Reliable modeling, analysis and planning tools to improve distribution system performance

Base package

CYMDIST is the distribution system analysis base package of the CYME power system analysis software. It bundles all the modeling and analysis tools required to perform the various types of simulations involved in electric distribution system planning. The calculation engines support balanced or unbalanced distribution models that are built with any combination of phases and operated in radial, looped or meshed configurations. CYME software is part of the Brightlayer Utilities suite, a set of digital solutions to help you optimize grid performance and resilience while helping to accelerate decarbonization. Following is a list of the capabilities of CYMDIST as well as option modules to expand the capabilities to meet your needs.

Software	Details	Description
CYMDIST distribution analysis software	**Unbalanced load flow**	Balanced/unbalanced voltage-drop and Newton-Raphson unbalanced (radial, looped or meshed).
	Fault analyses	Fault current calculations for RMS, asymmetrical and peak values for all shunt fault configurations. Short-circuit and fault voltage analysis throughout the network taking into account pre-fault loading conditions. Includes conventional/ANSI/IEC 60909/IEC61363 short-circuit, series fault, simultaneous fault, voltage sag, fault locator and equipment rating verification.
	Load allocation	Load estimation using customer consumption data (kWh), distribution transformer size (connected kVA), real consumptions (kVA or kW) or the REA method. The algorithm supports multiple metering units as fixed demands and large metered customers as fixed load.
	Load growth	Load growth studies for multiple years.
	Optimal capacitor placement	Optimal capacitor placement and sizing to minimize losses and/or improve voltage profile.

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Software	Details	Description
CYMDIST distribution analysis software	Load balancing	Load balancing to minimize losses, or to balance the current/load/voltage.
	Motor starting analysis	Voltage dip and maximum motor size calculations.
	Batch analysis	Several analysis scenarios are performed on a selection of study files, self-contained files or circuits. Detailed reports of every simulation as well as summary reports for network results are available.

Additional modules	Requirement	Description
MODELING		
Enhanced substation modeling	CYMDIST	Modeling of all the major components of the distribution substation and the detailed modeling of any sub-network such as an industrial facility.
Low-voltage secondary distribution modeling	CYMDIST	Detailed modeling of low-voltage distribution systems including center-tapped distribution transformers (120/240V) and triplex/quadruplex cables.
Secondary grid network analysis	CYMDIST	Detailed modeling of secondary network distribution systems which include network protectors. Allows the power flow and short circuit analyses of heavily meshed secondary network distribution systems for any voltage level.
Microgrid modeling and analysis	CYMDIST	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.
Geographic overlay	CYMDIST	The display of raster or vector map images (geographical land base such as DWG, DXF, SHP, etc.) as layers directly underneath the electrical model.
Online maps service	CYMDIST	A complement to the CYME Geographic Overlay module to provide the capability to display Google™ maps and MapQuest™ Open maps as layers underneath the geographical view of your electrical network model.

Additional modules	Requirement	Description
PLANNING		
Advanced project manager	CYMDIST	Extensive tool that supports the collaborative and detailed preparation of future grid projects and mitigations. It enables tracking the chronological evolvement from as-built to as-planned networks.
Automated network forecast analysis	CYMDIST	Planning and management of expansions and changes over time on your distribution network (includes the Advanced Project Manager).
Long-term planner	CYMDIST	Powerful forecast visualization and analytics capabilities paired with a robust reporting technology that aggregates data from multiple contexts to bridge the gap between forecasting and system analysis. The embedded Analysis Orchestrator enables automation of area-wide engineering studies on the as-planned network model.
Techno-economic analysis	CYMDIST	Analysis to help electric utilities invest into their infrastructure by analyzing the technical impacts of modifications made to the network and the cost they entail. Assists in the determination of the feasibility and the profitability of a project.
OPERATION		
Distribution state estimator	CYMDIST	Estimation of the unbalanced power consumption and the voltages at every level of a distribution power system.
Contingency assessment and restoration	CYMDIST	The impact of single outages on the electrical distribution system are studied to find the optimal switching plan to restore electrical power to priority customers and to recover the maximum possible load in the affected areas.
Load flow contingency (N-p)	CYMDIST	Assist in the power-flow-related static contingency analysis. To create contingency events and single- or multiple-outage scenarios and compare them to a base case.
Advanced fault locator	CYMDIST	Quick and precise identification of possible fault locations based on a mix of inputs such as fault indicator status, telemetry data during fault condition, range of possible fault impedance, etc. Field measurements can be read directly from COMTRADE oscillography files.

Additional modules	Requirement	Description
PROTECTION		
Protective device analysis	CYMDIST	Wide range of tools to efficiently and accurately design and validate the coordination scheme of the power system. Includes system-wide analysis, minimum fault analysis, sequence of operation and branch device coordination. TCC library of more than 15,000 devices.
Arc flash hazards	CYMDIST	Assessment of the electrical safety of employees working on or near electrical equipment by computing the necessary parameters required to assess the risk level and adopt the adequate safety procedures.
Distance protection	CYMDIST	Module to assist electrical engineers in identifying challenges and find solutions to power system protection problems using distance protection relays.
DER		
Integration capacity analysis	CYMDIST	Assessment of the generation or load hosting capacity of the system without compromising system reliability and power quality. Different limiting criteria with adjustable thresholds can be considered.
EPRI DRIVE	CYMDIST	The EPRI DRIVE software determines the maximum amount of DER each distribution feeder can accommodate in its current state before unacceptable reliability, power quality, protection and thermal issues start to emerge.*
DER impact evaluation	CYMDIST	Verification criteria, multiple loading scenarios and distributed generators contribution levels are integrated into a comprehensive system impact study that generates a tabulated report where results for each criterion are color-coded based on limit violations.
Network disturbance assessment D-A-CH-CZ	CYMDIST	Evaluation of network disturbances caused by new load, motor or generator interconnections based on a set of technical rules established by a European working group.
Load relief DER optimization	CYMDIST	Determination of the optimal sites and sizes for energy storage systems and dispatchable generation in support to load relief projects based on non-wires alternatives. Sizing of non-dispatchable generation is also supported.

Additional modules	Requirement	Description
POWER QUALITY		
Reliability assessment	CYMDIST	A framework within which predictive and historical reliability assessment scenarios are run and the impacts of the related investment such as DA (Distribution Automation) can be evaluated and understood.
Harmonic analysis	CYMDIST	Harmonic penetration assessment in electric power systems.
Dynamic motor start	CYMDIST	Simulation of the dynamic behavior of starting motor to assess system voltage dips and acceleration times using a variety of starting methods.
OPTIMIZATION		
Network configuration optimization	CYMDIST	Determination of the optimal feeder configuration that will minimize losses, improve the voltage profile and balance the load between feeders.
Volt/VAR optimization	CYMDIST	Optimal settings for Volt/VAR control devices are evaluated to optimize distribution networks.
Optimal voltage regulator placement	CYMDIST	Optimal regulator locations are identified to improve the network conditions based on selected objectives.
Optimal recloser placement	Reliability assessment	Optimal recloser locations are identified to improve the network conditions based on selected objectives.
TIME-SERIES		
Steady state analysis with load profiles	CYMDIST	This tool uses historical or forecasted data to create profiles for network demands, loads, DERs and customer types to execute time-series load flow studies. The time span of the study can be from a single day to multiple years.
Long-term dynamics analysis	CYMDIST	Time-series simulation to study the impact of insolation variations, wind fluctuations and load variations on network controls.
Transient stability analysis	CYMDIST	Simulation of the dynamic behavior of distribution systems with distributed generation under various transient events.

Additional modules	Requirement	Description
SCRIPTING		
Scripting tool with Python	CYMDIST	Assists in the automation of routine studies, creates new algorithms, quickly retrieves network/equipment information and performs batch analysis through a simple mouse-click on a Python® script.

* Distribution Resource Integration and Value Estimation (DRIVE) is provided under license and is powered by technological research developed by the Electrical Power Research Institute, Inc. (EPRI).

EPRI does not endorse or advocate for any particular measure, valuation, answer, finding, conclusion, hypothesis, assumption, or other result.

For more information visit **Eaton.com/CYME**

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Distribution System Analysis

Reliable analytic and planning tools to improve electrical network performance

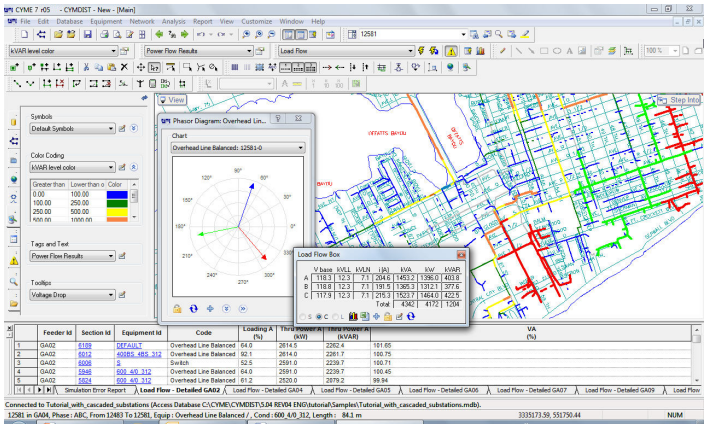
The Distribution System Analysis of the CYME Power Engineering Software is designed for planning studies and for the analysis of the entire distribution network.

The modeling capabilities of CYME includes the detailed representation of medium and low-voltage distribution networks, and secondary grids. From planning to contingency scenarios to optimization, the CYME software is the perfect tool to address any distribution system analysis need.

The CYME power engineering software features a powerful graphical user interface that is fully customizable to provide the one-line diagram representation, results and reports in a level of detail needed by each user. In addition, innovative engineering technologies and industry standards are at the core of the CYME algorithms. With its extensive built-in equipment libraries and advanced analyses, the CYME software can help you create the most accurate network representation to yield the accurate results that are needed.

Major features

- Customizable interface and reports
- Load flow
- Motor starting
- Load allocation
- Fault analysis:
  - Short-circuit
  - Fault locator
  - Series and simultaneous fault
  - Voltage sag
- Load balancing
- Optimal capacitor placement and sizing



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Distribution System Analysis

Reliable analytic and planning tools to improve electrical network performance.

Power Flow Analysis

Main analysis tool for the design, planning and operation of any electrical power system.

Fault Analyses

Tools to assess the effects of different types of short-circuits, evaluates fault contributions from machines and helps the verification of equipment rating.

Enhanced Substation/Sub-Network

To model and analyze all the major components of distribution substations and sub-networks such as industrial facilities, switchgear and vaults.

Secondary Grid Network Analysis

Detailed modeling and analysis of heavily meshed secondary grids, which include complete vaults with their transformers, protective devices such as network protectors, secondary lines and cables.

Low Voltage Distribution Network

Detailed modeling of low-voltage distribution network with single-phase center tap transformers and service drop cables. It also allows comprehensive analysis to calculate technical losses and identify overloaded equipment.

Volt/VAR Optimization

To achieve peak shaving, reduce system losses and improve voltage profile to optimize network efficiency.

Optimal Voltage Regulator Placement

Network optimization through voltage regulation by finding the optimal location and tap settings for voltage regulators.

Optimal Recloser Placement

To achieve a better level of reliability by placing reclosers at optimal locations.

Network Configuration Optimization

To reconfigure radial networks to an optimal topology through switching configurations.

Single Contingency Assessment and Restoration

To study what-if situations of a single outage on a radial system to establish an optimal switching plan.

Reliability Assessment

To assess the historic and predictive performance of network assets and evaluate improvements due to different initiatives and configurations.

Protective Device Analysis

Wide range of tools and analyses to assist in the design and validation scheme of power networks.

Long-Term Dynamics

Time-series simulation to study the impact of insolation variations, wind fluctuations and load variations on network controls.

Steady-State Analysis with Load Profiles

To perform time series load flow analysis based on a combination of historical consumption patterns and real-time monitoring based on a combination of AMR data and historical consumption patterns.

Load Flow Contingency (N-p)

Allows the study of what-if scenarios and N-p contingencies to establish optimal network operation.

Advanced Project Manager

To manage time-based projects and assess multiple scenarios in a flexible framework.

Automated Network Forecast Analysis

To manage and analyze time-referenced projects in batch mode.

Arc Flash Hazards Analysis

To assess the safety risk of the network to help ensure a safer work environment.

Harmonic Analysis

To evaluate the impact of non-linear loads on the network to help engineers find mitigation methods to harmonics issues in the system.

Geographic Overlay

To display raster or vector map images (geographical land-base) as layers directly underneath the electrical model for a better visualization of the electrical network.

Online Maps Service

To display map images from online map providers as background of the distribution network and locate specific equipment and devices using street addresses and GPS coordinates.

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Enhanced Substation Modeling

Model substations for a thorough analysis of your power system

Increased complexity in voltage and power controls, higher DER penetration with possible back feeding, evolving protection schemes; it is important to model, analyze and simulate the substation details.

The CYME Enhanced Substation Modeling module allows for the creation of the comprehensive model of the substation components required to perform thorough analyses such as power transits, effect on voltage regulation and other phenomena inside the substation.

Substation Modeling

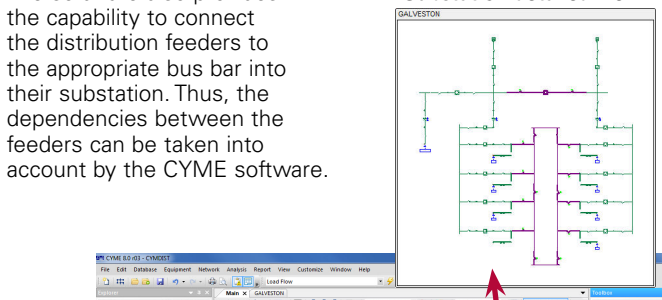
With the Enhanced Substation Modeling module of the CYME software, the user can model all the major components of distribution substations. The calculations done with the CYME analysis modules can then take into account the effects of these installations on the overall distribution system to produce results that closely reflect reality.

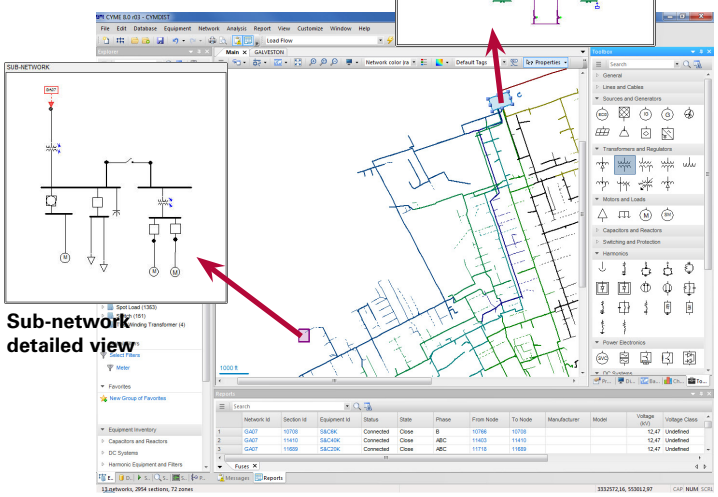
The Enhanced Substation Modeling module supports the three-phase modeling of substations, in a schematic representation connected to the overall grid.

It is used to model the interface between the distribution system and the transmission or sub-transmission system.

The software also provides the capability to connect the distribution feeders to the appropriate bus bar into their substation. Thus, the dependencies between the feeders can be taken into account by the CYME software.

Substation detailed view





Sub-network detailed view

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Enhanced Substation Modeling

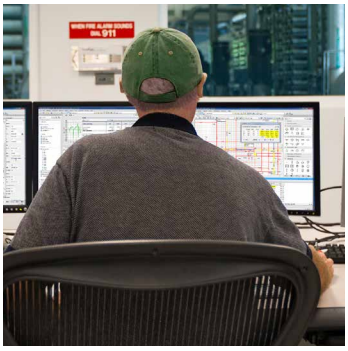
Model substations for a thorough analysis of your network

Features

The substations modeled appear as icons on the overall representation of the circuit to avoid cluttering the view. A click on any one of those nested views reveals the content in a separate editable schematic view.

The substations can be modeled in details using the extensive CYME equipment library (buses, cables, transformers, switches, circuit breakers, protection devices, etc.). The user can also create new components based on the very detailed templates of the library to allow the right match with the nameplate data of your particular equipment. Once installed on the system model, the settings of the components can be adjusted as required.

The CYME software utilizes the data of the complete connected model in its calculations.



Enhanced analysis results

The ability to add modeling detail upstream of distribution feeders provides the capability to indicate the dependency between the feeders connected to the same substation bus bar. This valuable data translates into the more precise simulation of the distribution system.

- **Fault Analysis** - Ability to simulate the effects of a fault on one circuit on the other circuits connected to the same bus bar. This includes:
  - Voltage drop
  - Fault contribution (if DG or DER is present on the network)
- **Load Allocation** - Ability to compute the substation transformer and/or voltage regulator diversity factor.
- **DER Impact Evaluation** - Ability, through a load flow simulation, to identify reverse power flow from one feeder to another, or even to the transmission/sub-transmission system.
- **Contingency Analysis** - Simplifies contingency analysis by allowing to easily simulate an out-of-service substation transformer (and thus all feeders connected to this transformer).

Sub-networks modeling

More accurate simulation results lead to the more precise planning and management of the expansion and maintenance of the distribution system, and a greater facility to manage the integration of the Distributed Generation (DG) and Distributed Energy Resources (DER) in the power grid; saving time and money.

The Sub-Networks Modeling module is included with any of the other CYME circuit/system modeling modules, and shares similar features. It supports the creation of any sub-network, including utility vaults, switching cabinets and modular substations; DG and DER components, in a nested representation connected to the overall grid.

The user can create a sub-network in a schematic or georeferenced view style as needed. Each can be shown as clickable nested view icons on the overall main representation of the system, revealing the editable view of the sub-network.

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Low-Voltage Distribution Network Modeling and Analysis

In-depth network planning with low-voltage distribution system modeling and analysis

In common practice, distribution system modeling stops at the high side of the distribution transformer. However, with the rise of an interconnected energy system, engineers seek to study the distribution system as a whole, which requires the modeling of the secondary distribution system.

The CYME Low-Voltage Distribution Network Modeling and Analysis module allows the detailed modeling and simulation of any circuit beyond the distribution transformer.

As most utilities are interested in improving the energy efficiency of their distribution system and assessing the impact of distributed energy resources, it has become increasingly important to have a complete network model. The CYME Low-Voltage Distribution Network Modeling and Analysis module supports the modeling of the low-voltage distribution system within your current one-line diagram.

The analysis of your network will be more complete without adding any complexity.

The detailed modeling of low-voltage distribution systems is possible thanks to the following features:

- Single-phase and three-phase center-tap transformers
- Service drop cables: triplex and quadruplex
- Low-voltage spot load connected to the center-tap
- Center-tap connected sources and meters
- Single phase center tap connected generators, motors, shunt capacitors and reactors

The secondary distribution system can be built and shown in a distinct view, giving the possibility to add more information without further complicating the rest of the distribution system view. Report functionalities allow the display of the relevant information and results.

The module provides a complete and accurate representation of the distribution system. With the CYME software, medium and low voltage system losses can be calculated accurately and overloaded equipment can be identified to help you plan and improve the system for the future.

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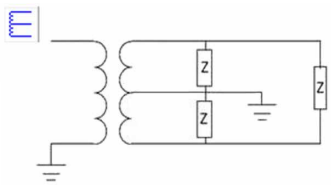
Low-Voltage Distribution Network Modeling and Analysis

In-depth network planning with low-voltage distribution network modeling and analysis

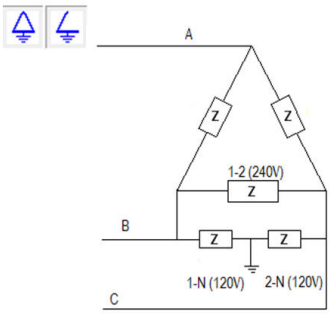
Center-tap transformer

The single-phase and three-phase center-tap transformer model supports connecting to either half or full secondary voltage.

With this center-tap transformer model, spot loads representing each individual customer can be connected to the center-tap as they are in reality.



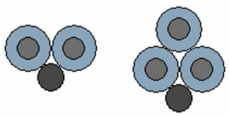
Single-phase transformer center-tap configuration



Three-phase transformers center-tap configuration

Service drop cables

Overhead and underground triplex and quadruplex cable constructions used as service drop are available to allow accurate network modeling.



Low-voltage network view

The low-voltage distribution system can be modeled in a distinct view or in the same view as the feeders.

- Display options will allow the user to distinguish the secondary distribution system from the primary and see where they overlap (i.e. using the same poles).
- The secondary distribution system can be loaded alone or simultaneously with the primary distribution system. Even when only the primary or the secondary distribution system is loaded, the network equivalent of the unloaded portion is calculated accurately and taken into consideration for simulations. System losses, equipment loading, and contingency scenarios can all be studied with ease.

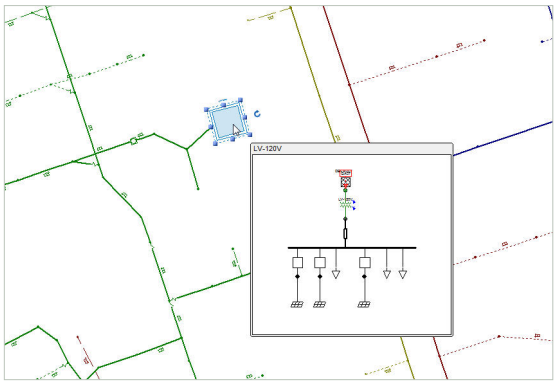
All the relevant CYME analyses (load flow, short-circuit, load allocation, etc.) that can be executed on the medium voltage distribution system will run on the low voltage distribution system, with the same accuracy.

Sub-networks modeling

More accurate simulation results lead to the more precise planning and management of the expansion and maintenance of the distribution system, and a greater facility to manage the integration of the Distributed Generation (DG) and Distributed Energy Resources (DER) in the power grid; saving time and money.

