



**POWERFACTORY**

## PowerFactory 2021

INTEGRATED POWER SYSTEM  
ANALYSIS SOFTWARE FOR

- # TRANSMISSION
- # DISTRIBUTION
- # INDUSTRY
- # GENERATION
- # INTEGRATION OF RENEWABLES

**PF2021**

**POWER SYSTEM SOLUTIONS**  
MADE IN GERMANY



**BE A PART OF  
THE ENERGY  
SUPPLY OF  
THE FUTURE**

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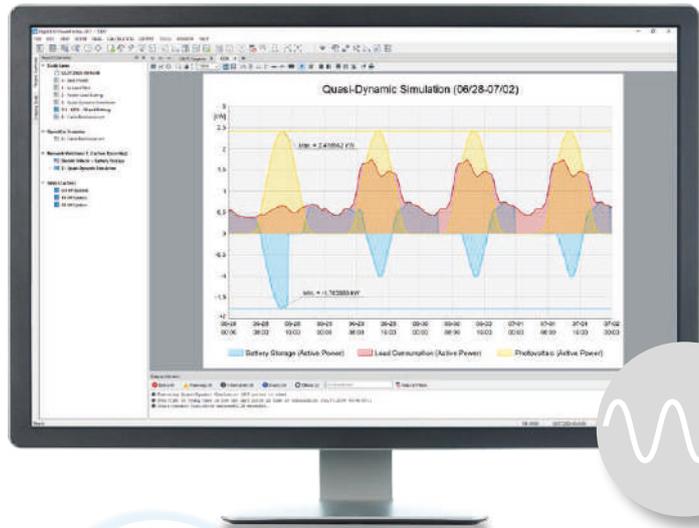
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# EXTENSIVE POWER SYSTEM ANALYSIS SOFTWARE

PowerFactory comes with built-in modelling tools such as the recording of topological changes in network variations and expansion stages, and the representation of power system equipment operating conditions in operation scenarios. Ensure that your planners always have an up-to-date model, by using master and derived projects.



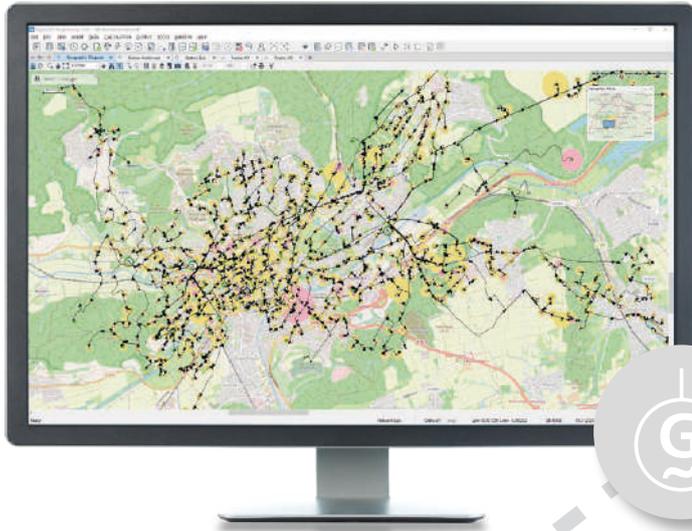
## CALCULATION MODULES

PowerFactory provides a wide range of calculation functions, from steady state calculations to EMT simulations, from power system analysis to protection coordination. Whatever the application, PowerFactory offers fully flexible calculation combinations.



