recovery ramp rates). Diagnostic flags (e.g. flags to show control mode changes or which protection has been activated) should be accessible to facilitate analysis and should clearly identify why a model trips during simulations. |  |
| 11 | Be capable of running at a minimum time step of 10 us. Most of the time, requiring a smaller time step means that the control implementation has not used the interpolation features of PSCAD, or is using inappropriate interfacing between the model and the larger network. Lack of interpolation support introduces inaccuracies into the model at higher time steps. |  |
| 12 | Include documentation and a sample implementation test case. Test case models should be configured according to the site-specific real equipment configuration. Access to technical support engineers is desirable. |  |
| 13 | Be capable of initializing itself. Once provided with initial condition variables, models shall initialize and ramp to full output without external input from simulation engineers. Any slower control functions which are included (such as switched shunt controllers) should also accept initial condition variables if required. |  |
| 14 | Accept external reference values. This includes real and reactive power reference values (for Q control modes), or voltage reference values (for V control modes). |  |
| 15 | Allow protection models to be disabled. Many studies result in inadvertent tripping of converter equipment, and the ability to disable protection functions temporarily provides study engineers with valuable system diagnostic information. |  |
| 16 | Allow the active power capacity of the model to be scaled. This is distinct from a dispatchable power order, and is used for modeling different plant capacities or breaking a lumped equivalent plant into smaller composite models. |  |

**Model Efficiency Features**

In order to improve study efficiency, model compatibility, and enable studies which include the model to be performed as efficiently as possible, the model provided for each facility shall:

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| 17 | Be compiled using Intel Fortran compiler version 9 or higher. Intel Fortran version 12 or higher is preferred. The model should not be dependent on a specific Fortran version to run. |  |
| 18 | Use PSCAD version 4.5.3 or higher. |  |
| 19 | Initialize as quickly as possible (for example <5 seconds) to user supplied terminal conditions. |  |
| 20 | Support multiple instances of its own definition in the same simulation case. |  |
| 21 | Support the PSCAD “snapshot” feature. |  |
| 22 | Support the PSCAD “multiple run” feature. |  |
| 23 | Allow replication in different PSCAD cases or libraries through the “copy” or “copy transfer” features. |  |