The Sub-Networks Modeling module is included with any of the other CYME circuit/system modeling modules, and shares similar features. It supports the creation of any sub-network, including utility vaults, switching cabinets and modular substations; DG and DER components, in a nested representation connected to the overall grid.

The user can create a sub-network in a schematic or georeferenced view style as needed. Each can be shown as clickable nested view icons on the overall main representation of the system, revealing the editable view of the sub-network.



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Secondary Grid Network Analysis

Understand the issues related to secondary networks through modeling and analysis

Secondary networks are designed to provide reliable power distribution to highly dense load areas through redundancy based on different interconnection possibilities.

The CYME Secondary Grid Network analysis module allows the modeling of any spot network and secondary grid, and is equipped with robust power flow and short-circuit algorithms to analyze such heavily meshed networks.

The planning and operation challenge of secondary grids resides in its unique and complex topology developed to ensure high power availability and reliability for sensitive and critical loads.

Such challenge brings along the need to model the grid with all its key components and to have robust algorithms to cater for heavily meshed networks.

The CYME Power System Analysis software brings the technologies together and is the perfect tool for any secondary grid network analysis.

Detailed modeling

The Secondary Grid Network Analysis module offers the capacity to model the important components of any spot network and secondary grid. It includes the representation of feeders, transformers, network protectors, cables, and loads.

The complexity of the secondary grid modeling is made easy through the CYME software's user-friendly interface, of its intuitive drag-and-drop operations and its many editing tools and functionalities. The secondary grid or the spot network can be presented in a separate view to offer better visualization while maintaining the geo-referenced view of the rest of the distribution system.

Distribution System Analysis

Once the secondary grids are modeled, the power, refinement and robustness of the CYME calculation engines is fully revealed:

- Unbalanced Newton-Raphson load flow method for the analysis of unbalanced heavily meshed networks
- Short-circuit analysis of secondary grids
- Evaluation of the state of the network protectors with complete relay settings based on the operating condition (backfeed, contingency, etc.)
- Integration of Distributed Generation (DG) into the secondary grid
- Contingency scenarios study
- Conductor resistance adjustment based on temperature is taken into account for both load flow and short-circuit analyses making the calculations on spot networks and secondary grids more accurate

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Secondary Grid Network Analysis

Understand the issues related to secondary networks through modeling and analysis.

Network Protector

The network protector is a key component of secondary grids and spot networks as it prevent back-feeding to the primary distribution circuits. The Secondary Grid Network Analysis module provides the ability to model the network protectors with complete relay settings which include trip functions and close functions.

Trip functions include:

- Insensitive
- Remote Open/Block Open
- Sensitive
- Sensitive Plus Non-Sensitive
- Time Delay

Close functions include:

- Straight Closing Curve
- Circular Closing Curve

Polar plots are available to provide graphical visualization of the trip and close regions.

Distributed Generation

The complexity of secondary grid analysis increases with the integration of distributed generation. The CYME Power System Analysis software supports the modeling of distributed power resources such as photovoltaic panels, and synchronous and induction machines. Being able to include distributed generation into the network model would allow a more comprehensive study in the goal to maintain a proper grid operation.

Load Flow Contingency

The optional CYME n-P Load Flow Contingency module With it, the power engineer can create n-P type contingency events and single or multiple-outage scenarios in a few mouse clicks.

Single or multi-contingency scenarios which take into account of the automatic operation of network protectors can be simulated to study the effect of the loss of a combination of feeders, transformers, cables or any other network component.

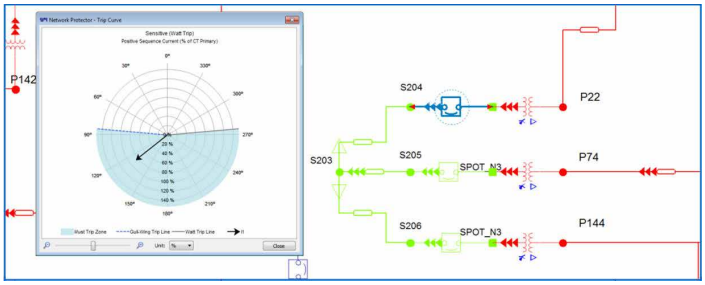
Distribution State Estimator

The optional Distribution State Estimator module is a robust algorithm for the estimation of load and power flow in order to provide more detailed network models. It considers different measurement types such as power and voltage meters, handles measurement redundancy and identifies errors in topology while performing the required load estimation. The module is capable to solve for heavily meshed networks such as secondary grid networks and it takes into account distributed energy resources.

Sub-networks modeling

More accurate simulation results lead to the more precise planning and management of the expansion and maintenance of the distribution system, and a greater facility to manage the integration of the Distributed Generation (DG) and Distributed Energy Resources (DER) in the power grid; saving time and money.

The Sub-Networks Modeling module is included with any of the other CYME circuit/system modeling modules, and shares similar features. It supports the creation of any sub-network, including utility vaults, switching cabinets and modular substations; DG and DER components, in a nested representation connected to the overall grid.



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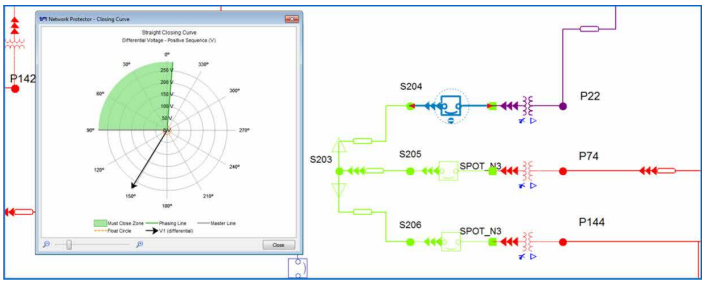

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Microgrid Modeling and Analysis

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.

CYME power engineering and analysis software
Brightlayer Utilities suite

Geographic Overlay

Visualize the distribution system over a comprehensive landbase

The geographical data needed for a comprehensive view of the electric distribution system come from several sources within the utility or originate from other organizations.

With the CYME Geographic Overlay module, digitized maps can be displayed as layers along with the network model. This allows the power engineer to efficiently prepare planning and maintenance projects that take into account the relevant infrastructure information.

The CYME Geographic Overlay allows the engineer to view geographic information useful to the utility as multiple layers underneath the representation of the distribution network. This includes the network connection information, assets, resources, etc.; but also land register, rights of ways, hydrography, topography, land cover, land use, population density, etc.

The module allows the import and display of several maps of different formats (raster or vector) along with the capability to enable for viewing and disabling any layer or theme. They can be placed in any order, with the CYME distribution system model on top.

The module imports map files as data layers. The formats supported are:

- AutoCAD® .DXF and .DWG maps
- ESRI Shapefiles .SHP
- Google™ KML files

The module allows the automatic display of the geographic background whenever the network model is loaded or a study opened.

The module can be used in conjunction with the CYME Online Maps Service to display offline and online maps simultaneously; allowing to the user to locate equipment and devices on the one-line diagram using street addresses, X/Y Coordinates or GPS coordinates.

The functionality of both components is accessed through a comprehensive background map control tab in the CYME software.

For more information on the CYME software, or for a web demo, contact us at **cymeinfo@eaton.com** or learn more at **Eaton.com/cyme** or **Eaton.com/BrightlayerUtilities**

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Online Maps Service

Complement your distribution system model with an online map

Access to online map tools to locate an address or to get directions to a specific location is commonplace. Power engineers benefit from such a tool to quickly locate a substation, a particular feeder, a street corner, or to pinpoint the address where a fault occurred.

With the CYME Online Maps Service, you can now view the most commonly used online maps as a background map of your georeferenced distribution system model.

The CYME Online Maps Service provides the capability to view your electrical network model over Google™ maps and MapQuest™ Open maps.

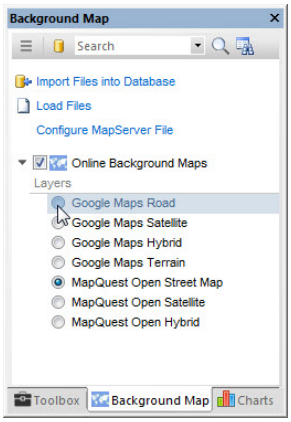
More specifically, the service allows you to use different map formats from popular online map providers, including:

- Google™ Road
- Google™ Satellite
- Google™ Hybrid
- Google™ Terrain
- MapQuest™ Open Street maps
- MapQuest™ Open Satellite
- MapQuest™ Open Hybrid

With this option, the user can locate equipment and devices on the one-line diagram using street addresses, X/Y coordinates or GPS coordinates. Additionally, the simulation results can be viewed just as if in a Google™ map view.

The Online Map Service can be used in conjunction with the CYME Geographic Overlay module to display online and offline maps simultaneously; allowing the engineer to view additional geographic information more specific to the utility as multiple layers. This includes the network connection information, assets, resources, etc.; but also land register, rights of way, hydrography, topography, land cover, land use, population density, etc.

The functionality of both components is accessed through a comprehensive background map control tab in the CYME software.



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Advanced Project Manager

Managing studies in a quick and efficient manner

For each project, engineers create studies and analyze various what-if scenarios to examine a problem and find the best solution. Having proper tools which facilitate working with these scenarios and studies is imperative to successful project management.
The Advanced Project Manager module is an extensive tool that supports the collaborative and detailed preparation of time-based projects in order to assess scenarios in an effective way.

The CYME Advanced Project Manager module is equipped with tools to help engineers work with multiple scenarios and plan their projects in the most effective manner. Note that the functions of the Advanced Project Manager module are embedded in the optional Automated Network Forecast Analysis module.

The Advanced Project Manager module includes:

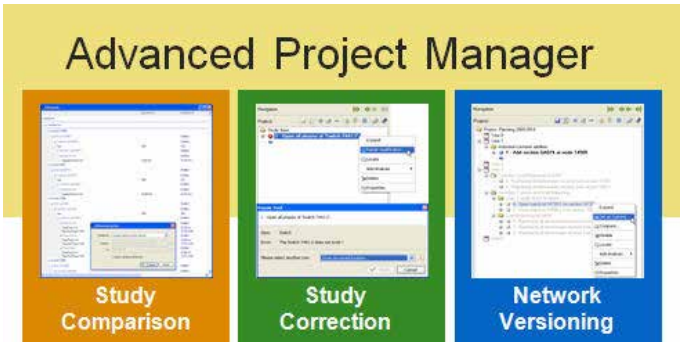
- The capability to setup and edit the project chronology
- Network versioning
- Scenario building
- Scenario Manager / Comparator
- Study correction wizard
- Study comparison and merge capability

The module offers a multi-level database structure which retains all modifications, making any project sharing and team work easy.

Users can create multiple sub-projects and/or independent scenarios to better structure their projects. A series of modifications can be combined into one single project for better identification, and scenarios can be created for time-based studies.

The detailed information available for each modification facilitates study reviews, and the interface offers user-friendly navigation from scenario to scenario.

Once the scenarios are created, the Scenario Manager function allows performing comparative analysis or batch studies to help you determine which scenario suits your planning need best.



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Advanced Project Manager

Managing studies in a quick and efficient manner.

Network versioning

This powerful functionality allows the creation of multiple versions of the same network within the same database. The users can select groups of modifications and create different versions of their network with which they can base their project on. This tool is ideal to create winter and summer versions of your networks, including modifications to the network topology, loads, capacitor status and much more.

To distinguish one study file from another and to make sure it carries modifications that are still pertinent, the module allows working with study files as easy as ever.

Study correction wizard

This wizard guides you in resolving any error in applying a modification. Error-filled study files due to a change in the base case or the database will emerge as updated and corrected through the Study Correction Wizard.

Studies – Compare and merge

The module offers a Comparison Mode which allows comparing two self-contained studies, two scenarios, two specific locations within a study, or the current location versus a base case. No more puzzles and numerous tracking reports: the Comparison Mode lists the differences between two studies or scenarios in one comprehensive tabular format.

The module is also equipped with the capability to allow merging selected modifications from different studies.

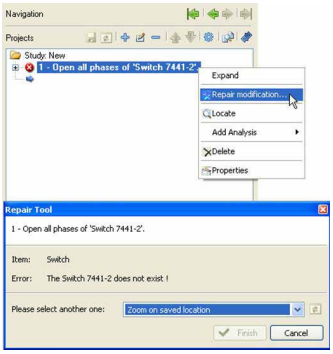
Easy scenario evaluation for efficient decision making

The Scenario Manager functionality provides easy batch analysis and comparative studies for engineers to promptly evaluate the benefits and set-backs of each scenario.

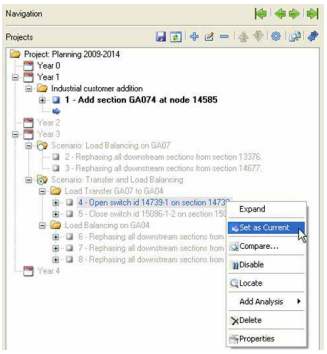
Run a particular analysis such as load flow or short-circuit on any number of cases, at selected modification, sub projects, scenarios, or see the effect of different simulation parameters on your network; the choice is yours with the Scenario Manager functionality.

Reports and charts can be generated for all the cases studied individually. To compare results effectively, indicate the locations to be monitored and the information desired, and the Scenario Manager will automatically generate comparative tabular reports and charts to illustrate the differences of the scenarios studied.

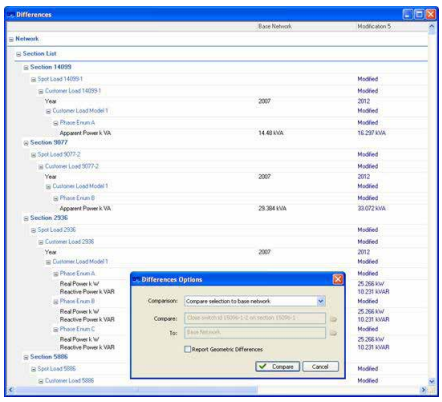
Start to use the Advanced Project Manager today to see the effectiveness of a better-structured project that could transform hours of cumbersome file and result manipulation into one easy effortless task.



Study Correction



Time Positioning



Study Comparison

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Automated Network Forecast Analysis

Manage and plan your network expansions and changes over time

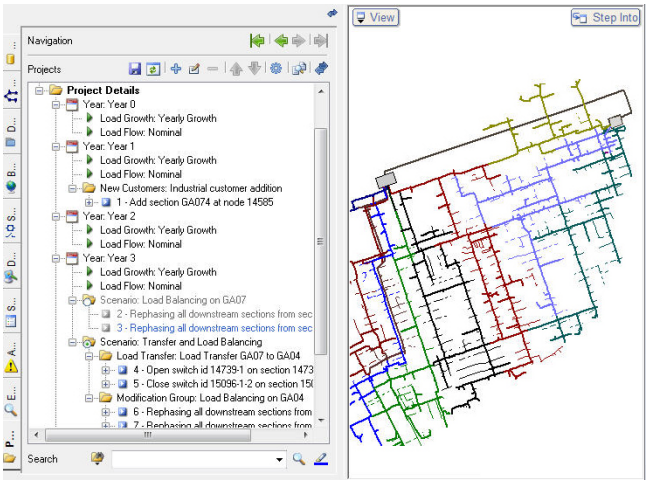
The Automated Network Forecast Analysis module is the add-on to the CYME software designed to help you plan and manage expansions and changes over time on your distribution network. It allows creating, viewing and modifying time-dependent projects/ scenarios in a selected period. This module will considerably help you structure distribution planning projects.

The module inherits its main analytical and topological functions from the base and optional modules of the CYME software. Taking into account future changes on the network, you will be able to simulate different scenarios (such as addition of loads at a given date (year, month or day), change/ replacement of power transformers within the substation, rephasing/ reconductoring project, network switching or reconfiguration, etc.) that will allow identifying and correcting problems related to system growth.

Network changes can be grouped to facilitate the viewing and editing of the main project. For example if a project is delayed, the user can simply move the concerned group of modifications to a different year and see the impact on the whole network. If a project is cancelled or put on hold, the associated tasks can be disabled to reflect that situation and the module will flag any abnormal conditions due to this change.

The module's capabilities are further enhanced by the Advanced Project Manager functions which are included in the Automated Network Forecast Analysis module. These combined functionalities support detailed preparation of time-based projects that can span over several years.

Specific analyses and reports can thus be attached to any group of network changes.



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Automated Network Forecast Analysis

Manage and plan your network expansions and changes over time.

Program Features

The main features of the module include:

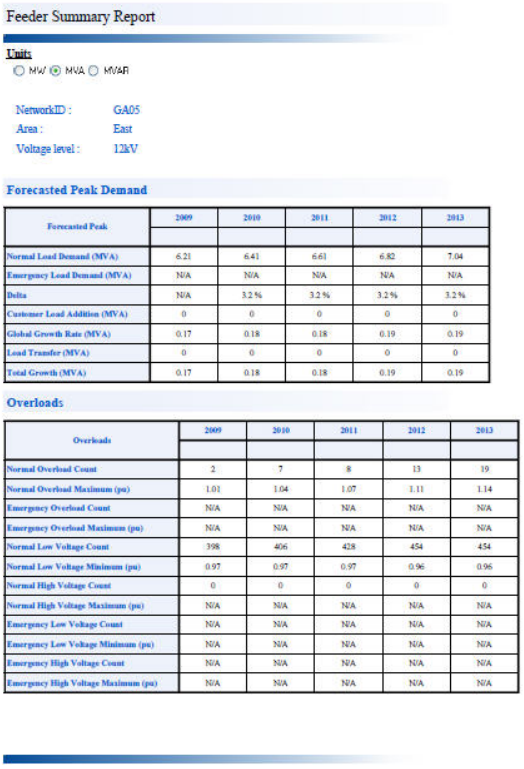
- Automated analyses insertion such as: load flow, short-circuit, load growth, load allocation, contingency that can be related to any point on the network, at any point in time, based on identified network modifications for both normal or contingency mode of operations.
- Save analysis configurations. User-defined configurations can be saved so that parameters can be reused in additional analysis.
- Validation process: the sequence of tasks is verified to avoid inserting invalid changes. The same validation process is run when loading an existing project to verify the project against any updates to the base case.
- Multi-level structured project: allows multiple users to work on the creation and modification of the same network easily and concurrently in a project database apart from the main CYME database.
- Migration tool: facilitates the transfer of forecasts from one year to the next, thus minimizing data handling and modifications going from one planning cycle to the other.
- Scenario mode: allows the user to analyze all the alternatives contemplated and easily compare the impacts of each solution.

Results Viewer

The results are presented in an enhanced reporting tool that conveys an overall view of the network over the project scheduled years and allows the user to dig into more detailed data on any part of the network.

With this results viewer, you can generate reports for each distribution line, substation, and zone contained in the network.

- Contingency report: backup feeder and outage feeder.
- Network / Feeder summary report: results over the forecasted years for demand, overloads, losses, new customers, load transfers, abnormal conditions etc.



Feeder Summary Report

Units:

MW MVA MVAR

NetworkID : GA05
Area : East
Voltage level : 12kV

Forecasted Peak Demand

Forecasted Peak	2009	2010	2011	2012	2013
Normal Load Demand (MVA)	6.21	6.41	6.61	6.82	7.04
Emergency Load Demand (MVA)	N/A	N/A	N/A	N/A	N/A
Delta	N/A	3.2 %	3.2 %	3.2 %	3.2 %
Customer Load Addition (MVA)	0	0	0	0	0
Global Growth Rate (MVA)	0.17	0.18	0.18	0.19	0.19
Load Transfer (MVA)	0	0	0	0	0
Total Growth (MVA)	0.17	0.18	0.18	0.19	0.19

Overloads

Overloads	2009	2010	2011	2012	2013
Normal Overload Count	2	7	8	13	19
Normal Overload Maximum (pu)	1.01	1.04	1.07	1.11	1.14
Emergency Overload Count	N/A	N/A	N/A	N/A	N/A
Emergency Overload Maximum (pu)	N/A	N/A	N/A	N/A	N/A
Normal Low Voltage Count	398	406	428	454	454
Normal Low Voltage Minimum (pu)	0.97	0.97	0.97	0.96	0.96
Normal High Voltage Count	0	0	0	0	0
Normal High Voltage Maximum (pu)	N/A	N/A	N/A	N/A	N/A
Emergency Low Voltage Count	N/A	N/A	N/A	N/A	N/A
Emergency Low Voltage Minimum (pu)	N/A	N/A	N/A	N/A	N/A
Emergency High Voltage Count	N/A	N/A	N/A	N/A	N/A
Emergency High Voltage Maximum (pu)	N/A	N/A	N/A	N/A	N/A

Powering Business Worldwide

CYME power engineering and analysis software
Brightlayer Utilities suite

Long-term planner module

Optimizing the transition to modern grid capacity planning framework

As utilities continue to move toward grid modernization, innovative planning tools are key enablers.

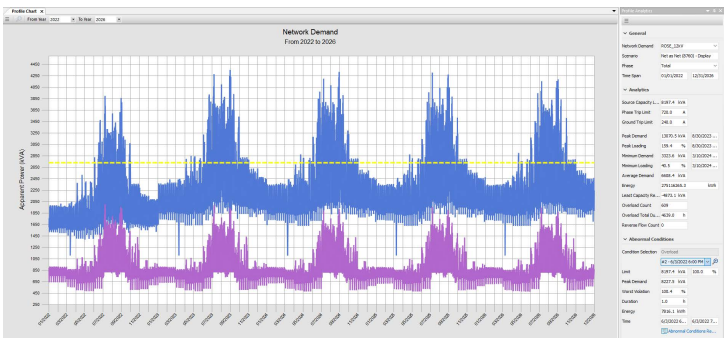
The CYME 9 series, part of the Brightlayer Utilities suite, features the long-term planner module specifically designed to help utilities with optimizing their long-term grid planning framework. Engineered to simulate exponential scenarios of future changes on the network, the long-term planner module provides crucial insights to identify and correct problems related to system growth.