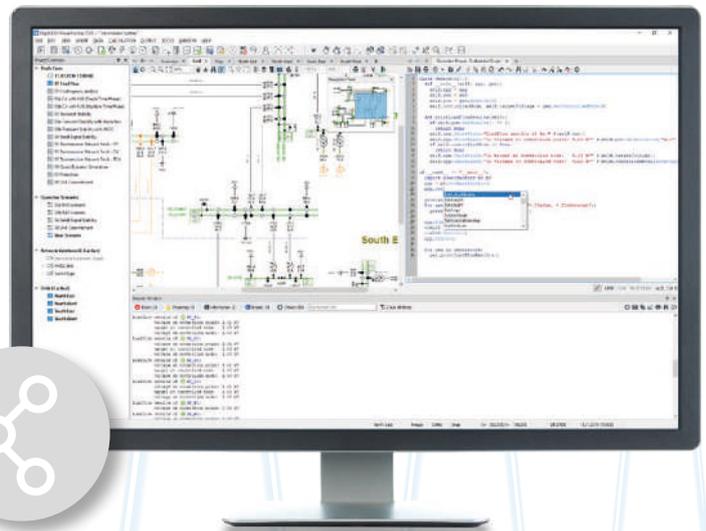
## REPORTING

Built-in and user-defined reporting options are available, via the graphical interface, tabular views, plots and diagrams or external files. Built-in reporting options offer easy and direct access to the relevant network elements.



## NETWORK REPRESENTATIONS

Networks are visualised in different graphical formats, used in any combination: Overview diagrams (including geographic representations), single-line bus-branch diagrams, and detailed substation views which show all components.



## SCRIPTING AND INTERFACE

Full read and write access to network components, diagrams and results is possible using generic interfaces (DGS), scripting interfaces (DPL and Python) and built-in converters.

PowerFactory engines allow for full integration into SCADA and GIS systems, and can be used for process automation. Embedding into third party applications can be realised via the PowerFactory Application Programming Interface (API).

## MULTI-USER DATABASE

The ideal solution for easy sharing of data amongst a group of users. The central database can be used in conjunction with the base/derived project concept for coordinated working.





PowerFactory is a leading power system analysis software application for use in analysing generation, transmission, distribution and industrial systems. It covers the full range of functionality from standard features to highly sophisticated and advanced applications including wind power, distributed generation, real-time simulation and performance monitoring for system testing and supervision.

## **POWERFACTORY HIGHLIGHTS**

PowerFactory is easy to use, fully Windows compatible and combines reliable and flexible system modelling capabilities with state-of-the-art algorithms and a unique database concept. Also, with its flexibility for scripting and interfacing, PowerFactory is perfectly suited to highly automated and integrated solutions in your business applications.



## MODELLING, ANALYSING AND REPORTING IN ONE TOOL

All-in-one solution with broad coverage of state-of-the-art power system applications

Time-based network extension modifications, ensuring accurate network modelling

Supports all network representations and phase technologies, i.e. any kind of radial or meshed 1-,2-,3- and 4-wire (combined) AC and DC networks

Powerful network diagram and graphic/visualisation features, including flexible colouring options

Extensive and flexible modelling capabilities with a rich suite of power equipment models and libraries

Flexible options for node-breaker and bus-branch modelling

Efficient and robust calculation algorithms for simulation and optimisation

Wide range of plots, both standard and usage-specific

## COLLABORATIVE WORK IN THE TEAM-EDITION

Collaborative working environment using a common master model together with deriving concept and compare and merge tools

Unique data management concept, including project versioning and archiving mechanisms

Single- and multi-user environment with support of team-working, user accounting, profiles and flexible customisation

## INTERFACING

Unlimited opportunities in process automation and optimisation based on integrated scripting functionality, with full access to the software

Rich interfacing and system integration options, e.g. GIS, SCADA, EMS, ESB, ...

## DOCUMENTATION AND SUPPORT

Professional support via customer portal or hotline as well as continuous maintenance and development

Large application example library, demonstrating all the main calculation functions

Detailed user manual, technical documentation, rich set of application examples with video explanations, tutorials and online knowledge base

# SOFTWARE EDITIONS

## PowerFactory Single-User Edition

- Single-user licence with local database
- Local licence

## PowerFactory Team Edition

- Multi-user licence for multi-user database with Microsoft SQL Server and/or Oracle Database
- Network licence with optional floating licence

## PowerFactory Multi-User Edition

- Multi-user licence with local databases
- Network licence with optional floating licence

## PowerFactory Engine Edition

- GUI-less application for integrated/automated solutions
- Local licence or network licence



