CYME
Power Engineering Software and Solutions

Microgrid Modeling and Analysis

Perform engineering analysis of islanded and grid-connected microgrids

The rise of distributed generation and, in a broader sense, of distributed energy resources (DER) challenges electric utilities, but also creates a new space for engineers to design innovative solutions to improve grid performance. Often referred to as non-wires alternatives (NWA), this new class of solutions leverages modern technology to mitigate grid risks without resorting to traditional capital expenditures. The CYME Microgrid Modeling and Analysis module is part of this trend and enables unprecedented simulations of islanded – but also grid-tied – microgrids.

The IEEE Standard for the Specification of Microgrid Controllers (IEEE STD 2030.7™) defines a microgrid as "a group of interconnected loads and distributed energy resources with clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid and can connect and disconnect from the grid to enable it to operate in both grid-connected or island modes."[1]
The implementation of microgrids can yield several benefits to electric utilities and their customers: improved grid reliability and resilience, loss reduction and cost savings, decreased grid congestion, capital infrastructure deferral, etc.

The CYME Microgrid Modeling and Analysis module enables the modeling and simulation of grid-tied microgrids operating in either islanded or grid-connected mode as well as isolated microgrids, such as those of remote communities far from any transmission and distribution infrastructure. Simply put, the module lifts the simulation requirement for a source equivalent to exist in any connectivity model. Capabilities of the module include:

- The detailed modeling of grid-forming DERs, such as isochronous and droop control modes, considering their operational and/or physical limits.
- The ability to perform unbalanced power flows, short circuit analyses and time-series simulations on islanded and grid-connected microgrids.
- A customizable load shedding and curtailing algorithm embedded into the power flow solver for islanded simulations where the load offsets the available generation.

This unique combination of detailed system modeling and refined steady-state analyses facilitates the design, planning and operation of microgrids, allowing for instance:

- The identification of under- and over-voltage conditions and overloads under multiple scenarios.
- The verification of power and energy availability for the operation of islanded microgrids at peak and during extended periods.
- The impact assessment of starting motors.
- The ability to calculate fault current duties to support protection coordination studies and to evaluate temporary overvoltage (TOV).
- The conduction of arc flash hazards studies to ensure safety of utility personnel.

[1] IEEE Standard for the Specification of Microgrid Controllers," in IEEE Std 2030.7-2017 , vol., no., pp.1-43, 23 April 2018

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Modeling

The new Microgrid circuit type is now available for the creation of a state-of-the-art model for both isolated and grid-tied topologies. The former is a standalone system without a connection to a feeder or a substation and has all its energy supplied by DERs connected to it. The latter typically has a single point of interconnection (POI) to a distribution circuit through a switching apparatus – although having multiple POIs is possible – and can generally operate both grid-connected or islanded. All these configurations are permitted with the module.

As a microgrid needs clearly identified electrical boundaries, it is now possible to define a Microgrid Simulation Zone (MSZ) that includes the sections from the connectivity model located between the microgrid reference node and the delimiting device(s). As such, infinite sources, namely a source equivalent or a synchronous generator in swing mode, are not permitted within the MSZ.

The microgrid-supporting DERs also have their model enhanced to properly emulate the different islanded control modes. In fact, any type of dispatchable DER, such as battery energy storage systems (BESS), inverter-based generators as well as synchronous and induction generators, whose control mode are set to isochronous or droop, will enable a simulation-ready microgrid.

While non-dispatchable DERs can exist on a microgrid, they are normally insufficient to guarantee the active power balance required for viable islanded operation. This is the exact purpose of the isochronous and droop islanded control modes. While the first fixes the voltage magnitude at the DER's terminal and provides the necessary active power – thereby keeping the frequency constant –, the second adjusts the active and reactive output power based on frequency and monitored voltage, respectively.

Analysis

Whenever the active power balance is not guaranteed, a load shedding and curtailment algorithm can be implemented by identifying a prioritized list of participating loads and motors. If insufficient active generation is identified during a load flow simulation, the Newton-Raphson Unbalanced solver will start shedding or curtailing loads and motors one at a time until enough generation is available, or the entire list has been cleared.

Running load flows on microgrids is a simple way to obtain several important information regarding the network performance, such as abnormal conditions, losses, generated power per DER, etc.

Fault analyses also take into account grid-connected and islanded microgrids using the same DER short-circuit models as in standard networks. This makes possible the determination of by-phase short circuit currents for all types of fault at each node of the microgrid.

Remote Load Center

A new topology detection tool identifying remote load centers based on a set of user-defined criteria related to downstream load, distance from the substation and presence of circuit ties complements the module. When cross-referencing the results of the detection with system reliability metrics and a load density heat map, engineers can easily identify circuits where reliability-improving NWA opportunities exist.

The following optional add-on modules also support microgrid topologies and unleash even more power from your CYME software.

Steady-State Analysis with Profiles

Time-series analysis based on profiles of varying granularity (60-minute to 1-minute intervals) for different elements of the model (load, generation, meter, customer types, etc.). Profiles can be built out of historical or forecast data, enabling historical playback or long-term planning simulations.

Long-Term Dynamics Analysis

Time-series simulation to study the impact of sub-minute phenomena such as fluctuating irradiance and/or wind speed as well as load variations on network dynamics like tap changers and reactive power compensation controls, BESS and other DERs converter controls, and on the behavior of microgrids.

Arc Flash Hazards Analysis

Risk evaluation of arc flash hazards of a network for the safety of employees working on or near electrical equipment. It calculates the fault current, determines the clearing time from time-current characteristic curves and calculates the resulting incident energy and risk level. The analysis is compliant with industry-recognized standards and methods to perform arc flash hazard calculations for all types of electric power systems.

For over 30 years, the CYME team has built a strong reputation with its clients by delivering the best software solutions backed by excellent customer-oriented service. For more information on the CYME Software, or for a web demo, please reach out to us at cymeinfo@eaton.com.

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