Utilizing Advanced Project Manager and Load Flow with profiles, the long-term planner module features powerful forecast analytics capabilities and a robust reporting technology that aggregates content from different contexts to provide a holistic view of distribution circuits and substations performance over time.

Key features include:

Forecast analytics:

- **Long-term hourly circuit forecast data** is interpreted based on circuit capacity limit providing valuable insights prior to taking any further actions to prioritize or exclude circuits from planning process.
- **Graphically represented forecast scenario profiles** with key information such as circuit capacity and reverse flow limits as well as indicators for grid projects.
- **Profile analytics explorer** assess the time-stamped data to extract key performance indexes and abnormal conditions for the specified time span of the desired forecast demand.
- **Top-down demand disaggregation** to create load-flow based forecast profiles for loads and DERs from circuit level demand that can be saved in the database, utilized for future load transfer project studies and enhance the run-time performance of time-series load flow analysis.[1]



Profile analytics

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Planning summary:

- **A new tool with tabular structure and interactive design** that aggregates relevant content from multiple data sources, transforming it into decision-making information essential to the long-term planning process.
- **Circuit capacity** from as-built and as-planned network models is extracted by the Planning Summary as the basis for all capacity analysis KPIs.
- **Profile analytics** provide an overview of strategic data points such as peak/minimum demand and loading and their corresponding dates as well as statistics about overloading and reverse flow violations. These interactive data reports keep users informed on grid performance and mitigation projects.
- **Third-party hourly forecast data** is processed either per year, per season or per month, and presented in a tabulated format for an easy period-over-period comparison. Detailed abnormal conditions reports are immediately accessible, providing visualization to correlating data.
- **Time-series load flow results**[1] are captured and integrated into the same period-over-period which delivers various KPIs including but not limited to: demand, loading level, demand growth and capacity reserve.
- **Time-series ampacity results**[2] for underground cable installations can also be added to the Planning Summary.
- **Abnormal conditions** for each planning period are summarized to identify affected equipment as well as the amount and duration of violations.
- **Project summary section** gives the user visibility on the as-planned network configuration by extracting the most salient project information[3] such as the number of new customers, the amount of new generation and storage as well as the amount of load transfers.
- **On-demand refresh capabilities** allow the Planning Summary to reflect the impact of the grid upgrade project on circuit capacity at any given time.

Drill-down reports:

- **As time-series forecast data and analysis results** creates a large volume of information, the long-term planner module always presents synthesized data to the user to facilitate interpretation and enable data-driven actions.
- **The high-level summary results** can easily be granularized using the different levels of drill-down reports (circuit level to device level to individual occurrences) allowing engineers to focus on a specific potential grid risk.

Planning Summary

Search

Planning Summary - N206

Feeder: N206

	2024	2025	2026	2027	2028
Capacity	Updated by E0657on 2022-08-10 10:00:12				
Capacity (kVA)	8700.0	8700.0	8700.0	8700.0	8700.0
Forecast Profile Analytics	Updated by E0657 on 2022-08-10 10:00:43				
Forecast Profile Source	N206				
Peak Demand (kVA)	8370.4	8537.8	8708.2	8882.0	9059.3
Peak Loading (%)	96.2	98.1	100.1	102.1	104.1
Peak Demand Date	2024-01-02 10:00	2025-01-08 10:00	2026-03-03 10:00	2027-03-03 10:00	2028-12-12 10:00
Peak Demand Growth (kVA)		167.34694	170.40816	173.8094	177.27853
Minimum Demand (kVA)	1685.1	1710.1	1733.0	1759.5	1786.3
Minimum Loading (%)	19.4	19.7	19.9	20.2	20.5
Minimum Demand Date	2024-06-06 6:00	2025-06-06 6:00	2026-06-19 6:00	2027-06-10 6:00	2028-06-09 6:00
Least Capacity Reserve (kVA)	329.6	162.2	-8.2	-182.0	-359.3
Average Demand (kVA)	4492.5	4581.2	4667.6	4761.8	4879.6
Overload Count	0	0	16	15	16
Overload Total Duration (h)	0	0	17	30	64
Reverse Flow Count	0	0	0	0	0
Reverse Flow Total Duration (h)	0	0	0	0	0
Load Flow Results	Updated by E0657 on 2022-08-10 10:03:58				

1. *Requires CYME Steady State Analysis with Profiles module license (pre-requisite)*
2. *Requires CYME Cable Thermal Rating module license*
3. *Requires CYME Advanced Project Manager module (pre-requisite)*

The **Brightlayer Utilities suite** is a full complement of software applications that enable utilities to use data to optimize the performance and reliability of the grid, integrate renewables, comply with regulations and plan for the future. As a key solution in the Brightlayer Utilities suite, the CYME power engineering and analysis applications provide advanced network modeling and simulation capabilities, addressing the needs for planning, operation support, protection, DER interconnection and other critical duties. **Learn more at: eaton.com/BrightlayerUtilities**

For more information on CYME power engineering software, part of the Brightlayer Utilities suite, or a web demo, please contact us at Eaton.com/cyme or cymeinfo@eaton.com.

Powering Business Worldwide

CYME
Power Engineering Software and Solutions

Techno-Economic Analysis

Effective planning and design of the power system in line with financial objectives

Power utilities and industrial facilities are facing the complex challenge of upgrading and developing their power systems while assuring an optimal return on their investments and their long-term viability.

The CYME Techno-Economic analysis module facilitates the evaluation of the feasibility and the profitability of a project, based on the factual system model, leading to a realistic planning in line with technical, service reliability and financial objectives.

Whether planning maintenance, replacements, improvements or expansions to a power system, the Techno-Economic Analysis module is intended to help electric utilities and large industries invest into that infrastructure by analyzing impacts of modifications made and the cost and gains they entail over the years.

For each study, costs can be associated to any modification to the power system model, whether it is the cost resulting from the installation or relocation of an asset or from a load transfer like a phase balancing operation. In addition to the asset cost, economic parameters such as operation and maintenance cost, salvage value and depreciation can be defined and taken into account by the analysis.

The reports created present load flow results in terms of benefits following from reduction in losses and mitigation of abnormal conditions. The economic results include an income statement, a cash flow statement and a capital budgeting. When used with the CYME **Reliability Assessment** module, mitigation valuation can be based on improvements of a single reliability index, or a combination of multiple indices.

The techno-economic analysis can be performed on a project created using the CYME **Advanced Project Manager** module. It allows the individual or collective analysis of mitigation projects that are planned for different moments in time. The integration of the two modules brings the analysis to another level by including the technical impacts of concurrent future approved projects, and by allowing a more detailed load growth that combines organic growth, active growth and load transfers.

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Techno-Economic Analysis

Effective planning and design of the power system in line with financial objectives

Features - Technical

- A library of costs for each equipment type and network operation can be created and subsequently applied to the relevant modifications on the power system.
- The impact of corrective measures is assessed on the following: loss reduction, abnormal conditions reduction (voltage violations and overloads). Reliability indices improvement is proposed by the analysis with the Reliability Assessment module installed.
- These impacts are valuated based on the library of costs and expressed in terms of worth per kWh, abnormal condition or improvement in point of index.

Features - Economic

- Economic settings such as the discount rate, the inflation rate and the tax rate are applied on all costs to determine the present value of future cash flows.
- The investment activities (i.e. the costs of the modifications) related to the corrective measures are compared to their economic revenues and gains.
- The analysis can be performed on a calculation period that considers an estimated or forecasted global or detailed load growth.
- The economic results include the Net Present Value (NPV), the Internal Rate of Return (IRR), the Return On Investment (ROI), the estimated payback period and estimated discounted payback period.
- The return on investment is calculated taking into account objectives such as losses reduction, mitigations of abnormal conditions and, in option, the improvement in reliability.
- Asset depreciation over the span of the analysis can be considered with the possibility to consider the half-year rule and/or to include the salvage value and tax.

Reports

The technical results are available for a base case (i.e. prior to modifications) and for the study/project where the planned measures are applied, for easy comparison.

- The technical results are presented per year for the simulation period.
- The technical results used for valuation, i.e. system losses, abnormal conditions and/or reliability indices, are shown with their absolute value and as a reduction compared to the base case.
- The impact of the corrective measures on the power and energy losses (kw and Kwh), on the under- and over-voltage conditions, on the overload condition and/or on the selected reliability indices are shown for each year.
- The modifications contained in the study/project for which costs have been defined are also tabulated.

The economic information shown in the reports includes:

- An income statement (revenues and gains, expenses and losses) for the period simulated.
- A cash flow statement (operating activities, investing activities) for the period simulated.
- A capital budgeting report that gives an overview of the economic indicators such as the NPV, IRR, ROI and the payback period.
- The details of the depreciation calculations related to the figures printed in the income statement are also presented.

CYME
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Distribution State Estimator

Process various measurements in order to estimate the power flow and voltages of the system

As distribution systems are becoming more interconnected and complex, their efficient planning and operation require an accurate and trustworthy power flow solution obtained from a detailed electrical model with its inherent share of imprecision.

The CYME Distribution State Estimator module features a refined algorithm which takes detailed network modeling to a newer level by being able to process various measurements in order to estimate the power flow and voltages of the system.

The CYME Distribution State Estimator analyzes the unbalanced power flow and the voltages at every level of a distribution power system. The module uses a rigorous mathematical formulation which solves for all distribution system topologies (radial, looped, meshed), including heavily meshed systems such as secondary grid networks.

The details provided by the module help the distribution engineer design the best solution to the problems identified. The module is seamlessly integrated to the CYME framework, making it easy to utilize the results for other CYME simulations and for adjusting settings on the distribution model.

The CYME Distribution State Estimator can:

- Estimate unbalanced load and power flow
- Process various types of by-phase measurements (volts, amps, kW, kVAR) with user-specified precisions
- Handle measurement redundancy
- Estimate voltage regulator and transformer on-load tap changer tap position
- Include distributed generation
- Provide solution quality indices
- Cleanse the data based on user-defined rules to remove bad data prior to the analysis
- Perform load initialization in preparation of distribution system analysis (capacity analysis, volt-VAR optimization, contingency analysis, etc.)
- Assist with identification of potential errors in topology and measurements (switches state, shunt capacitor state, tap position, etc.)

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Distribution State Estimator

Detect potential power flow and voltage problems on your electric distribution system

State estimation for secondary grid networks

The Distribution State Estimator analysis is based on a rigorous mathematical formulation that can handle large interconnected systems. This robust algorithm makes the state estimation of heavily meshed systems such as secondary networks possible. Load values can be estimated while low-voltage cable currents can be calculated for increased grid awareness.

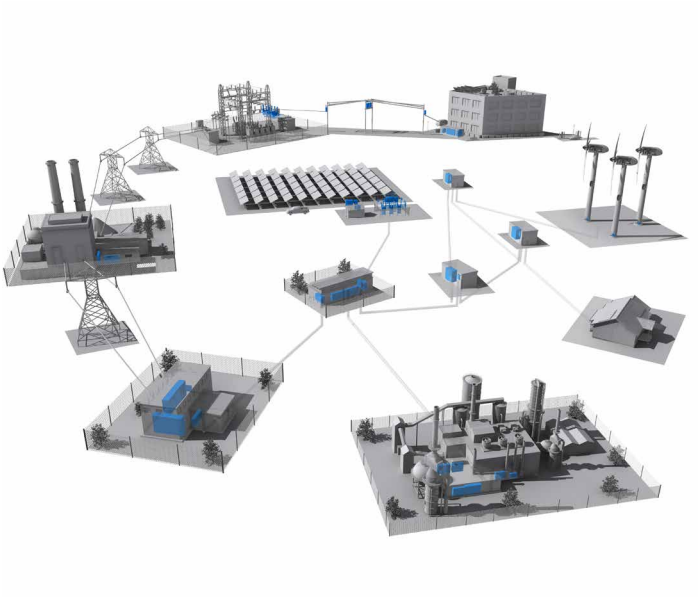
Voltage measurements

Unlike traditional algorithms such as power flow and load allocation, the Distribution State Estimator takes into account by-phase voltage measurements, along with other traditional measurements (Amps, kW, kVAR). A voltage meter can be installed at any node of the distribution system model.

Meaningful results

The Distribution State Estimator analysis module includes several detailed reports that can be further customized by the user. They provide insights on the solution by tabulating meaningful results such as estimated load values, meter measurements and calculated meter values. A series of quality indices is also available to help the engineer assess the accuracy of the solution:

- Normalized residuals
- Weighted residuals
- Normalized Lagrange multipliers
- Solution cost
- Measurement mismatches



Powering Business Worldwide

CYME
Power Engineering Software and Solutions

Contingency Assessment and Restoration

Find optimal switching plans to enhance the security of your power system

An unscheduled outage can easily put a power system's security at risk. Understanding the impact of plausible outages can help engineers identify weak points of their networks and put emergency switching plans in place.

The CYME Contingency Assessment and Restoration Analysis module is a comprehensive tool to study the impact of contingencies on the distribution system in order to find an optimal switching plan for power restoration.

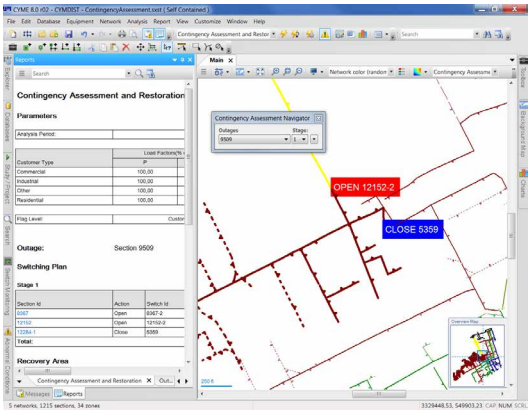
One of the possible impacts of equipment failures is the interruption of service to customers. Outage duration can extend beyond customers level of tolerance if no adequate switching plan considering equipment overloads and voltage violations has been planned. Therefore, contingency analysis is essential to engineers to assess the robustness of the networks by identifying potential problems with outages and planning maintenance in order to assure rapid service restoration.

The Contingency Assessment and Restoration Analysis module studies the what-if situation of outages on a radial system to establish viable switching plans.

The features of the module include:

- User-defined outage locations
- Batch mode contingency simulations
- Outage data can be saved in an external file for easy re-evaluation of the same event at a later date
- Different restoration modes and objectives
- User-defined criteria for switching operations
- Illustrative one-line diagram display
- Detailed reports

With its many features, the Contingency Assessment and Restoration analysis module is a powerful tool to help engineers understand the strengths and weaknesses of a power system through the study of outage impacts at different locations. It suggests contingency switching plans, so that you can be prepared for quick intervention in case of unplanned loss of supply.



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Contingency Assessment and Restoration

Find optimal switching plans to enhance the security of your power system.

Restoration Plan

The analysis simulates the outage at the user-defined locations and evaluates all the alternatives to propose a sound switching plan.

The module takes into account the selected restoration mode and restoration priority.

The selection criterion is also defined by the relative importance of different objective functions, such as:

- Minimize the number of switching operations
- Maximize the total load restored
- Balance the load among available feeders
- Minimize the loading of every component
- Minimize the distance between the customer and the substation

The analysis also respects the following user-defined criteria:

- Maximum equipment loading limits
- Maximum and minimum voltage limits
- Operable switching devices
- Number of backup feeder layers
- Load factors

Satisfying all the user-defined criteria, the module provides the best-suited solution specific to each user's operating conditions.

Meaningful Results

Results are presented in the form of both one-line diagram display and reports.

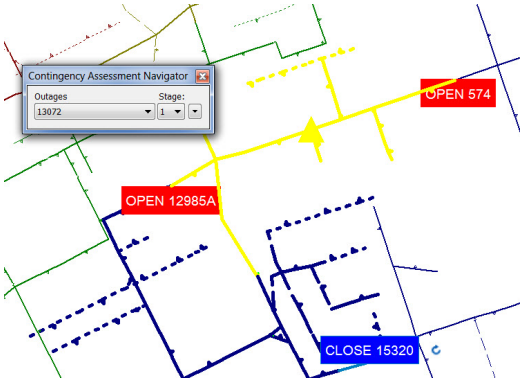
One-line diagram display includes:

- Navigator to display the post-contingency network status and switching plan for each single-contingency scenario in a batch mode simulation
- Color-coding to show outage location, restored sections, un-served area and isolated sections
- Color-coding to show switching operations
- Tags to show information on the switched devices

Reports include:

- Detailed report for each outage, listing the proposed switching plan, the load restoration and the area left un-served
- Report listing the weak points in the network which would be overloaded when a switching operation is attempted

The information available helps engineers study multiple what-if scenarios, to understand the security of the system, and to be better prepared for undesired service interruption.



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Load Flow Contingency (N-p)

Create contingency events and scenarios, and compare results with the base case network

This module is designed to assist in contingency analysis of grid networks. It operates in conjunction with the CYME power flow analysis modules. With it, the power engineer can create contingency events and single or multiple-outage scenarios, and compare results with the base case network data and connectivity model.

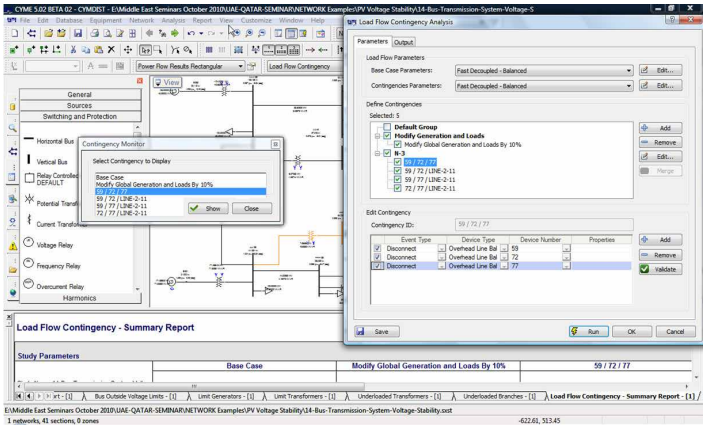
The analytical approach used by the Load Flow Contingency (N-p) module is the same as the CYME power flow. In other words, the contingency analysis produces full AC power flow solutions with no DC approximations. The module features the sequential solution of all contingencies in a single run.

Analytical Capabilities

The Load Flow Contingency (N-p) module allow the simulation of multiple "what-if" situations in a batch analysis. Those "what-if" cases represent the loss and/or disconnection of a device. All system modifications related to a contingency refer to the base case network. Several contingencies can be concurrently defined to represent a network operation adverse scenario.

This includes the following:

- Modify loads globally, individually or by zone
- Modify generation globally, individually or by zone
- Connect and disconnect sections
- Modify shunts
- Add and remove induction and synchronous motors



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Load Flow Contingency (N-p)

Create contingency events and scenarios, and compare results with the base case network.

Contingency N-1, N-2, N-3

With this option, you can define a group of single-, double-, or triple-section outage contingency studies. The network sections can be selected along with the combination of up to three elements per contingency. The program will create the desired group automatically, including the corresponding studies.

Contingency Ranking

This feature allows you to add or eliminate contingency indexes (ranking) to the tabular report. This contingency ranking methodology is for the automatic ranking, selection of contingency cases and for the identification of the most severe contingencies.

CYME power engineering and analysis software
Brightlayer Utilities suite

Advanced Fault Locator module

Improving operational efficiency with more accurate fault location

The growth of distributed energy resources (DER) and natural disaster incidents has changed the traditional distribution system and introduced complexity in the coordination of protection devices. Existing fault location methods are becoming less effective.

Utilities have started using multiple devices to get field measurements data to help identify the fault location and provide rapid service restoration to those affected.

Part of the Brightlayer Utilities suite, the CYME Advanced Fault Locator **analysis** offers improved operational support by helping engineers locate the faults more rapidly, enabling crews to be dispatched much closer to the fault location. This in turn, reduces line inspection time as well as outage duration and improves SAIDI. This can be extremely effective when used as part of a wildfire mitigation strategy.

The Advanced Fault Locator Analysis module, part of the CYME powering engineering software, offers a rigorous method to calculate and visualize possible fault locations on the detailed network model:

The user can model fault indicators as instruments installed on the network using a drag-and-drop fault indicator icon. The flexibility to specify the type and trip thresholds for fault indicators helps focus in on the area where the fault occurred. Along with fault indicators, the analysis brings a range of methods to analyze different fault situations that impact results such as:

- **Single faults in multiple locations** where it simulates a single fault seen from multiple monitoring device locations. Here the user can input several concurrent measurements for the same fault from different monitoring device locations.
- **Multiple faults in a single location** where it simulates an evolving fault in same monitoring device location. Here the user can input several concurrent measurements for different fault types for the same monitoring device location.

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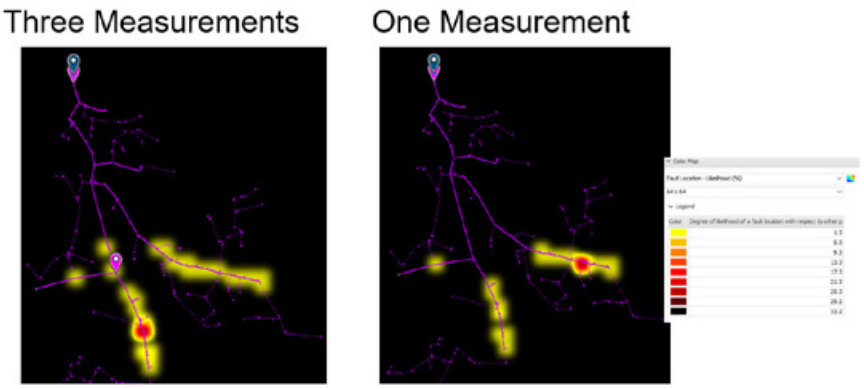

Other inputs to the analysis include:

- **By-phase currents** can be specified allowing to capture the exact faulted phases of the monitoring device.
- **The type of fault recorded** by the monitoring device such as, phase current, sequence current, range of fault impedance.
- **Sliding fault feature** refining the resolution of faults on long lines subdivision of long conductors providing a better precision on the location of the fault by testing cables and overhead lines on their whole length.