### Minimum System Requirements

- Display with minimum 1280x1024 resolution
- Intel/AMD CPU; 2 GHz or faster
- 2 GB available hard disk plus additional 5 GB per user
- Minimum 2 GB RAM available for PowerFactory process depending on network size and type of calculations
- Licence requires regular online access (every 30 days)

### Supported operating Systems:

- Microsoft Windows 8.1, 10
- Microsoft Windows Server 2012, 2012 R2, 2016, 2019

### Supported Database Systems (for Team Edition):

- Microsoft SQL Server 2012, 2016, 2017, 2019
- Oracle Server 12c Release 1, 12c Release 2, 18c, 19c with corresponding client versions

## BASE PACKAGE

The PowerFactory Base Package provides analysis modules coupled with a wide range of power equipment models, integrated tools and features for fundamental power system applications.

### BASIC FUNCTIONS AND INTEGRATED FEATURES

Load Flow Analysis

Short-Circuit Analysis

Sensitivities / Distribution Factors

Basic MV/LV Network Analysis

Power Equipment Models

Network Representation

Network Model Management

Network Diagrams and Graphic Features

Results and Reporting

Various Data Converters

> For details, see the Product Specification

## ADVANCED FUNCTIONS

The Base Package can be extended using a wide variety of additional functions according to specific user requirements. In addition, various interfaces are available to further customise the PowerFactory package.

Contingency Analysis

Quasi-Dynamic Simulation

Network Reduction

Protection Functions

Arc-Flash Analysis

Cable Analysis

Power Quality and Harmonic Analysis

Connection Request Assessment

Transmission Network Tools

Distribution Network Tools

Outage Planning

Probabilistic Analysis

Reliability Analysis Functions

Optimal Power Flow (OPF)

Unit Commitment and Dispatch Optimisation

Economic Analysis Tools

State Estimation

Stability Analysis Functions (RMS)

Electromagnetic Transients (EMT)

Motor Starting Functions

Small Signal Stability (Eigenvalue Analysis)