This combination of modeling and device measures and allow for a more precise and rapid fault location identification. This can be achieved through:

- **Comprehensive reporting** listing information on fault location, faulted phase, distance from the monitoring device and the fault likelihood
- **Color-coding layers** to visualize the device(s) and fault event(s) critical path(s) on the one-line display and color maps detailing fault likelihood
- **Based on** the IEEE C37.114© and C37.111-2013© standards

Brightlayer Utilities suite is a full complement of software applications that enable utilities to use data to optimize the performance and reliability of the grid, integrate renewables, comply with regulations and plan for the future. As a key solution in the Brightlayer Utilities suite, the CYME power engineering and analysis applications provide advanced network modeling and simulation capabilities, addressing the needs for planning, operation support, protection, DER interconnection and other critical duties.

For more information on the CYME Software, or for a web demo, please reach out to us at **Eaton.com/cyme** or contact us as **cymeinfo@eaton.com**.

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CYME INTERNATIONAL T&D

Protective Device Analysis

Verify and enhance your power system's protection with CYME's Protective Device Analysis.

The Protective Device Analysis module is an indispensable tool to help power engineers effectively address protection issues by analyzing time-current curves.

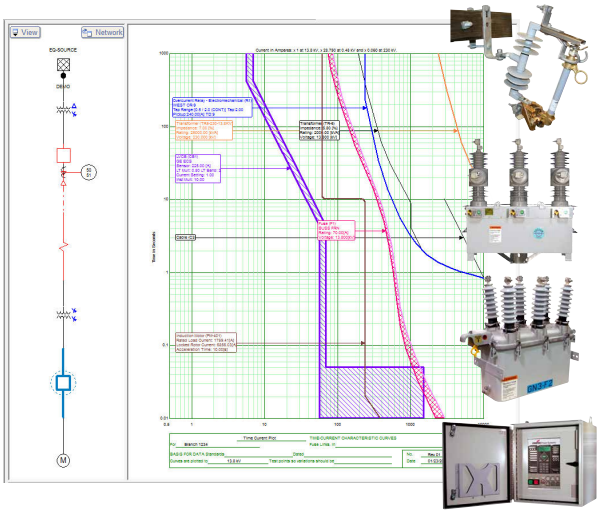
With an extensive library of over 15000 protective devices, an intuitive graphical plot and a broad range of tools and analyses, planning and validating protection schemes has never been easier with the CYME Power System Analysis Software.

The right selection of protective devices and their proper sizing are important issues for engineers desiring to reduce the impact caused by any short-circuit on the network and to minimize equipment failures. CYME's Protective Device Analysis module provides engineers with a wide range of tools to efficiently and accurately design and validate the coordination scheme of their power system.

Time over current plots are generated within the user-friendly interface of CYME, which offers:

- Log-log plot to display time-current curves of protective devices such as fuses, relays, circuit breakers and reclosers
- Library containing more than 100 000 curves from North American, European and Asian manufacturers
- Online update of the library of curves
- Inspection of the proper coordination for motor starting, transformer inrush and cable damage
- Tools to calculate precisely the time and current margins between curves
- Modification of any setting to visualize the change interactively on-screen
- Customizable display options for curve colors, tags and other grid options
- Export function to easily include time-current plots in reports

Not only does CYME provide the useful tools listed above to make any study simple, it also offers advanced analyses to assist engineers in examining the coordination and protection range of the devices on the network more closely.



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Protective Device Analysis

Verify and enhance your power system's protection with CYME's Protective Device Analysis.

Network Protection Analysis

The Network Protection analysis can be used to verify the coordination, the protective reach and the loading of all protective devices in a network.

Main capabilities include:

- Verify the coordination between successive pairs of devices according to user-defined criteria
- Examine whether a device operates for all faults in its protection zone within a user-defined maximum permitted operating time
- Compare the current through each device to a user-defined maximum permitted continuous load current
- Verify if cables are protected by a device on all its length
- Fuse clearing or fuse saving option
- Study both primary and secondary protective devices
- Specialized report and indication on one-line diagram to highlight curve intersections, reach and loading problems

Minimum Fault Analysis

The Minimum Fault analysis is offered to assist engineers in the verification of whether the protective devices can adequately detect and clear the minimum faults seen in their respective protection zone.

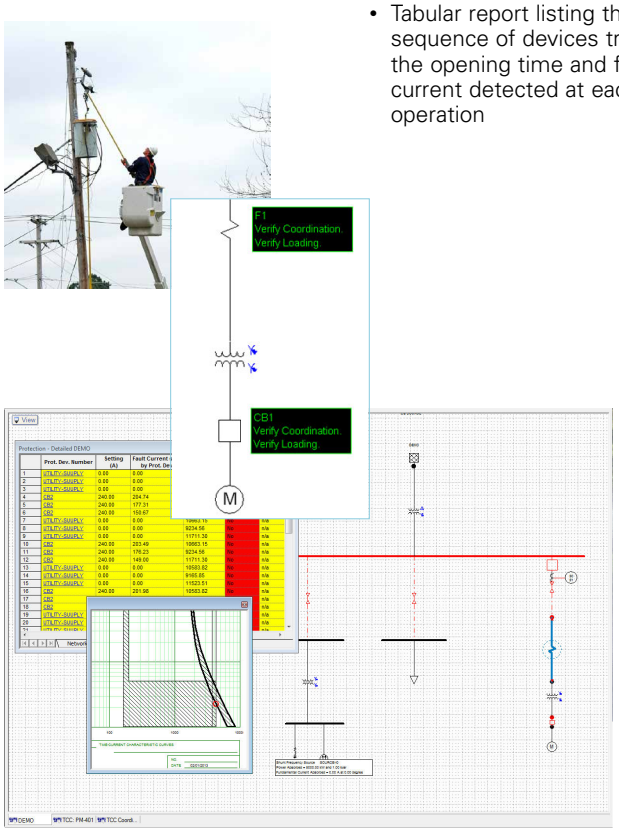
A detailed report is provided to list all areas that are inadequately protected. Those areas are also color-coded on the one-line diagram for easier visualization.

Sequence of Operation

The Sequence of Operation analysis evaluates the impact of a fault on the network to provide the sequence of protective device operations triggered.

Main capabilities include:

- User-defined fault location
- Simulation of any fault type
- Calculation of the fault current and opening time of each protective device while taking into account the state of the network at each operation
- Take into account device settings, including delays and reset times
- Tracing of the protective devices triggered in the one-line diagram
- Tabular report listing the sequence of devices triggered, the opening time and fault current detected at each operation



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Arc Flash Hazard Analysis

Improve electrical safety by assessing arc flash hazard risk level and recommending safety measures

Risk management and prevention have always been important aspects of safety programs within the electric industry. The proper assessment of arc flash risk level can help minimize operational downtime and ensure a safer work environment.

The Arc Flash Hazard Analysis module computes the necessary parameters required to assess the risk level and help you adopt the appropriate safety procedures in order to minimize the risks of burns and injuries to those working on or near electrical equipment.

As a module integrated in the CYME Power Engineering Software, it allows you to evaluate the risk of arc flash hazards on any part of your network. It calculates the short-circuit fault current using its robust short-circuit calculation algorithm, finds the clearing time from time-current curves of our extensive device library, and calculates the resulting incident energy and risk level.

The module is compliant with industry recognized standards and methods to perform arc flash hazard calculations for industrial, distribution and transmission systems. These standards are:

- NFPA-70E 2015©, Electrical Safety Requirements for Employee Workplaces
- CSA Z462, Workplace Electrical Safety Standard
- IEEE-1584™ 2011, Guide for Performing Arc-Flash Hazard Calculations

For the arc flash analysis in distribution and transmission systems, algorithms are available to cater for line-to-ground faults, which represent about 80% of the faults occurring on a distribution system. This added functionality facilitates the evaluation of arc flash hazards on any part of any network.

The algorithms are based on:

- NESC© 2012
- OSHA; to be used with single-phase arc in open air
- Lee Method
- Wilkins Method
- Heat Transfer Model, based on Heat Flux Calculations
  (Model published in Electrical Safety Handbook, by John Cadick, Mary Capelli-Schellpfeffer, Dennis K. Neitzel, published by McGraw-Hill Professional, 2001, Chapter 3.52)

The bus data of any network created with our software can be supplemented with Arc Flash related information such as working distance, bus gap, connected equipment and exposed circuit enclosed in a box or in open air. In addition, the Arc Flash module calculates the maximum bolted short-circuit levels at the desired work place (bus) for Arc Flash Hazard calculations.

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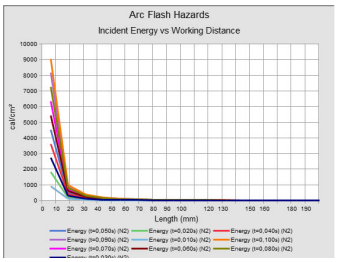
Arc Flash Hazard Analysis

Model and include substations, sub-networks and secondary networks in your simulations.

Capabilities

- One-line diagram and user-friendly GUI for all systems
- Batch mode simulation that will allow the analysis for every bus in the network in one single simulation
- Short-circuit current can be calculated using ANSI® or conventional fault calculation methods. Using ANSI®, the reduced fault contribution of motors and generators are taken into consideration
- Machine and inverter-based DG contribution, and duration of contribution
- Multiple contribution calculation
- Calculation using default values depicted by standards, or using user-defined values
- Accurate opening time is obtained from the protective device time-current curve library
- The module is equipped with the automatic detection and validation of protection schemes in the network
- Option to select the fastest protective device according to the time-current curves of the devices available at a given simulation
- The display of results in a tabular report
- Possibility to generate required results in a chart
- Result box for the visualization of results of selected points on the network

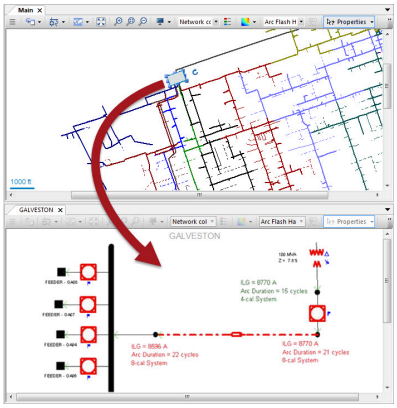


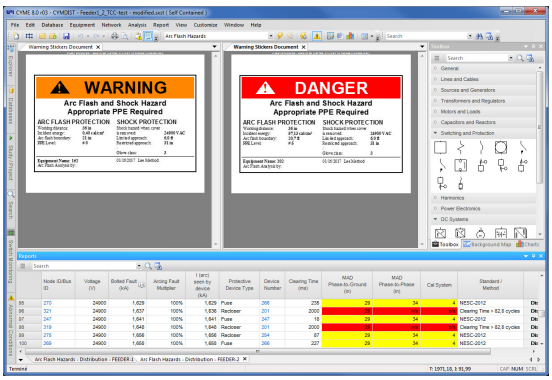
Warning Labels

The program generates warning labels that are ready to be printed and affixed to the electrical equipment. Different label templates are available, and it is also possible to create custom warning labels.

These warning labels include all the necessary information such as:

- Arc Flash Hazard boundary
- Incident energy
- Hazard/Risk category class
- Personal Protective Equipment (PPE)
- Potential shock hazard
- Limited, restricted and prohibited approach boundaries
- Equipment, node ID or downstream equipment identification





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Distance Protection Analysis

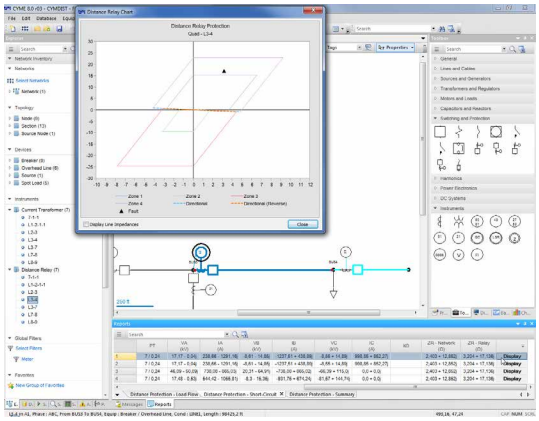
Analyze the operation of distance protection relays under normal and fault conditions

Distributed Generation involves the addition of generation capacity to a distribution system. Protection must be designed effectively and easily to ensure the reliability of the evolving system.

The CYME Distance Protection Analysis module is a powerful tool that can help engineers design and verify their protection scheme, and address different coordination issues in any power system.

Distance protection has the ability to clear any fault occurring inside the protection zone determined by the relay location and the reach point , depending on the impedance measured.

The CYME Distance Protection Analysis module is designed to help electrical engineers design and validate protection schemes that involve distance protection relays. It assists in identifying challenges and finding solutions to power system protection problems detected with the simulations.



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Distance Protection Analysis

Analyze the operation of distance protection relays under normal and fault conditions

Features

The Distance Protection Analysis module verifies the operation of all types of distance relays modeled, under normal conditions and under all fault types (LLL, LLLG, LL, LG and LLG).

Relays settings can be done automatically or manually in both primary and secondary sides. The user can select the right distance protection device and the software will help calculate its appropriate settings. Voltage and current are used for computing impedance.

- Estimate function to set the reach of each protection zone (impedance) and the compensation factor
- Load encroachment
- Protection characteristics displayed on R-X diagram

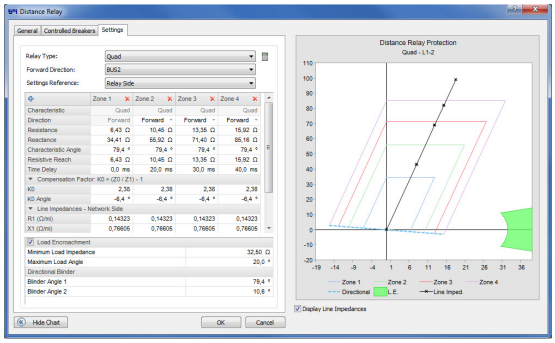
Distance relay types that can be modeled with the CYME software are:

- Mho
- KD-10
- HZ
- Quadrilateral
- RAZOA
- GCX51A
- GCXY51
- Reactance
- Polygon
- Polygon-Mho

Analysis results

- Load Flow – When the analysis is executed for normal conditions, the software will run a load flow simulation. The results (currents and voltages) are transferred to relays in order to check whether they are operating or not. The relays are reported with their measures (the currents, the voltages and the impedance computed on the primary and the secondary side).
- Short-Circuit – To see the details related to all relays that have detected a fault, and information about the fault and its zone location.

The fault and the relay impedance can be displayed in an R-X plane from the report. The user can examine the relay operation every time the system conditions are changed.



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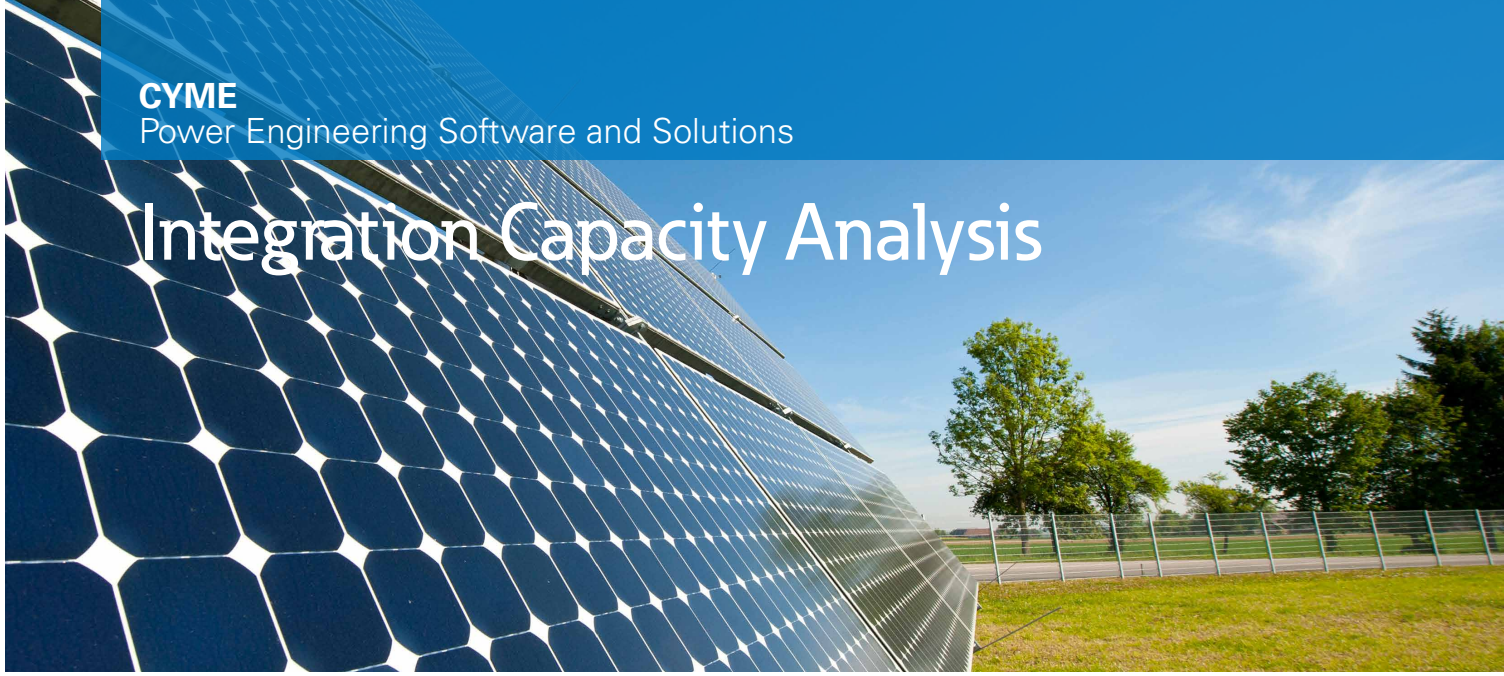
Integration Capacity Analysis



Determine the hosting capacity of your distribution system considering power quality and reliability.

The global trend for cleaner power, supported by the arrival of new technologies such as solar and wind farms as well as affordable rooftop photovoltaic panels, has changed the distribution system landscape. The ever-increasing volume of distributed energy resources (DER) interconnection requests creates a need for new innovative engineering tools. The CYME Integration Capacity Analysis module allows performing an assessment of the generation or load hosting capacity of a distribution system without compromising its reliability and power quality.

As the landscape of the distribution system evolves with the rapid emergence of new renewable energy technologies, electric distribution utilities are challenged to accelerate DER deployment and process interconnection requests in a timely manner.

The CYME Integration Capacity Analysis module comes in handy to efficiently and consistently calculate the maximum generation or load capacity that can be installed independently at each point of a distribution system without adversely impacting its reliability and power quality.

This productivity tool saves labor time by allowing engineers to run simulations without the use of manual tools. A minimum number of parameters, such as the maximum capacity to consider and the peak and minimum load conditions, are required before the assessment can be performed on a complete or partial model of the distribution system. The maximum hosting capacity is determined based on a set of user-defined thresholds referring to a list of criteria that includes thermal overloads, reverse power flow, abnormal steady-state voltages, transient voltage variations (flicker), reduction of protection reach and sympathetic tripping.

The accurate results provided by the CYME Integration Capacity Analysis are a key to support utilities in their current and future generation interconnection request processing. Moreover, the powerful reporting capabilities of the CYME software make it the perfect tool for publishing color-coded hosting capacity circuit maps for customers and developers interested in suitable locations for DER interconnection projects.

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Integration Capacity Analysis

Create comprehensive color-coded hosting capacity circuit maps using the CYME Integration Capacity Analysis module.

The CYME Integration Capacity Analysis module calculates the maximum generation or load capacity at each point of the distribution circuits analyzed.

Features

The analysis uses an iterative method which considers:

- Integration of generation or load up to a user-defined maximum capacity value
- Maximum fault contribution for generation integration, or customer type for load integration
- Load scaling factors or load models for peak and minimum load conditions
- Customizable load flow and short-circuit calculation parameters

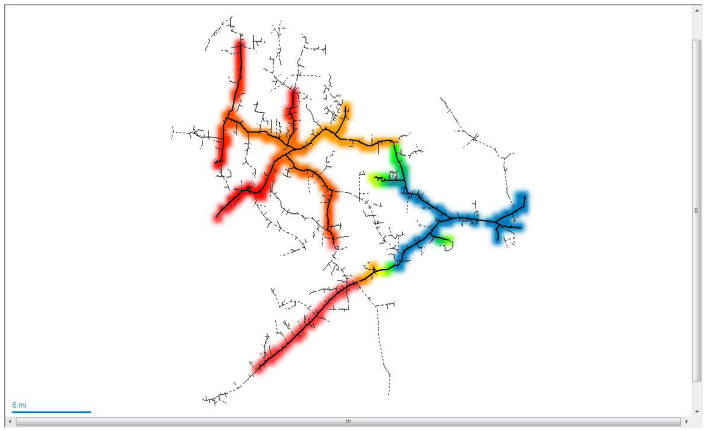
System reliability and power quality are ensured by a series of criteria-based verifications including:

- Thermal loading of monitored devices based on user-defined limits set by device type
- Reverse flow through monitored devices based on a maximum permissible user-defined value
- Abnormal steady-state voltages based on user-defined over- and under-voltage limits applicable globally or by voltage range (LV, MV, HV)
- Voltage variations caused by sudden generation or load fluctuations based on a user-defined limit
- Reduction of protection reach of monitored devices considering pickup security factor
- Sympathetic tripping of monitored devices considering security factor

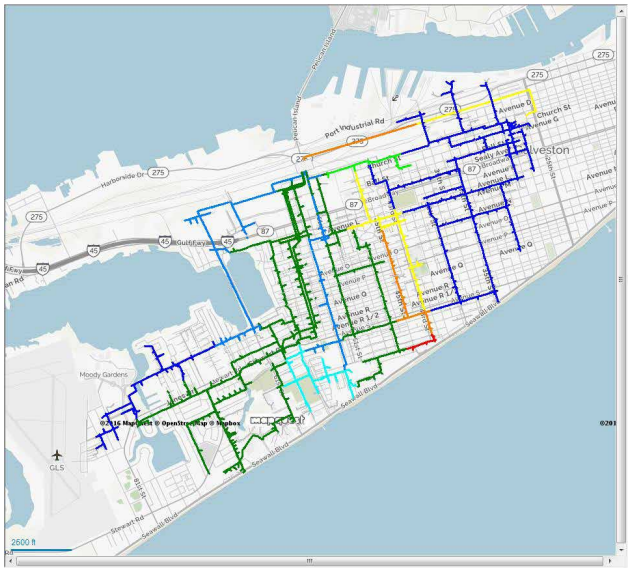
Illustrative results

Integration capacity analysis results are displayed in a tabular report detailing the maximum hosting capacity at each node of the circuits analyzed. Results for each individual constraint are also provided.

Results can of course be used to color-code the one-line diagram or feed the color map function in order to graphically emphasize locations with greater or lesser integration capacity.



ICA results in the CYME software



ICA Results on Map (MapQuest™)

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EPRI DRIVE™ Module

Take advantage of the synergy of CYME and EPRI for hosting capacity analysis

The EPRI DRIVE™ software determines the maximum amount of DER each distribution feeder can accommodate in its current state before unacceptable reliability, power quality, protection and thermal issues start to emerge.

Transparently integrated into the CYME Software graphical user interface, the EPRI DRIVE™ engine unfolds as a native analysis module that combines the sophistication of EPRI's engineering with the refinement of the CYME's distribution system modeling and analysis capabilities.

As the distribution system landscape evolves with a global trend for cleaner power, supported by the arrival of new technologies such as solar and wind farms as well as affordable rooftop photovoltaic panels, electric distribution utilities are challenged to accelerate DER deployment and process interconnection requests in a timely manner.

Through its Distribution Resource Integration and Value Estimation – DRIVE – initiative, the Electric Power Research Institute, Inc. (EPRI) has leveraged many years of detailed system impact study expertise and developed a streamline calculation method to assist distribution utilities in performing a rapid yet precise assessment of their system's DER hosting capacity.

The calculation method provides aggregate and granular hosting capacity results for each distribution feeder and considers numerous circuit-specific attributes, such as topology, equipment nameplate data, device settings as well as peak and minimum loading conditions. Thanks to its various analysis parameters, it also allows nuancing between different DER technologies, considering the particular impacts of each of the following resource types:

- Photovoltaic
- Wind Energy Conversion Systems
- Battery energy storage systems
- Fuel cells
- Microturbines
- Synchronous generators

Seamlessly integrated into the CYME Software graphical user interface, the EPRI DRIVE™ Module combines the engineering effort of the EPRI DRIVE™ engine with CYME's detailed distribution system model to return hosting capacity calculation results within a familiar environment. Forget about cumbersome scripting-based integration and unleash the full power of CYME and EPRI offered by the EPRI DRIVE module for your hosting capacity analysis.

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EPRI DRIVE™ Module

Take advantage of the synergy of CYME and EPRI for hosting capacity analysis

Features

The main highlights of EPRI's hosting capacity method are:

- Streamlined method based on heuristics
- Results available for three-phase large DER hosting capacity scenarios (centralized and distributed) and single-phase small DER scenarios (distributed)
- Thorough analysis based on multiple, diverse criteria covering thermal loading, power quality, protection and reliability

Power System Criteria			
Thermal	Power Quality / Voltage	Protection	Reliability / Safety
Substation transformer	Sudden (fast) voltage change	Relay reduction of reach	Unintentional islanding
Primary conductor	Steady-state voltage	Sympathetic tripping	Operational flexibility
	Voltage regulator impact	Element fault current	
	Load tap changer impact	Reverse power flow	

Distribution impacts evaluated in streamlined hosting capacity method (as implemented in the CYME module)
Reference: EPRI white paper, Integration of Hosting Capacity Analysis into Distribution Planning tools, January 2016, 3002005793.

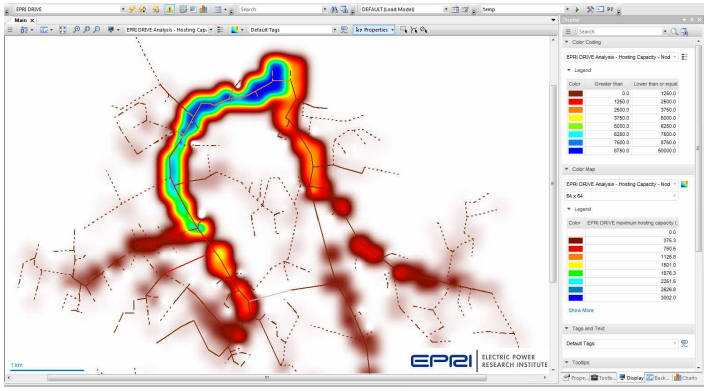
Results

The hosting capacity results are provided under several formats within the CYME software graphical user interface. Typical for this type of analysis, heat maps and one-line diagram color-coding layers are available for each aspect of the method:

- Node-level maximum and by-criterion hosting capacity
- Feeder-level maximum and minimum hosting capacity for each scenario (large centralized and distributed DER, small distributed DER) and criterion

A tooltip is also available on each node of the one-line diagram to consult node-level results (maximum and by-criterion hosting capacity) directly from the distribution system model.

A summary and a spreadsheet report complete the output of the analysis. While the former provides feeder-level results, the latter tabulates the node-level results. Both allow an exhaustive understanding of the distribution system capability to host distributed energy resources.



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DER Impact Evaluation

Tackle generation interconnection studies in a few mouse clicks.

The acceleration of distributed energy resources (DER) deployment imposes new challenges to electric distribution utilities. Handling the volume of interconnection applications and assessing the effects of each new installation on the distribution system require dedicated resources and tools. The CYME DER Impact Evaluation module enable engineers to perform generation interconnection system impact studies within minutes rather than hours through the automation of a series of repetitive, time-consuming and error-prone verifications.

Whenever a DER application fails the streamlined interconnection process, an engineer is required to carry further technical analysis to determine if any adverse effects exist and, in such case, decide on the appropriate mitigations. This task can take several hours, if not days, to accomplish since plenty of verifications on an array of load and generation scenarios are involved.

With the objective of speeding up the interconnection process, the CYME DER Impact Evaluation module automatically performs a comprehensive system impact study that integrates several criteria-based verifications and multiple scenarios in order to flag abnormal conditions.

The module brings an immediate productivity gain by reducing to a minimum the amount of manual work required at each step of the analysis. Relying on a simplified or detailed model of the installation, the module allows the creation of various study cases by combining system loading conditions (e.g. peak and minimum load) with minimum and maximum DER contributions (e.g. 0 and 100%), all defined as simulation parameters. Controlled load flow analyses are then executed on each scenario to assess the impacts on the system in terms of steady-state voltage, transient voltage variations (flicker), thermal overloads and reverse power flow.

A comprehensive set of color-coded summary and detailed reports permits a quick identification of the issues and an easy appreciation of their severity. Taking care of all the hassles, the CYME DER Impact Evaluation module lets engineers focus on what really matters.

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DER Impact Evaluation

Establish your analysis methodology using the different simulation parameters and let the software handle the rest.

Scenarios

Scenarios are created as the combination of diverse system loading conditions with minimum and maximum DER contributions.

- Definition of loading conditions using load scaling factors and/or load models
- Inclusion of one or many DER installations in the analysis scope
- Automatic detection or manual selection of point of common coupling (PCC)
- Adjustment of DER minimum and maximum contribution as a percentage of generator rated power, inverter rating or active generation

Verifications

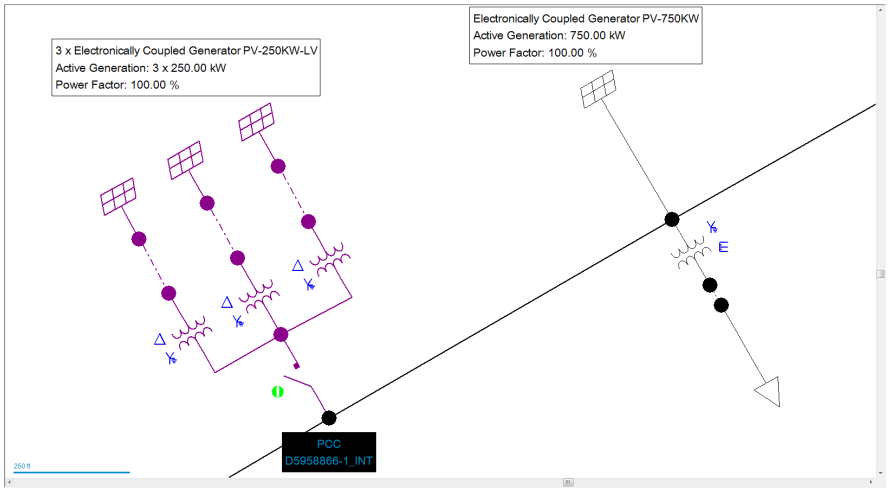
Verifications stemming from a set of criteria with adjustable thresholds are performed on each scenario.

- Steady-state voltage based on user-defined over- and under-voltage limits applicable globally or by voltage range (LV, MV, HV)
- Voltage variations caused by sudden generation fluctuations (max to min, min to max) based on user-defined limits set by voltage level and at the PCC
- Thermal loading of monitored devices based on user-defined limits set by device type
- Reverse power flow through monitored devices (e.g. voltage regulator, on-load tap changers, etc.)
- Generation ramping from minimum to maximum contribution by user-defined increment
- Power factor ramping from minimum to maximum value by user-defined increment

Results

Analysis results are returned in the form of a series of reports clearly highlighting violations using a simple and intuitive color coding.

- A summary report provides an overview of the most severe interconnection impacts for each scenario
- A steady state report details the system minimum and maximum steady-state voltages, including voltage regulators tap position and switchable capacitor bank status
- A voltage variation report presents results for both a rapid increase and decrease in generation



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Network Disturbance Assessment D-A-CH-CZ

Determine the effects of generation units and non-linear loads on power quality

The increasing amount of power electronics, non-linear loads and distributed generation installed on the electrical network can adversely impact power quality by causing unacceptable voltages levels and unbalances, harmonic distortion and flicker levels.

The CYME Network Disturbance Assessment D-A-CH-CZ module allows quickly determining the acceptability of a new load or generator interconnection by evaluating its impact on a series of power quality criteria.

On top of the interconnection of non-linear loads to the grid, the broadening of the distributed generation panorama and power electronics applications has increased the probability, frequency and severity of power quality issues such as over- and under-voltages, harmonic distortion, flicker and voltage unbalance on the power system.

Since these events can affect utility's customers in several ways ranging from discomfort to safety of persons, equipment malfunction, damage and/or overheat, processes disruption and data loss, an adequate evaluation of the impact of an installation prior to its interconnection to the power system is necessary.

In accordance with the standard *D-A-CH-CZ – Technical Rules for the Assessment of Network Disturbances*, the CYME Network Disturbance Assessment D-A-CH-CZ module quantifies and evaluates various voltage quality perturbations introduced by an equipment through a series of tests.

The module uses CYME's robust load flow and short-circuit simulations to evaluate voltage variations and rise, flicker levels and harmonic distortion to help in determining if the interconnection of a load or generator is acceptable or not, according to a series of adjustable limits.

The module produces a simple report indicating, for the installation analyzed, whether its operation is recommended or not, based on the outcome of the verifications performed. An intuitive color-coding function of the pass or fail status of each test is also used to draw attention on the unacceptable situations.

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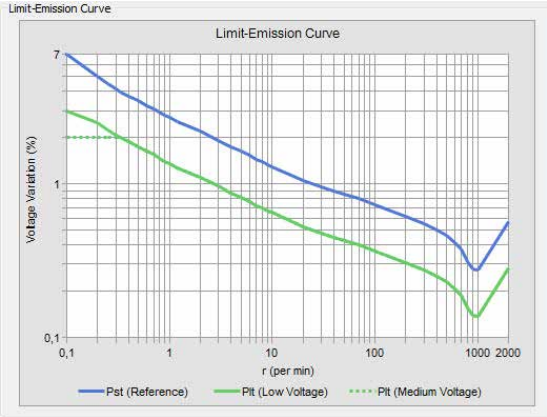
Network Disturbance Assessment D-A-CH-CZ

Determine the effects of generation units and non-linear loads on power quality

The assessment, performed according to the standard *D-A-CH-CZ – Technical Rules for the Assessment of Network Disturbances*, can be done for new or existing installations.

The following loads and DER types are supported:

- Spot load
- Induction motor
- Electronically coupled generator
- Photovoltaic system
- Wind Energy Conversion System (WECS)
- Solid Oxide Fuel Cell (SOFC)
- Micro-turbine
- Induction generator
- Synchronous generator



Verifications

The module executes the following verifications to determine if the installation has a negative impact on the power quality of the system. Different acceptability limits can be defined for low-voltage and medium-voltage systems.

- **Voltage variation limits** – An installation can disturb the network by being used at different intensities, the worst case being when it is switched on and off from full power. This validation checks if the worst system voltage variation exceeds the limit set by the user for the frequency of changes defined.
- **Flicker constraint** – Rapid and constant voltage fluctuations on the network can cause perceptible variations in light intensity. This quick and repeated change is called flicker and can be uncomfortable to the human eye. This validation evaluates the short-term (Pst) and long-term flicker (Plt) and compares the values to a standardized limit-emission curve (IEC 61000-3-7©).
- **Harmonic constraint** – The total harmonic distortion of the installation is calculated and compared to the standard admissible value based on the context. A user-defined harmonic spectrum can be specified when inverter-based generation is studied.
- **Voltage rise** – For generation units, a voltage rise check is performed to ensure the voltage at any point on the network does not rise beyond the percentage set by the user.

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Load Relief DER Optimization

Quickly determine the best sites and sizes for energy storage systems and dispatchable generation

Distributed energy resources (DER) are reshaping the grid. For electric utilities, this translates into an increasingly complex ecosystem where both the regulatory landscape and the customer expectations are evolving. Also, these technology-driven changes generate new opportunities to innovate and build a grid of the future that depends less on traditional capital expenditures. The CYME Load Relief DER Optimization module equips engineers with a tool to efficiently design non-wires alternatives to mitigate capacity issues on critical grid assets.

An increasing number of utilities is being requested to systematically evaluate non-wires alternatives against traditional solutions when planning for significant capital expenditures which are essential to maintain and improve grid performance. While the engineering analyses standing behind traditional solutions have been mastered for several decades, the technical know-how required to optimally site and size utility-scale generation and energy storage systems generally remains a highly specialized expertise.

The Load Relief DER Optimization module helps engineers with the evaluation of load relief projects using battery energy storage systems (BESS) as well as dispatchable and non-dispatchable generation.

The module bundles two distinct algorithms, one for the optimization of BESS and dispatchable generation and one for the sizing of non-dispatchable generation.

The Dispatchable DER Optimization Analysis optimally sites, sizes and sets the converter controls of BESS and dispatchable electronically-coupled generators (ECG) with the objective of reducing the loading on strategic grid assets. Simulation results unfold in a variety of outputs including summary and detailed reports, as well as heat maps highlighting optimal sites for BESS and dispatchable ECG.

The Non-Dispatchable DER Sizing Analysis determines the required generator size to mitigate assets overloads. The analysis supports up to three different types of technology simultaneously (e.g. PV, wind energy conversion system, etc.) and handles each technology's specific behavior. In terms of results, the analysis provides, for each asset experiencing an overload over the simulation period, the required active power generation to mitigate user-defined levels of overload occurrences (e.g. 70%, 95% and 99% of overload occurrences).

The Load Relief DER Optimization module turns weeks of engineering into minutes of computation and supports utilities in the modernization of their planning framework, an unavoidable step towards the alignment of their practices with the climate and clean energy goals of the 21st century.

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Efficiently design non-wires alternatives to mitigate capacity issues on critical grid assets.

Dispatchable DER Optimization

The primary objective of the analysis is to shave overloads at a user-defined device. Its simulation parameters include:

- An adjustable loading level target for the critical asset under mitigation
- The selection of a single-phase or three-phase converter
- The possibility to pre-select available BESS and ECG sizes
- The ability to define several BESS attributes, converter settings and lifetime parameters, such as:
- BESS minimum and maximum state of charge, efficiency, degradation, etc.
- Converter efficiency and losses
- Device lifetime and expected system load growth
- Multiple optional constraints to discard impractical installation locations
- A customizable multi-objective function for location score calculation based on new and legacy abnormal conditions

Non-dispatchable DER sizing

The primary objective of the analysis is to remove a user-defined amount of overload occurrences at each device of a network. Its simulation parameters include:

- The possibility to use different generation profiles (e.g. PV curves with and without cloud cover)
- The ability to perform the analysis for up to three different technologies or generation profiles simultaneously
- Three user-defined levels of mitigation performance (e.g. solve for 70%, 95% and 99% of overload occurrences)

Accurate BESS modeling

The BESS model is composed of many different components. The main part is the battery module that stores the active power and transfers it by charging or discharging the battery cells using internal DC/DC converters controlled by the battery management system. Power is then transferred to the AC side by the AC/DC converter. Using the capability of the converter, reactive power can be transferred in both directions, to and from the grid.

The amount of power that transits in both directions (charging/consuming and discharging/generating) is managed by the storage controller that determines, depending on its control settings and on network measurements, how much active and reactive power must be transferred to/from the network.

Several control types are supported, including power monitoring, DER monitoring and volt-var controls, to name a few.

Meaningful results at your fingertips

Beyond optimal locations, sizes and converter settings, the simulation results unfold into a variety of intuitive outputs including summary and drill-down reports, as well as heat maps highlighting the best sites for integrating BESS and dispatchable ECG.

The module can be used alone* or can leverage the power of the Steady-State Analysis with Profiles module to automatically determine the maximum energy demand and time parameters of the overloaded device.

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.

*the CYME Distribution Analysis base package (CYMDIST) is required.

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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Predictive and Historical Reliability Assessment

Assess the reliability of electric distribution networks

The Predictive and Historical Reliability Assessment module of the CYME power engineering software computes reliability indices for the overall system and their corresponding protection zones, as well as customer point indices. The predictive model can be calibrated based on historical data. The module is fully integrated in the CYME software and provides a high degree of flexibility for analyzing distribution system configurations.

This add-on module is designed to aid distribution engineers in assessing the reliability of electric distribution networks. The program computes a set of predictive reliability indices for the overall system and their corresponding protection zones such as MAIFI, SAIFI, SAIDI, CAIDI, ASAI, ENS (Energy Not Supplied), AENS and LEI. It also computes customer point indices such as the frequency of interruption, the duration, etc., for each customer. The module can calibrate the predictive model based on historical data. This functionality is very handy to adjust the failure rates and repair time for the overhead lines and cables in order to match the simulated model with historical indices.

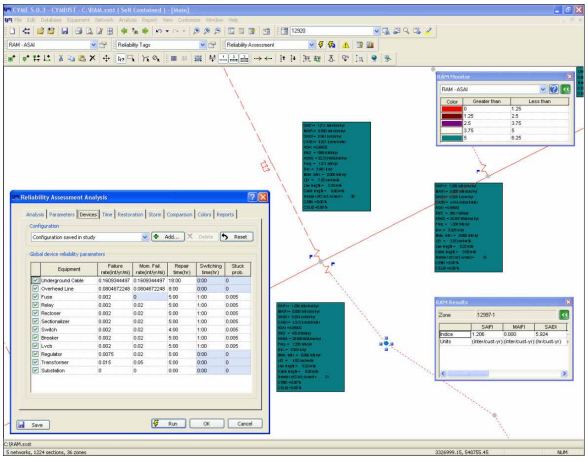
With it you can also display all historical failure data on the diagram and color code it based on the number of outages, the causes, the type of failures, etc.

Reliability System Data

In addition to the equipment data already modeled in the CYME software (ratings, impedances), the outage data for the different components are to be specified as follows:

- Failure rate (sustained and momentary)
- Repair time
- Switching / isolation time
- Stuck probability (on protective and switching devices)

The outage data can be computed and calibrated (adjusted) using historical data and can be furthermore modified graphically in various ways to reflect (for example) the impact of a tree trimming campaign by defining environmental factors that affect failure rates, and repair times at specific locations.



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Predictive and Historical Reliability Assessment

Assess the reliability of electric distribution networks.

Calculation of the Reliability Indices

Using either historical data or user-defined failure data the program can compute the different system and load point indices taking into consideration the re-closing scheme (fuse saving or fuse clearing) and the re-closer settings (single-phase trip, three-phase trip, individual phase lock-out, all phases lock-out, etc.).

Restoration may be enabled by using the pre-contingency load flow. The automation of some switching devices will impact the restoration time.

Indices are automatically calculated at the feeder level, zone level (start of a protected zone) and customer level.

The network one line diagram can be color coded based on any of the computed indices as a reference.

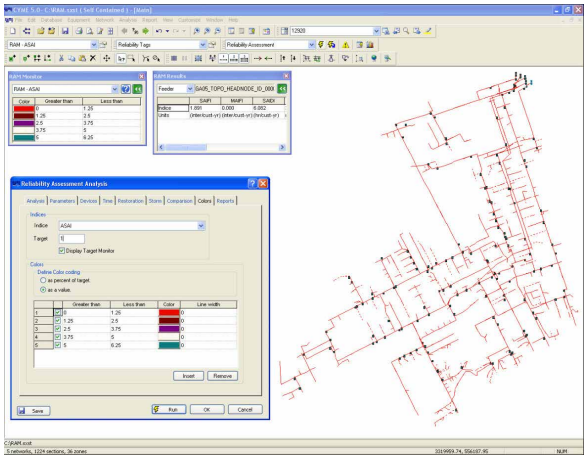
This allows the visual identification of areas where the number of interruptions or the outage time exceeds the predefined standard limits.