System Parameter Identification

Interfaces

Scripting and Automation

> For details, see the Product Specification



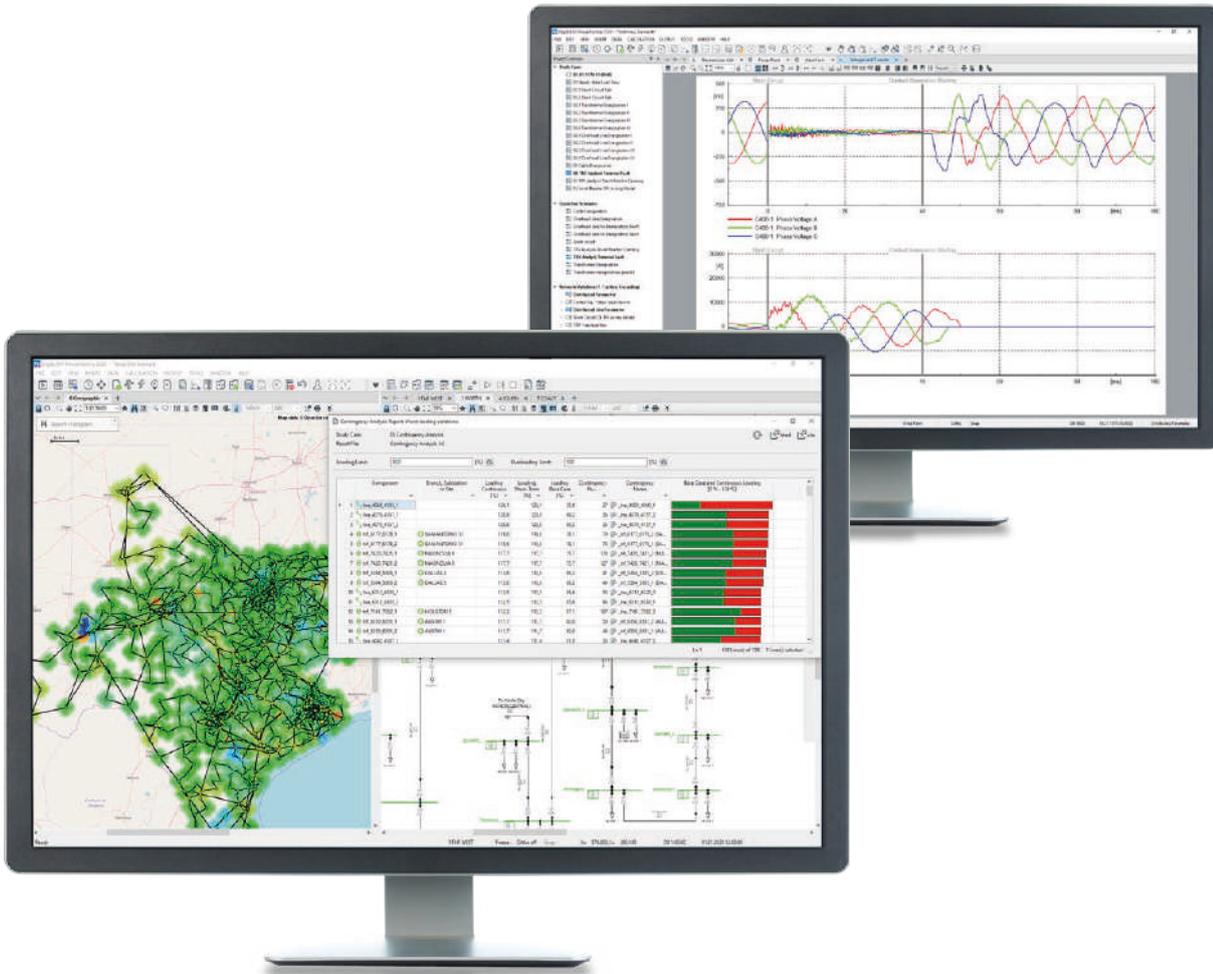
## PRODUCT APPLICATION

# TRANSMISSION SYSTEMS

Transmission grids are currently undergoing major changes, to reliably accommodate increasing amounts of nondispatchable resources while maintaining operational efficiency and minimising system-wide cost. The displacement of conventional generation by wind and solar power generators imposes new challenges on the ability of the grid to maintain system stability.

PowerFactory offers a complete suite of functions for studying large interconnected power systems and addressing these emerging needs. Its fast and robust simulation algorithms can be applied to any AC or DC network topology and support the simulation of new technologies such as converter-based power generation, FACTS, voltage-sourced converters (VSC), HVDC, cables and overhead lines, DC breakers, filters, and various types of MW- and Mvar-controllers and virtual power plants.

To maintain such a rich data model, PowerFactory comes with comprehensive planning tools. Operation Scenarios can be used to save operating points, thus enabling the user to study different scenarios with just a few clicks. Network Variations with time-related Expansion Stages allow the user to model network development projects including the (de-)commissioning of power system equipment. Just by changing the study time, the right network configuration will be automatically used for calculations.



PowerFactory is also perfectly suited to transmission system operation planning. It integrates a comprehensive set of tools to support automatic and parallel grid security analysis such as ENTSO-E D2CF/DACF/IDCF, and outage planning.

Multiple interfaces (API, DGS, CIM) and flexible scripting languages (DPL, Python) enable smooth integration with existing systems, and compliance with the ENTSO-E CGMES data exchange standard.