It also features a mode to compare the results of two studies and present the differences graphically. This allows the user to evaluate the improvement in reliability due to the installation or relocation of equipment, effect of tree trimming, etc. as compared to the base case.

What-If Scenarios

The module provides a high degree of flexibility for analyzing various distribution system configurations ("what-if" scenarios). The effects of network modifications can be analyzed to measure the improvement in reliability indices. The reports include numerous graphics showing the reliability indices by color as well as customizable tabular reports.

Reliability assessment has become more important for utility planners in recent years. Improved service reliability might be motivated by government regulation or by market competition, but providing superior service at an attractive price is in the interest of both the utility and the customer.



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Harmonic Analysis

Perform frequency scan, and voltage and current distortion calculations on balanced and unbalanced systems

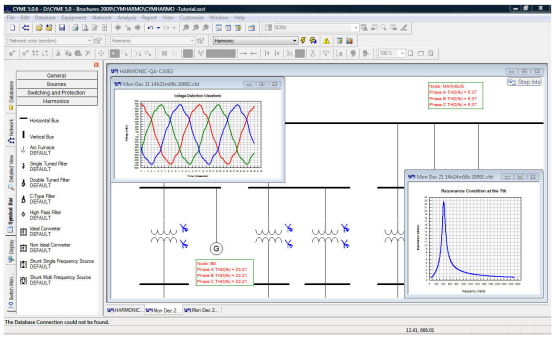
The number of electronic devices and other non-linear loads that are connected to the power system generate harmonics which affect the quality of the power to the end customers. Capacitors, which are installed to improve the system voltage and reduce losses, can create resonance if their location is not optimal. Such harmonic distortions, if un-mitigated, have a detrimental effect on the power quality as they can cause equipment malfunction, overheating of equipment and increase power losses.

The Harmonic Analysis module is an indispensable tool to help engineers evaluate the harmonic level of their electrical network and to assess different mitigation methods.

It features a number of analyses such as frequency scan, voltage and current distortion calculations, capacitor rating and filter sizing analysis, and K-Factor and Factor-K calculations. The module allows the user to model non-linear loads and other sources of harmonic currents such as converters and arc furnaces and toeasily detect resonant frequencies due to capacitor banks. With its many modeling and analytical capabilities, the Harmonic Analysis module makes it possible to accurately evaluate the impact of non-linear loads on the electrical network.

The module features both single phase and full three-phase modeling capabilities, with the flexibility to make the program easily adaptable to utility-type grids, industrial power systems and distribution feeders of any configuration. It utilizes state-of-the-art sparse matrix/vector methods with a three-phase nodal admittance network matrix representation. The Harmonic Analysis module uses the CYME robust load flow algorithm to obtain the fundamental frequency current and voltage system profile for harmonic distortion calculations and waveform display.

The Frequency scan capability included in this module is also available as an independent module. This analysis provides full impedance scan results and allows the user to see problematic areas even before installing harmonic devices.



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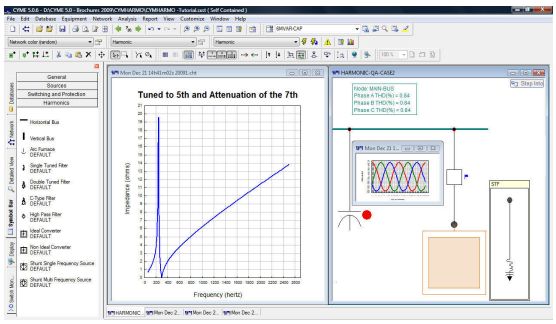
Harmonic Analysis

Perform frequency scan, and voltage and current distortion calculations on balanced and unbalanced systems.

Analytical Capabilities

- Phase or sequence analysis
- Driving point and transfer point frequency scan analysis
- Harmonic voltage distortion analysis
- Harmonic current distortion analysis
- Calculation of telephonic interference indices (TIF, IT, etc.)
- Evaluate system sensitivity level
- Harmonic cancellation
- System detuning via filter sizing
- Capacitor stress analysis
- Skin effect modeling
- User defined distortion limits or as per IEEE 519™ 1992 standard
- Selection of line/cable models: series R-L, nominal PI, transposed and un-transposed distributed parameters, and frequency-dependent
- Selection of load models: (Parallel R-L, Series R-L, CIGRE C-Type, etc.)



Capacitor Stress and Filter Sizing

The Harmonic Analysis module features stress analysis of capacitors, including those incorporated in filters, to help engineers determine whether the capacitors are rated properly according to user-defined or IEEE standard limits.

Likewise, fundamental resistor losses, fundamental and harmonic current through the reactance, and fundamental and harmonic voltage through the capacitor of filters are calculated to help engineers determine if the filters are sized properly.

Transformer K-Factor Calculation

The Harmonic Analysis module also offers the Transformer K-Factor (ANSI/IEC) and Factor-K (BS) calculation for the assessment of transformer rating with respect to the harmonic level of the system.

Equipment Library

Users can model multiple types of harmonic sources to assess the effectiveness of filters and modify them at will in order to attain acceptable level of harmonic distortion indices on your network.

Our extensive library includes equipment such as:

- Ideal and non-ideal converters
- Generic single or multiple frequency current and voltage source models. This includes a library of drives with typical harmonic spectrum as per IEEE 519.18™
- Arc furnace model
- Passive shunt filter models comprising single tuned, high-pass, double tuned and C-type
- Library of single phase and three-phase transmission line and cable models, series R-L, nominal PI and distributed parameters
- Synchronous and induction motor models
- Single phase and three-phase transformer models allowing harmonic cancellation through their phase shift angles
- Modeling harmonic sources of nonlinear loads and power electronics equipment
- Static load modeling: parallel R-L and CIGRE C-Type
- Series and parallel RLC branch circuits to create any user defined equipment

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Network Configuration Optimization

Reconfigure the network to an optimal topology through switching

One of the ways to optimize radial networks is achieved through changing the status of switching devices. The reconfiguration brings utilities economical gain by realizing energy savings, and it can also provide the networks more capacity to handle contingency situations.

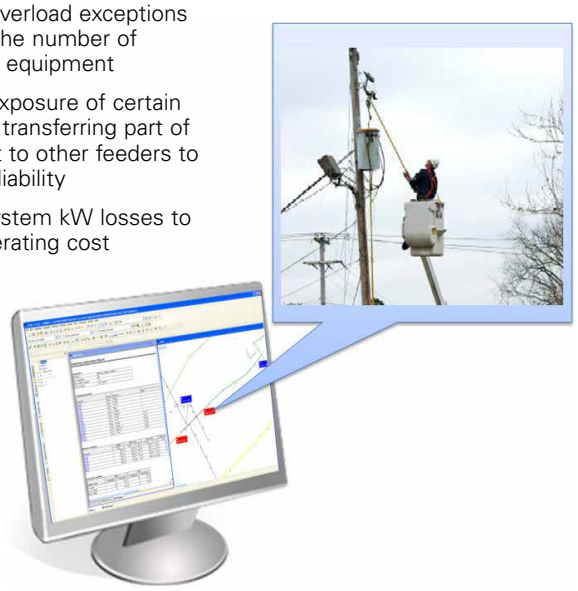
The Network Configuration Optimization module of the CYME software helps you determine possible network configurations to obtain an optimized distribution system.

It has always been a challenging task for utilities to ensure electricity supply with the current infrastructure while keeping the costs low. As engineers contemplate options such as capacitor placement and Volt/VAR optimization to yield a more optimal outcome from the system's assets, other solutions exist as a first step to reducing electricity cost while minimizing the impact on capital use. Reconfiguring the network through switching is one such solution.

The Network Configuration Optimization module is an additional module to the CYME power system analysis software designed to provide engineers with switching plans to obtain optimal network topologies.

The reconfiguration of networks often brings benefits such as reduction of power losses and voltage violations counts. The module offers the following different objectives:

- Perform load transfer studies to determine how loads can be transferred from a heavily loaded substation or feeder to another through tie-points
- Minimize voltage exceptions to reduce the number of voltage violations
- Minimize overload exceptions to reduce the number of overloaded equipment
- Limit the exposure of certain feeders by transferring part of their circuit to other feeders to improve reliability
- Improve system kW losses to reduce operating cost



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Network Configuration Optimization

Reconfigure the network to an optimal topology through switching.

Customizable Analysis

The analysis can be customized with user-specified constraints to give the best-suited results.

Constraints that can be specified include:

- Maximum/minimum limits for a switching recommendation
- Maximum loading limits for each type of equipment
- Voltage limits
- Selecting which switching devices to operate during the analysis

Besides suggesting an optimal network topology by switching existing devices, the analysis can also recommend optimal location for new tie points.

With the module's many options, users can easily simulate what-if scenarios to compare outcomes of different combinations of objectives and constraints.

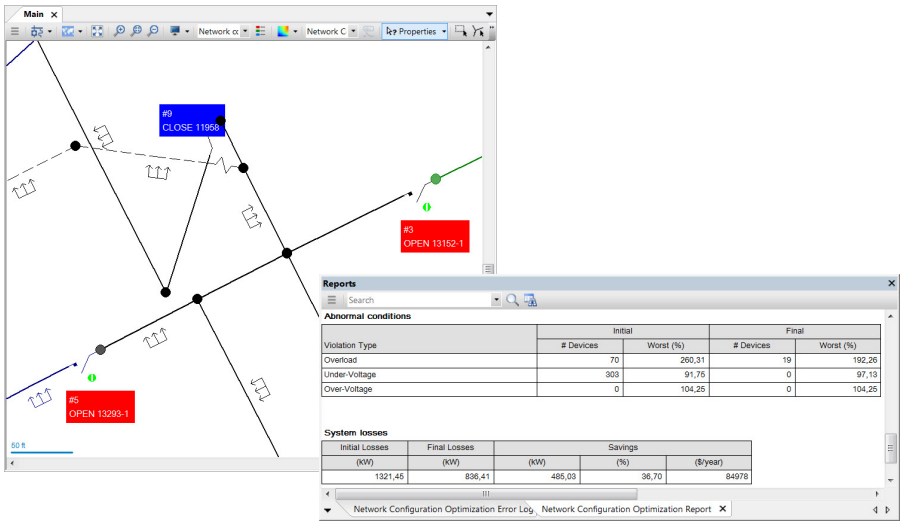
Illustrative Results

Results are presented both graphically and in reports to help evaluate the proposed solution.

After the simulation, tags displayed on the one-line diagram let you visualize clearly the switching operations proposed.

The comprehensive report provides:

- Detailed listing of the switching operations recommended
- Network summary on loading, kW losses and network length for both before and after the recommended switching operations
- Overloaded equipment count for the initial and final network configurations
- Number of voltage violations for the initial and final network configurations
- Evaluation of the annual cost of system losses



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Volt/VAR Optimization

Optimize your Distribution Network through Volt/VAR Management

To sustain the energy supply expansion utilities are now looking into emerging smart grid technologies in order to find methods to optimize their network. The CYME Volt/VAR Optimization module is a powerful tool that helps find the optimal way to operate distribution network such that the need of today's and tomorrow's demand can be met through energy efficiency improvement and demand reduction.

The Volt/VAR Optimization (VVO) analysis module simulates a Volt/VAR management application. Simulating such a system gives crucial information such as the switching of capacitors and optimal tap positions of voltage regulators and LTC's leading to loss and demand reduction. Utilities can know beforehand how much their network can be improved taking into account power factor, kvar constraints, voltage limits and varying loading conditions.

The CYME Volt/VAR Optimization module capabilities include:

- Conservation Voltage Reduction (CVR) analysis
- Var optimization analysis
- Capacitor priority sequencing by defining capacitor switching priority
- Multiple power system constraints
- Single load scaling factor or multiple load scaling factor
- Economical benefits evaluation
- User-defined voltage profile charts and tabular reports

Include the CYME Volt/VAR Optimization module in your distribution planning to achieve a more efficient and reliable network.

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Volt/VAR Management

Optimize your Distribution Network through Volt/VAR Management.

CVR and VAR Optimization

The CYME Volt/VAR Optimization module can perform:

- VAR Optimization
- Conservation Voltage Reduction (CVR)

The conservation Voltage Reduction objective is contrary to the normal approach of operating Volt/VAR control devices individually. It recommends concurrent device settings for shunt capacitors, load tap changers and voltage regulators all at the same time to recommend the optimal settings for the devices.

Multiple System Constraints

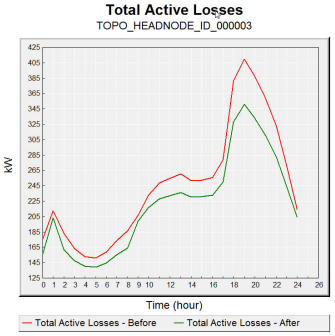
Optional constraints can be applied to a given simulation such that the analysis considers them when making a setting recommendation. Constraints include:

- Minimize active power demand
- Minimize active power losses
- Remove abnormal conditions
- Power factor constraint at substation or at multiple selected devices
- Reactive factor constraint at substation or at selected devices

Load Factors and Capacitor Sequencing

A single load factor or a user-defined load scaling table can be used. With multiple load scaling factors, capacitor bank sequencing can be selected to meet the varying power factor needs.

Through illustrative charts and reports, the CYME VVO analysis module will provide a much more comprehensive Volt/VAR control device management to help you find viable ways to save energy.



Economic Benefits

The reduction in active power generation and the decrease in active power loss brought by the VVO module are both measurable.

Initial Cost		Final Cost	
kWh	k$ / Year	kWh	k$ / Year
2100000	100560	2046000	95620

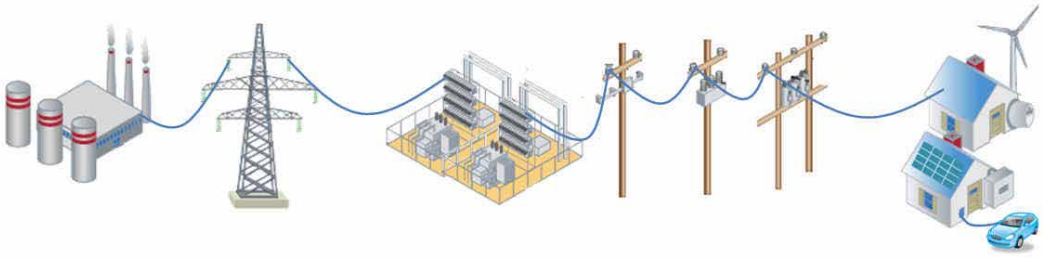
With the CYME software, VVO case studies can be built and the annual savings of different scenarios compared.

Equipment operating beyond their nominal ratings, risk failure and a shortened lifespan. Since the VVO module helps alleviate overloading conditions, installations of new equipment can be postponed and maintenance cost reduced, resulting in further savings.

Real-time Simulation with CYME Server

The CYME Server solution* offers a complete Service Oriented Architecture solution that is embedded into your enterprise applications. It is possible to perform quasi real time Volt/VAR management studies to quickly respond to any network change.

** See our CYME Server – Real-Time Engineering Analysis brochure*



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Optimal Voltage Regulator Placement

Install your voltage regulators at optimal locations on your distribution feeder

The necessity to maintain voltage within specified limits has always been an essential part of distribution planning. Among the solutions commonly used is the installation of voltage regulators. To help engineers tackle this problem efficiently from both an economical and technical point of view, CYME offers the Optimal Voltage Regulator Placement module.

Handling the challenge of voltage regulation

Distribution engineers seek to maintain and improve the power quality of the distribution network to deal with the ever increasing demand. Distribution generators, different load characteristics, single-phase sections and unbalanced lines all contribute to the complexity of the voltage regulation problem.

Keeping the voltage within specified limits has the benefit to reduce energy losses and to prevent voltage collapse. A flatter voltage profile also helps achieve power efficiency improvement.

Common techniques employed include network reconfiguration, phase balancing, placing shunt capacitors and voltage regulators on the network.

Optimal Voltage Regulator Placement

Placing voltage regulators on the network is not always an easy task. Selecting the regulator location, setting its tap position and determining the amount of regulators required while making sure the solution achieves energy cost savings or a flatter voltage profile can be a challenge.

The CYME Optimal Voltage Regulator Placement module handles the complexity of the problem to give engineers one simple and indispensable tool to achieve voltage regulation efficiently.

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Optimal Voltage Regulator Placement

Install your voltage regulators at optimal locations on your distribution feeder.

Robust Calculations

Using the robust CYME Load Flow Analysis, the module provides a weighted-objective optimization technique that allows to:

- Flatten voltage profile at a specified target voltage and to minimize abnormal conditions
- Minimize active power losses

The Optimal Voltage Regulator placement provides two algorithms:

- Sequential Search – find optimal location for one regulator at a time
- Iterative Search – An exhaustive analysis which evaluates each possible location to give the overall best solution

Features

To make the analysis more comprehensive, multiple user-defined options are available:

- Install single or multiple regulators
- Install different types of regulators
- Specify search distance for the addition of a regulator
- Include or ignore existing regulators
- Evaluate locations downstream to feeders, specific sections or specific nodes
- Define voltage regulator control settings
- Set user-defined constraints such as under- or over-voltage limit margin, maximum buck and boost limits, ignore sections or laterals

The Optimal Voltage Regulator Placement module is centered on robust algorithms and used-defined criteria to provide users with results that are both trust-worthy and operationally acceptable.

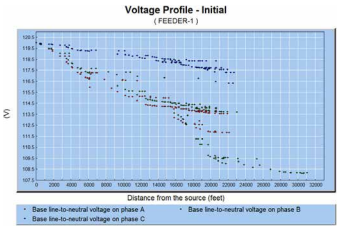
Customization of the reports is possible to allow:

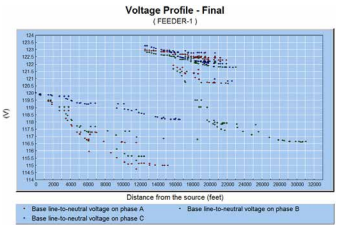
- The results display of the optimal solution, of all tested solutions or of a maximum number of solutions
- Show active power losses for each result displayed
- Report abnormal voltages count for each result displayed

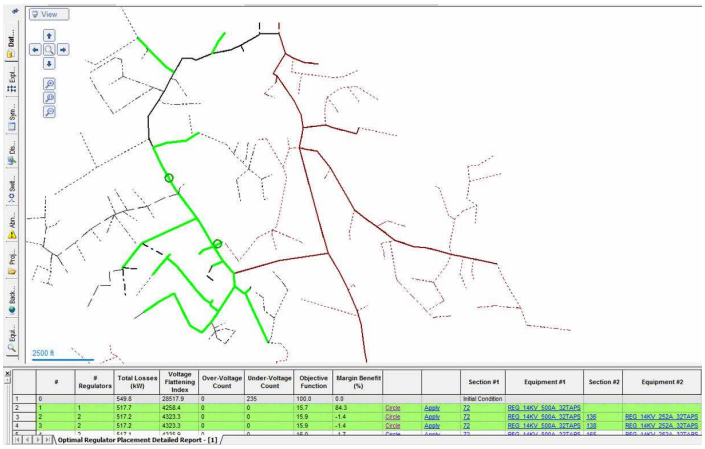
Charts and display on the one-line diagram are other means to help visualize the results.

The user can display the voltage profile chart of the initial network and that of the best solution to see whether voltage regulation is achieved as expected.

The one-line diagram can be color-coded to highlight evaluated sections. The voltage regulator suggested by the module can be applied to the network via buttons in the report.







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CYME
Power Engineering Software and Solutions

Optimal Recloser Placement

Improve network reliability by placing reclosers at optimal location

One of the major concerns for distribution planning is to achieve and improve system reliability while meeting different constraints. A common practice is to install reclosers. Engineers can use reliability indices to decide where to install the additional protective devices, but such evaluation may not yield the most beneficial outcome. The Optimal Recloser Placement Analysis module offers a comprehensive assessment and proposes solutions that correspond to your criteria.

Improving reliability – a challenging decision

System reliability is an integral part of distribution system planning and operation. Growing energy demands, aging infrastructure and network expansion are among the factors that influence system reliability.

Outages cannot be prevented, and the amount of failures has a direct impact on end-customer satisfaction and the cost of electricity. Hence, it is imperative to maintain a good level of network stability.

A popular reliability improvement strategy involves the addition of protective devices, particularly the addition of reclosers. With proper analytical tools, engineers can obtain reliability indices that would give them an idea of the locations at which an improvement is needed.

However, engineers are often bounded by limited capital spending. It then becomes important to make sure the investment yields the most beneficial return. Placing the reclosers at optimal locations is considered a challenging and yet a vital decision in distribution planning.

Optimal Recloser Placement

The Optimal Recloser Placement analysis module was designed to help engineers handle the complexity of the system reliability improvement issue.

The analysis is built upon the robust CYME Reliability Assessment module (required). It takes into account different objectives and criteria, studies the reliability indices, evaluates the expected improvement and finds the best solution.

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Optimal Recloser Placement

Improve network reliability by placing reclosers at optimal locations.

Comprehensive Analysis

The Optimal Recloser Placement analysis offers a weighted-objective optimization technique which improves:

- SAIDI (System Average Interruption Duration Index)
- SAIFI (System Average Interruption Frequency Index)
- User-defined criteria based on CYME keyword expressions

The analysis also provides two optimization methods:

- Sequential Search
- Iterative Search

Features

The analysis is designed to take into consideration a wide-range of user-defined criteria:

- Define the number of reclosers
- Specify a searching distance for the possibility of adding a recloser
- Evaluate locations downstream to feeders, specific sections or specific nodes
- Choose the recloser to be used from the equipment library
- Choose operation mode and define reclose settings
- Include user-defined constraints (ex: loading limits, distance between reclosers, etc.)
- Ignore specific locations

Meaningful Results

As all other CYME analyses, the Optimal Recloser Placement analysis generates results in report formats.

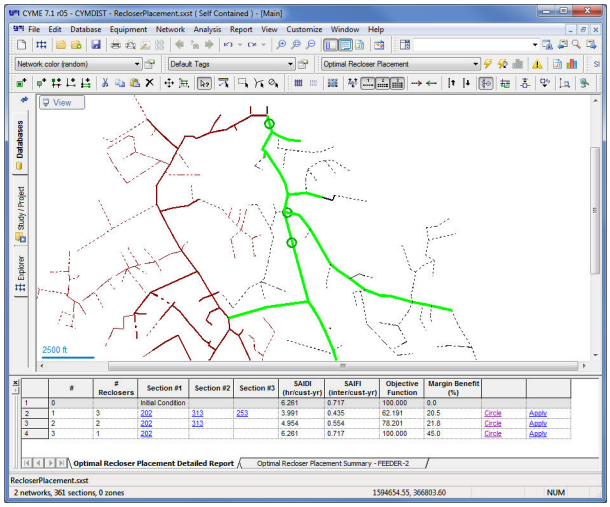
Reports include:

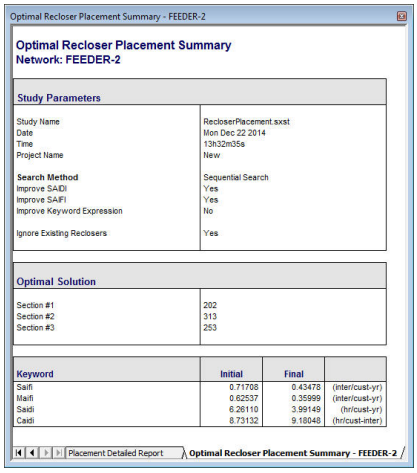
- Summary report which summarizes the reliability indices of the initial network compared to the optimal solution network
- Detailed report which gives details on each recloser to be added
- Reliability assessment reports

Options are also available to customize these reports.

Another mean to help users visualize the results is their display on the one-line diagram.

Users can choose to highlight the evaluated sections via color-coding. Suggested reclosers can be applied to the network via buttons in the report.





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Steady State Analysis with Load Profiles

Perform accurate time range analysis based on AMR, historical and real-time data

New tools are necessary to help distribution utilities exploit the integration of automated meter reading (AMR) in distribution systems, short-term load forecast calibrated by AMR telemetry and energy billing records.

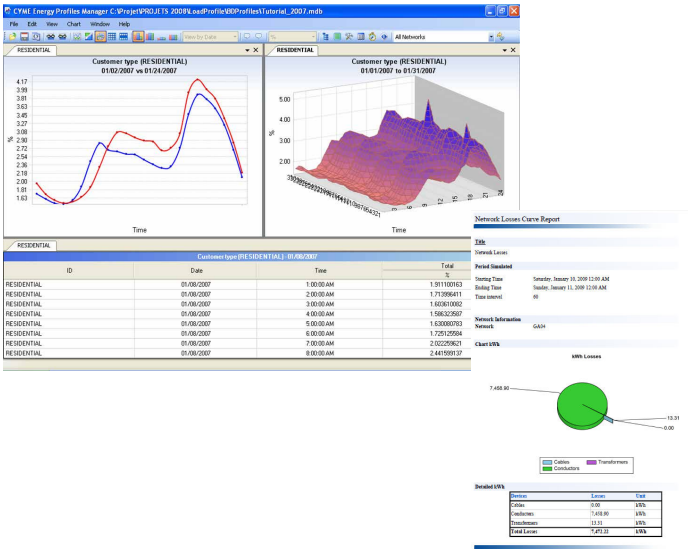
The CYME optional module Steady State Analysis with Load Profiles assists users in performing accurate time range analysis based on a combination of AMR data and historical consumption patterns.

Program Features

The module comes with its own user interface and wizard for the optimal viewing, editing and importing of load profiles and demand profiles.

More specifically, the module:

- Allows the creation of curves (load profile) for customers whose load is measured. The curves can also represent a typical load such as customer types, a meter reading or a network demand. The user can also input generation curves.
- Facilitates the import of interval (15 min, 30 min, 60 min) and non-interval (monthly kWh) metered data such as automated meter reading systems, customer billing information systems. This metered data along with load behavior studies data can be used for load flow analysis.
- Simplifies the creation of profiles by proposing templates for the standard profile types such as the "8760 hour profile" and "day-type" (Typical week-day and week-end)
- Supports the import of profiles from ASCII format (.csv)
- Supports various units for the profiles: Average Demand kW, Amps-PF, kW & kVAR, kVA & PF, %, p.u. (by-phase or total)
- Provides the functionality for the creation, viewing, and editing of profiles. The profiles are available in tabular and graphical form
- Provides a tool to import and synchronize the devices that are kept in the CYME databases
- Allows the visualization of 2D, 3D and isoline plots
- Supports the creation of profiles for holidays and special days



Powering Business Worldwide

Steady State Analysis with Load Profiles

Perform accurate time range analysis based on AMR, historical and real-time data.

Load Flow with Profiles

The Steady State Analysis with Load Profiles module includes a Load Flow with Profiles analysis functionality that utilizes the data organized with the module. When running a voltage drop simulation for a specified period, it produces significant information for the system planners about the network conditions.

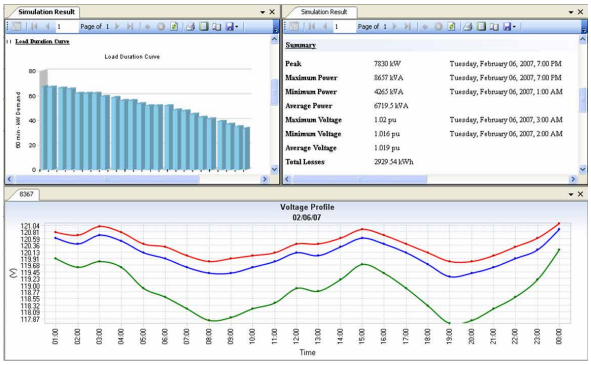
This analysis allows the users to:

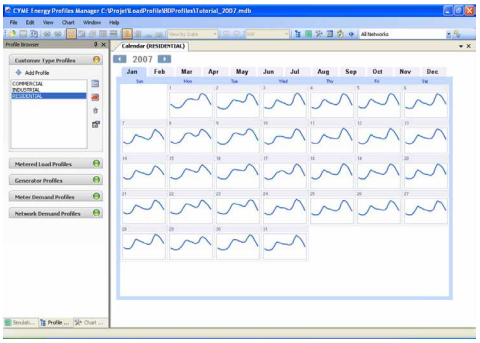
- Run a load flow analysis as a day-type or as a time-range simulation
- Use of historical data to validate the network model
- Accurately model the loading conditions (load curves) at any moment in time at critical points on the networks
- Identify off-peak overloads and abnormal voltage conditions that often go undetected using typical peak condition system analysis
- Evaluate actual load using customer consumption curves (Billing information) or customer typical load curves
- Validate device setting adjustments such as voltage regulators, switching capacitors and load tap changers considering load variation over a period of time
- Confirm the recommended capacitor placement analysis results considering load variation over a period of time.

Charts and Reports

Using the Load Flow with Profiles analysis functionality, the user can generate several reports and charts based on monitored device and summary networks results. Users can generate reports and charts such as:

- Network summary reporting total system losses, peak voltage and peak power
- Abnormal conditions reporting overloads and abnormal voltage conditions in duration and percentage of a period, such as the number of hours/ days that an equipment has been overloaded
- Tabular reports with customized values for monitored devices
- Load duration curves for a distribution transformer or any monitored devices displaying the loading of the device in percentage





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Long-Term Dynamics Analysis

Study the impact of irradiance variations, wind fluctuations and load variations on network controls.

The growing demand for renewable sources of clean energy has significantly increased the presence of wind and solar power supplies for power generation portfolios. Utilities are now facing the challenge of managing variable sources of energy interconnections to the grid. To prepare for increased penetration levels and to plan the deployment of Distributed Generation Resources (DER), new simulation tools are needed.

The CYME Long-Term Dynamics Analysis module offers a time-series simulation tool to study the impact of irradiance variations, wind fluctuations and load variations on network controls such as regulators, load tap changers and switched capacitors, and on the behavior of battery energy storage devices.

Long-Term Dynamics – Analysis for Distributed Energy Resources

The intermittency of wind and cloud-over periods alters the output of wind energy systems and photovoltaic (PV) generation. By analyzing the impact of such variations on regulators, load tap changers and capacitor switching, the Long-Term Dynamics Analysis allows power engineers to properly assess the impact of DER integration and to better understand related technical issues such as var control and voltage regulation.

The module also allows the study of reserve capability of any battery energy storage device.

Sun Radiation, Wind Speed and Load Profile

A curve library is included in the CYME software to allow the user to create their own long-term dynamics curve models along with generation curve models and motor curve models. The Long-term Dynamics Analysis module uses the following curves:

- Insolation
- Wind speed
- Load
- Generation
- Motor

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Long-Term Dynamics Analysis

Study the impact of irradiance variations, wind fluctuations and load variations on network controls.

Accurate Equipment Modeling

Detailed distributed generator models, such as wind energy conversion systems (WECS), are available. The CYME software features a detailed PV system model for which the output function is represented by manufacturer data such as:

- Insolation curve model
- Current at maximum point
- Voltage at maximum point

Evaluating System Impact

With the Long-Term Dynamics Analysis module, time-series simulations can be performed to assess how the DER output profile affects:

- Voltage regulators
- Load tap changers
- Capacitors

The user can specify the activation time delay, tap changer delay and mechanism delay data of the regulators and LTCs tap changing algorithm in order to prevent unnecessary switching due to voltage fluctuations. Time delays are also available for shunt capacitors and switchable shunt banks to specify closing and tripping delays. The user also has the option to start the analysis at any moment in time (other than zero) in order to include time-controlled capacitors in the analysis.

Voltage regulators have four reset modes: fast, induction disc, delay and delay freeze reset.

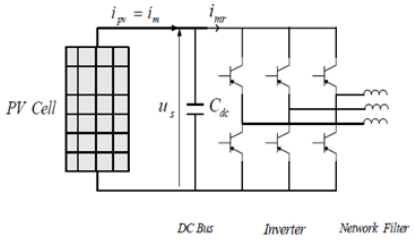
The presence of battery energy storage systems has increased to support the importance of DER integration and to allow peak-shaving.

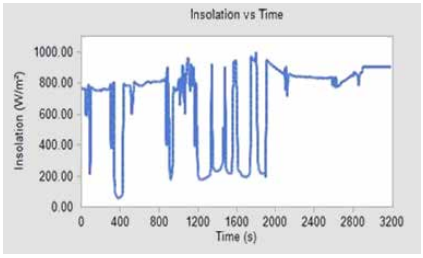
The energy storage model takes into account of charge and discharge delays, and features the following controls:

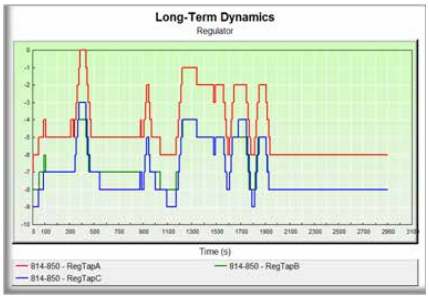
- No monitoring: time driven and load shape modes
- Power monitoring: power driven, power peak shaving, power following, power levelling modes
- DER monitoring: DER driven, DER levelling, DER support and DER smoothing modes

Time-based simulation results are illustrated in comprehensive graphs. Reports are available for device controls such as regulator tap changers, and for the penetration level of each type of distributed generation in the network. Detailed reports and charts are also available for monitored devices. Power engineers can easily evaluate the performance of the system with or without DER, determine the impact of different DER locations and evaluate the effect of different variable profiles.

The Long Term Dynamics Analysis module is a powerful tool to evaluate solar array and wind farm impacts on the power system, preparing the network for tomorrow's higher DER penetration levels.







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Transient Stability Analysis

Simulate electromechanical transients in electrical power systems

The Transient Stability Analysis module of the CYME power engineering software is dedicated to simulating electromechanical transients in electrical power systems. It features an extensive library of equipment and control models; the capability to include user-defined controls, a very flexible user-interface and powerful graphics.

The module utilizes the simultaneous implicit trapezoidal integration solution technique for network, machine and controller equations. The program supports the capability to test the step response of controllers and user defined modeling for system equipment and controllers.

The initial voltage profile of any balanced or unbalanced network is computed with balanced power flow algorithms namely the Newton Raphson or Fast Decoupled. The simulation in Transient Stability Analysis module will be for the equivalent balanced three-phase network.

Analytical Capabilities

- LLL, L-G, LL and LL-G fault application and removal
- Global setting of control parameters for generators, motors and electronically coupled generating units
- Line switching and line re-closing
- Single pole switching including line charging effects
- Load shedding and load adding
- Generation loss
- Disconnection of lines, cables and transformers
- Tripping and reclosing of protective devices
- Frequency-dependent modeling of generators
- Networks with multiple nominal frequencies
- Ability to monitor specific equipment during the simulation
- Load modeling as a function of voltage and frequency at individual bus bars or throughout the system
- Disconnection of static VAR compensator controls
- Addition and removal of shunts
- Direct on-line or assisted induction motor starting and stopping
- Direct on-line or assisted synchronous motor starting
- Automatic validation of maneuvers and their sequencing in time
- Verification of equipment and controller data
- Ability to vary the integration step during the simulation
- Ability to interrupt the simulation temporarily and restart
- Range validation for controller settings and simulation parameters

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Transient Stability Analysis

Simulate electromechanical transients in electrical power systems.

Control Model Library

The control model library of the Transient Stability Analysis module is an extensive library of dynamic models of equipment and their controls. This includes default data values of the parameters, their description and block diagrams as per published transactions and papers.

This includes control models of:

- Round poles and salient poles generators
- Modeling of excitation systems taking saturation into account, based on IEEE® standards
- Power system stabilizers
- Governor models comprising hydraulic, thermal, diesel, and gas turbines
- Detailed modeling of static-VAR compensators
- Under-voltage, under-frequency, frequency droop relays and over current relay modeling
- Impedance relay with typical circular trip characteristics including single reset time reclosing
- Induction motor models with frequency dependent modeling
- Dynamic modeling of distributed generation such as Wind Energy Conversion Systems (WECS), photovoltaic (PV cells), fuel cells and micro turbines

User-Defined Modeling

The Transient Stability Analysis module features a unique ability to supplement the existing array of control models for system equipment and controllers, giving the user the opportunity to model any desired control system using user-defined modeling.

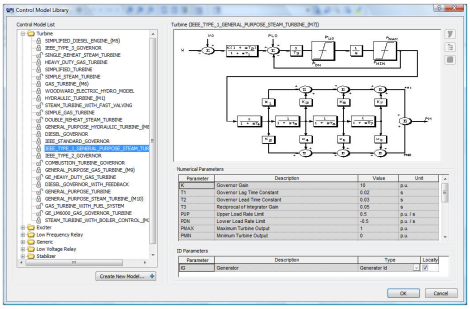
The user-defined modeling approach is based on the premise of solving the user-defined equations. The program is provided with an extensive library of elementary functions and building block controls to model any control scheme, including system-wide operations.

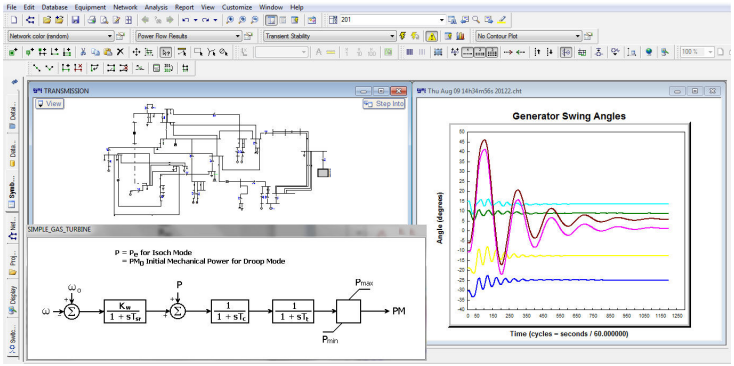
The model can be created with a simple text editor and there is no need to recompile the software to integrate the new model into the library.

The control model library is so flexible in its design that the user can create or import into the library any control model created with the built-in user defined modeling functions. This includes any model created previously for the PSAF software or any new one that the user may wish to add to the CYME software library in order to include it in any study requiring such model. In addition the user can import dynamic model block diagrams in bitmap image format.

Dynamic Modeling of Distributed Energy Resources

The Transient Stability Analysis module includes extensive modeling capability of Distributed Energy Resources (DER) equipment such as Wind Energy Conversion Systems (WECS), photovoltaic, fuel cell and micro turbine dynamics. The advanced solution algorithms provide the user with the necessary tools to carry out power system studies comprised of these types of installations.





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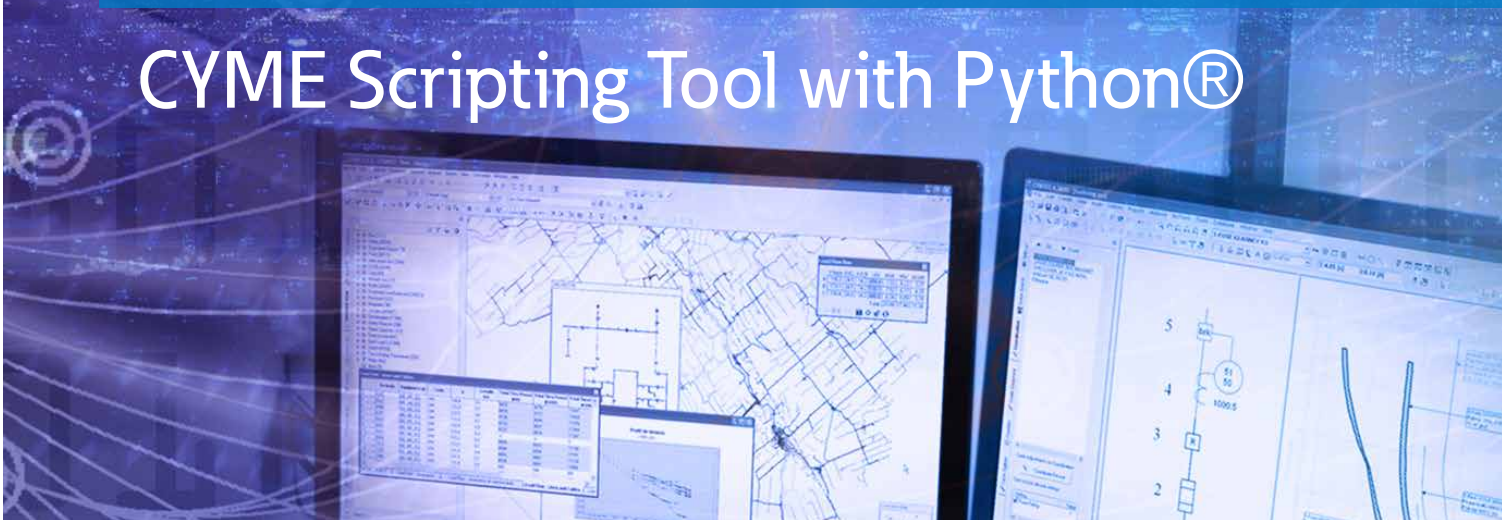
CYME
Power Engineering Software and Solutions

CYME Scripting Tool with Python®



Extending CYME capabilities through Python® Scripting

Today's fast evolving power systems require engineers to perform thorough studies for the purpose of evaluating the operation of their networks under different conditions. Although informative, some of these studies could be repetitive and time-consuming. Automation relieves engineers from any redundant and laborious procedures, and provides them the information and results required in an effortless manner.

Aiming to ease the effort required in performing several simulations by hand and to extend the customization of the CYME applications, Python® scripting has been integrated into the CYME power system analysis software.

Python scripting comes with a Site Package, a Console, a Toolbox and a built-in script editor. It can be used in a stand-alone mode or in a mode directly embedded into the CYME software.

- The Python Site Package contains all the Python modules and functions required to access network properties, manipulate equipment and devices, perform various analyses and more importantly, obtain meaningful results.
- The Console allows the users to carry out commands directly in the CYME application to allow command testing and quickly retrieve information.
- The Toolbox allows the users to add and execute scripts. Variables defined in the scripts can be accessed through the Toolbox without having the scripts being modified.
- The built-in script editor that is simple to use and includes features such as syntax highlighting, color-coding, code-completion and debug mode.

With Python scripting, users can easily perform batch analysis, automate routine studies, create new algorithms and quickly retrieve information through a simple mouse-click on a script. Take advantage of all the possibilities offered by the CYME Scripting Tool and appreciate the increase in productivity brought by the creativity of your scripts.

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CYME Scripting Tool with Python®

Extending CYME capabilities through Python® Scripting

Easy Scripting with Python®

Python is a scripting language that is open-source and cross-platform.

Unlike other programming languages, Python does not have difficult syntax and offers code completion. Its high readability combined with the CYME function names make Python easy to learn for beginners while staying powerful for experts.

Not only does it take care of exception handling, the CYME Scripting Tool with Python has also been robustly designed to provide you with the latest data model so that you can always be up to date.

Python scripting takes advantage of all the power accessible through regular expressions, along with an advanced filtering mode that comes to hand when accessing data collection.

Python® suits your needs and style

The Python Console and Toolbox allow an embedded Python usage within the CYME software for the rapid execution of several command lines and scripts.

The user can write scripts using the built-in script editor, and can as well write scripts in any text editor and execute them in a "stand-alone" way outside of the CYME application environment, via your favorite Python IDE (IDLE, Komodo IDE, Eclipse, PythonWin, PyCharm, etc.).

Extending CYME

Whether scripts and commands are run in the embedded or non-embedded way, the possibilities to extend the capabilities of the CYME software are unlimited.

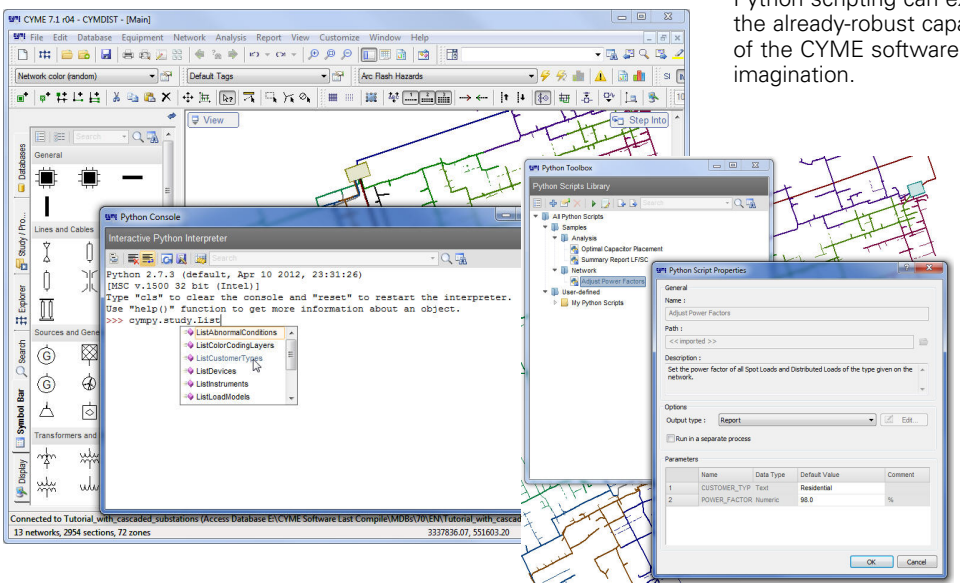
The Site Package developed offers many modules designed to be powerful and easy-to-use: network modeling, database access, equipment, and report and error management. These modules are constantly evolving to better suit the growth of the application.

Besides quickly retrieving information through several command lines or to run routine analysis through the use of scripts, the users can also create their own algorithms and write their own analysis. For example, you can create your own Load Growth analysis to modify the loads in a complex way that cannot be easily achieved with the default Load Growth analysis. Likewise, your commands can be inserted to apply modifications to the network. Charts and reports are easily customizable to display the results according to your preferences.

Several device controls and customization tools now offer embedded scripting functionalities. Scripts can now be used to define the control for capacitors, regulators, and centralized capacitor control systems. They can also be used to create custom keywords and filters.

Python's power and user-friendliness make it the ideal tool for writing any large application to suit your needs and simplify your work.

Combined with your creativity, Python scripting can extend the already-robust capabilities of the CYME software beyond imagination.



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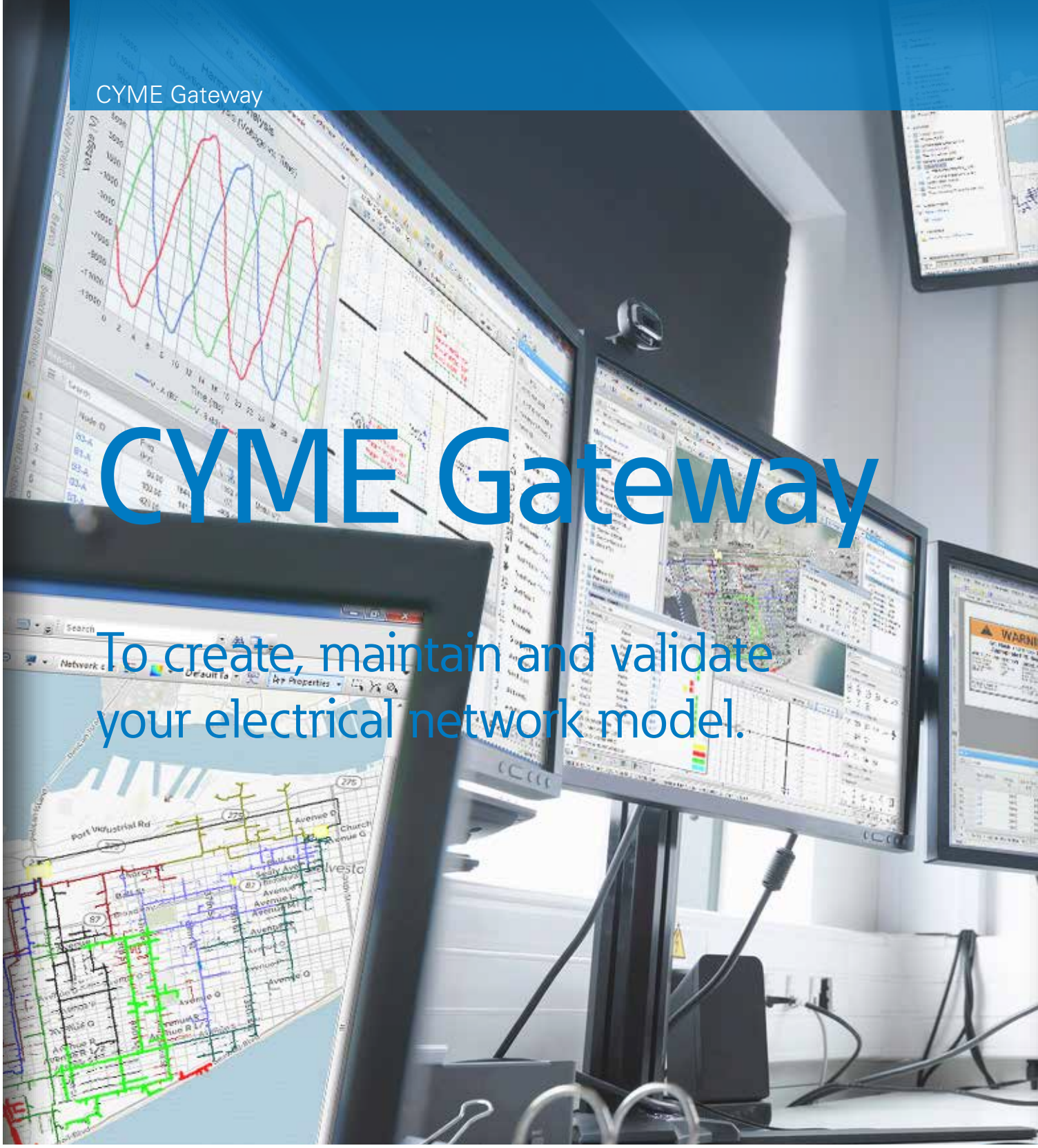

CYME Gateway

To create, maintain and validate your electrical network model.

EATON

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Ability to integrate with your enterprise systems

The ability to accurately analyze an electrical network depends heavily on the accuracy of the network model. The CYME Gateway is a complete solution which interfaces and transforms the intelligence of different enterprise systems into the most complete network model possible.

- GIS – network topology (ESRI, Intergraph, GE Small-world, in-house systems)
- AMI/AMR/MDM, CIS – load information
- SCADA – feeder demand

The resulting output is a complete, up-to-date network model in a CYME database which is ready to use for power engineering analysis in the CYME software; planning studies, reliability analysis, switching optimization, losses reduction, and more.

- DMS – dynamic settings, IED readings
- OMS – actual switch status, failure history
- Protective device data – Detailed settings of relays, reclosers, fuses, etc.

The CYME Gateway takes care of all the technical complexity in generating a reliable network model, so that you don't have to.

A solution tailored to suit your needs

The CYME Gateway also offers various optional features:

- Extract further complementary network information
  - Secondary network grids, low-voltage distribution systems, substations, load information, etc
- Automatically perform CYME analyses and data validation after network extraction
  - Network equivalents calculation, load allocation with feeder demands, etc.
- Productivity tools to improve data quality
  - Data validation, web reports, staging control tool

Each CYME Gateway is tailor-made according to each client's data sources and specifications, and our team assists you during the different project integration phases. The CYME solution combines engineering expertise and knowledge that stand behind more than 75 CYME Gateway installations worldwide.

The CYME Gateway is the solution you can trust to deliver the solid network model for all engineering analyses.

Data extraction

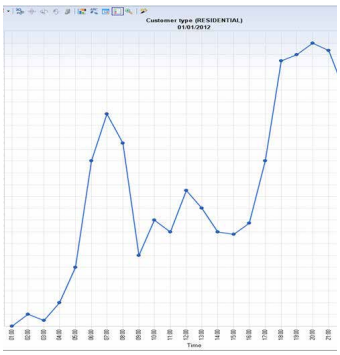
Powerful methods for extracting information to effectively model your system.

Secondary network and low-voltage distribution systems

Interfacing with the GIS system, the CYME Gateway can extend your distribution network model with the optional extraction of the low-voltage distribution system and secondary networks. This new complete model allows analysis of the highly-meshed secondary network grid as well as the secondary low-voltage side of distribution transformers.

Substations

When substation connectivity information for substations is not available in GIS, the substation models can be easily created using the CYME software. The CYME Gateway will incorporate them with the rest of the extracted networks. Complete substation models include multiple transmission line feeds, power transformers, protective devices and tie points to make the model more detailed to give more realistic analysis results.

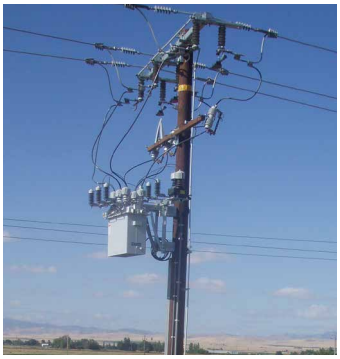


Feeder demands

The CYME Gateway can interface with systems such as the OSIsoft PI System™ to import feeder demands to be allocated in the CYME Software. The automation of feeder demand extraction from systems such as the OSIsoft PI System™ can ensure the availability of up-to-date data for meaningful system analysis.

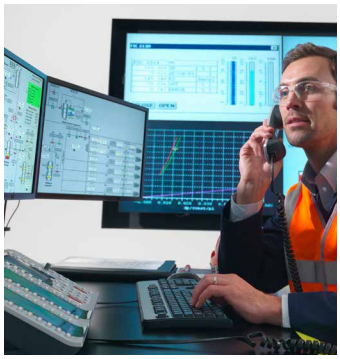
Load and customer information

Extracting from the CIS system, the CYME Gateway can provide precise information about the consumption of each load. It can also provide the detailed demands through interfacing with the AMR/AMI/MDM system. The availability of this information makes the distribution network more complete for more accurate simulation results.



Protective device settings and TCC parameters

Settings of protective devices can be extracted from various asset management systems such as ESRI ArcGIS™ and IBM Maximo®, or even your in-house system, to be incorporated into the CYME model. The availability of such information saves you time from manual data entry and makes your network ready for any protection scheme validation.

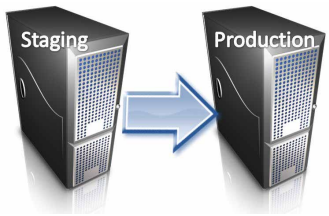


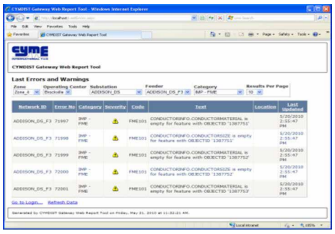
Dynamic settings

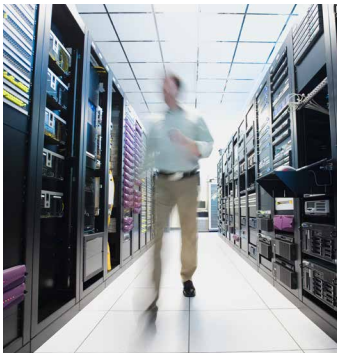
The status and settings of voltage regulating devices can have a big impact on the performance of the network, which can be reflected by simulations in the CYME software. In order to properly simulate the effect of such devices, the ability to acquire up-to-date information to better characterize them in the network model is important, and can be done using the CYME Gateway.

Productivity tools

The CYME Gateway can be tailored to meet your specific requirements.







Staging control tool

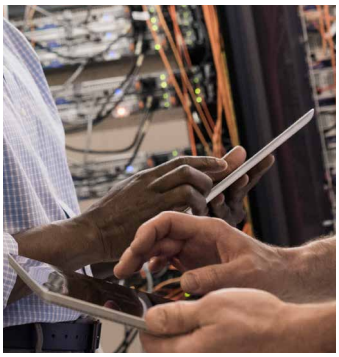
This features a Windows® desktop application to control the transfer of a CYME network model from a Staging Database to a Production Database. Based on the results from the CYME Gateway extraction process, the Staging Control Tool determines if a circuit can be moved from the Staging Database to the Production Database. Using the Staging control tool limits the shortcomings of poor data to ensure better quality control.

Web report tool

The Web Report tool displays the errors and warnings of the last extraction for each feeder. The user-friendly web-based tool allows filtering of the results such that users can easily browse through different information about problems which occurred during the latest extraction.

Parallel processing

Parallel processing improves CYME Gateway performance by allowing the extraction of multiple circuits at the same time, as well as multiple batch calculations in parallel. This capability ensures that the CYME Gateway solution is scalable for large network models.



Automated CYME calculations

The CYME Gateway can include optional components for additional calculations to be performed automatically as the network is being extracted. An example of a useful analysis to be automated is the network equivalents calculation, which computes source and load equivalents by phase for each secondary network, substation and feeder. Another example is the Load Allocation analysis, which retrieves the feeder demands from the OSIsoft PI System™ database and allocate the demand to all feeders.

Enhanced data validation

The CYME Gateway can be customized to include the Enhanced Data Validation component such that additional validation on the extracted network is performed according to customizable rules set within the CYME software. These rules can pinpoint abnormalities, missing equipments or unexpected values in order to refine the model.

Incremental updates

The Incremental update option allows updating only the circuits that have changed since the last extraction. The network model can be updated more often and in less time than using the full extraction process.

CASE STUDY 1

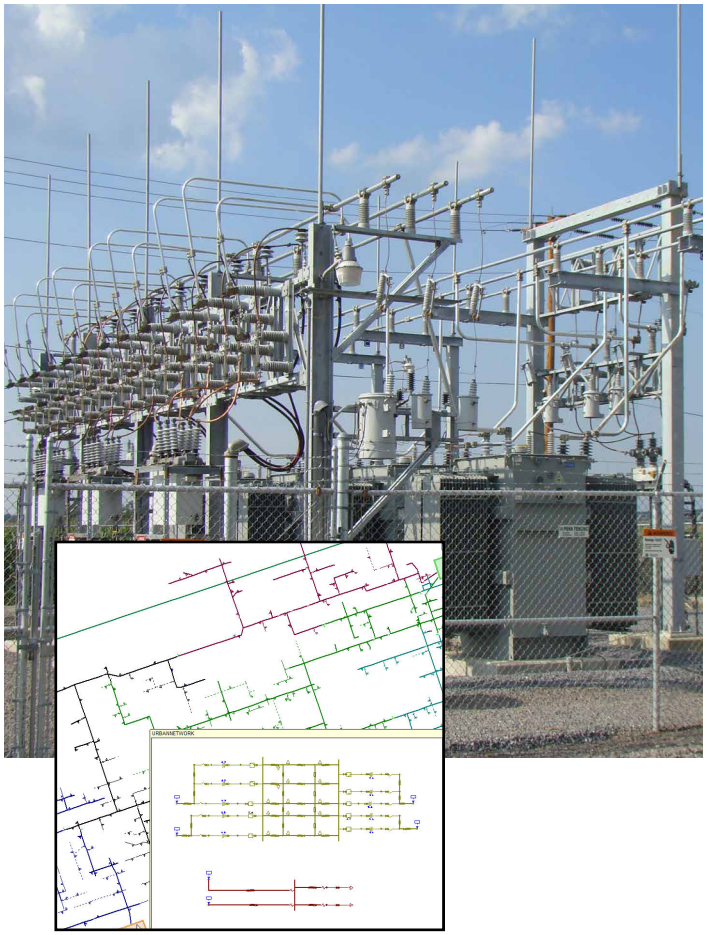
Extraction of low-voltage distribution system and secondary grids for AES Eletropaulo

In 2011, AES Eletropaulo in Sao Paulo, Brazil, acquired the CYME software for distribution system planning and opted for the CYME Gateway solution, the ideal tool to create an accurate distribution network model for analysis.

The CYME Gateway customized for AES Eletropaulo has been designed to interface with ESRI ArcGIS™ seamlessly. In addition to producing a network model of primary distribution feeders, the CYME Gateway also creates the model for the low voltage secondary distribution systems and secondary meshed grids with ring buses. The complete network topology allows AES Eletropaulo to conduct power engineering analysis with the CYME software.

"Having the option to create the LV system model allows us to perform detailed loss analysis, study DG integration impacts, and helps us solve voltage problems and optimize our very dense, heavily loaded LV system,"

said Eduardo Tadeu Mattos Mentone, Operation Systems Manager, AES Eletropaulo.



CASE STUDY 2

Integration of the substation model for Hydro One, Ontario

Hydro One, an Ontario based distribution utility who have been using the CYME software for many years, chose to model its substations directly in the CYME software. Hydro-One has approximately 200 substations, for which complete models were prepared in the CYME software through its user-friendly network editor. The CYME Gateway was customized to combine these substation models with the distribution network model created based on GIS information.

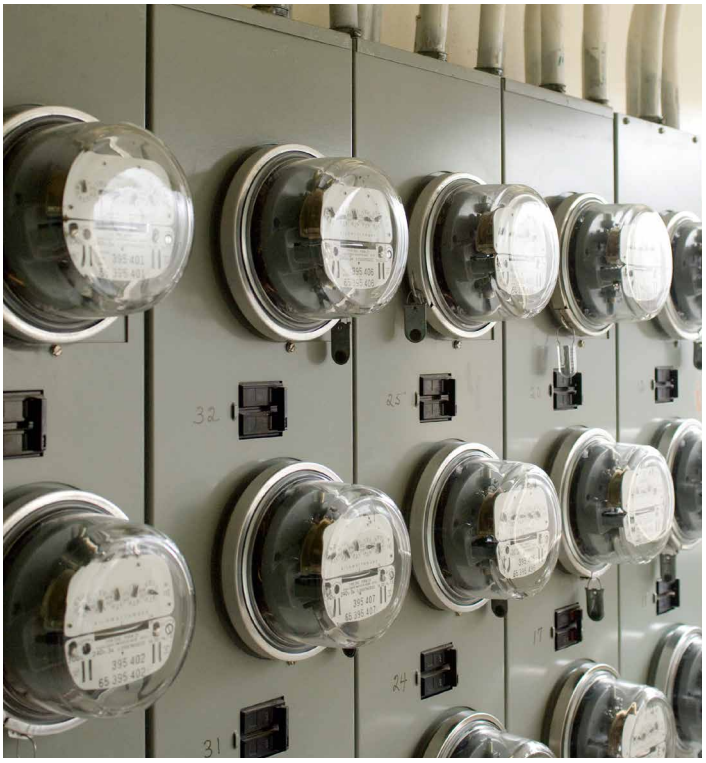
"The CYME Gateway gives Hydro One a complete network model which integrates feeders and substations of different voltage levels. It allows our engineering team to better analyze load transfers and to perform in depth N-x contingency analysis."

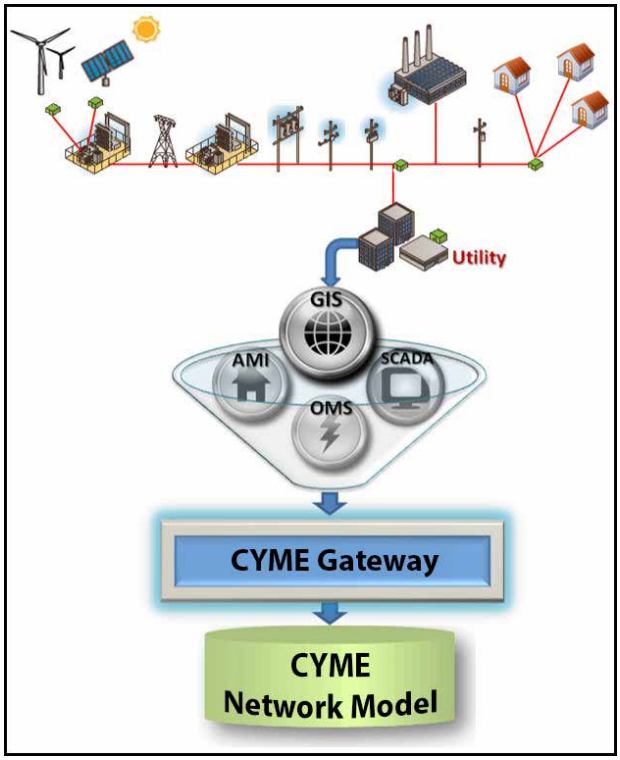
CASE STUDY 3

Making feeder demands available in the CYME model for Commonwealth Edison (ComEd/Exelon)

Feeder demands allow adjusting the network model to give an accurate representation at any given time, peak load or else, which is critical for any CYME power analysis. The information can be entered manually in CYME, or the demands can be imported by the CYME Gateway from any external systems such as the OSIsoft PI System™, or any DMS or SCADA system. Once the feeder demands are combined with the network model, users can easily allocate the loads of the system, a process that can also be automated within the CYME Gateway to improve efficiency.

"Having the CYME Gateway extract directly from the PI Historian database helps us tremendously in avoiding the trouble of gathering and validating demand information manually. A process that used to take hours is now performed automatically, which is more efficient and allows our engineers to put their focus on power engineering studies in CYME."





CASE STUDY 4

Completing the network with load information for Pacific Gas & Electric (PG&E)

A network model with individual customer load data reflects more accurately the actual system to be studied, and allows all CYME analyses to generate more meaningful results. The possibility to import load information directly into the CYME model foregoes the traditional manual work required. The CYME Gateway can extract from different in-house systems, such as CIS, AMI or MDM, to create the most complete network model possible for any system study.

"This option populates our CYME network with load information with such rapidity – it helps our engineers to obtain an accurate network representation at any loading level with ease,"

said David Lee, Supervising Engineer of the Engineering and Planning department of PG&E.

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