## RELATED FEATURES AND FUNCTIONS

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Outstanding power system modelling capabilities

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Study-time based model on demand options

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Support of multiple network diagrams with direct connections to the network elements

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Support of node-breaker and bus-branch models

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Seamless integration of network model, analysis and reporting

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Contingency Analysis

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Outage Planning

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Stability analysis (RMS and Modal Analysis)

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Electromagnetic Transients (EMT)

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Sensitivities / Distribution Factors analysis, including PTDF

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Harmonics / Power Quality

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Unit Commitment and Dispatch Optimisation

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PV/QV Curve calculations

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Transfer Capacity Analysis

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Network Reduction

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Optimal Power Flow



## PRODUCT APPLICATION

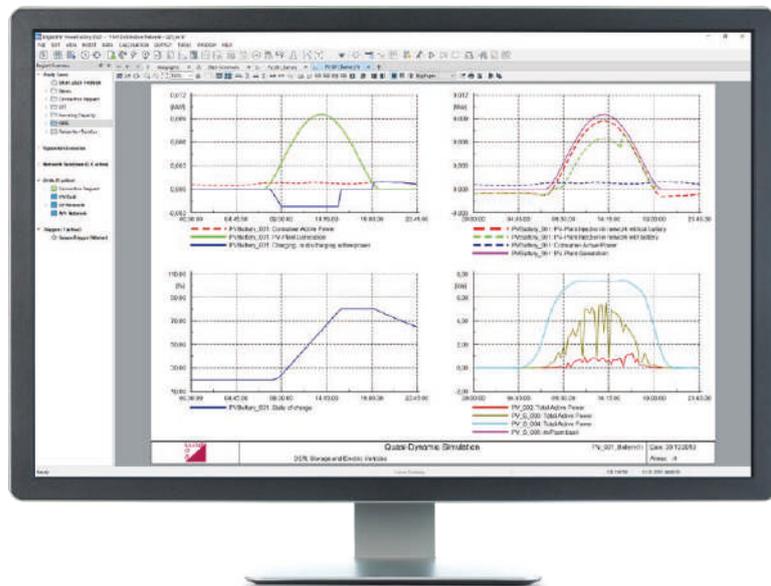
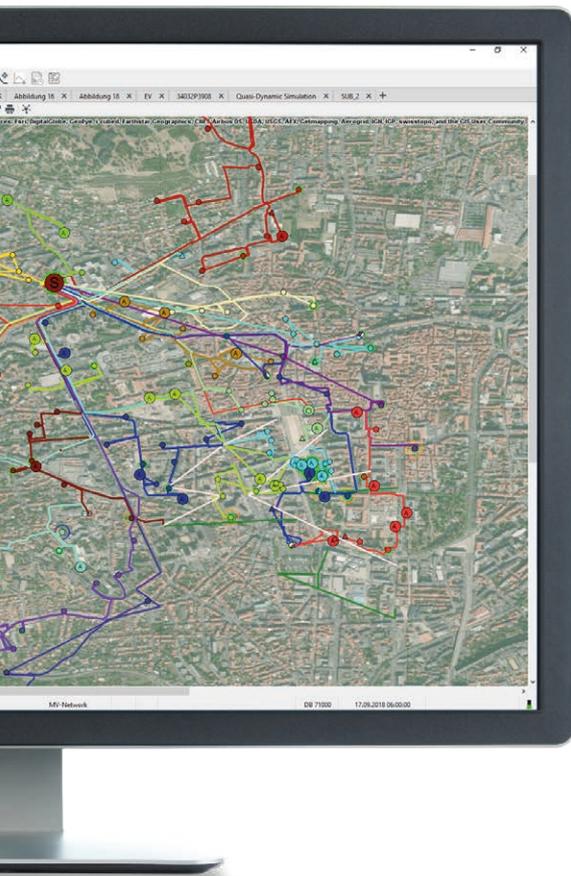
# DISTRIBUTION SYSTEMS

New challenges such as reverse power flow and voltage rise due to distributed generation, as well as the integration of e-mobility, have led to an increased complexity in the planning and operation of distribution networks. Handling the associated analyses calls for sophisticated and comprehensive network optimisation tools.

To handle these challenges, PowerFactory offers a wide range of powerful tools and functions. Using built-in interfaces, the creation of the network and the input of measurement values can be achieved using GIS and SCADA data. Based on this data, the current state of the network can be analysed, for example to evaluate the hosting capacity for load and generation. For further optimisation of the network, there are numerous functions available, such as tie open point optimisation, voltage

profile optimisation, phase balance optimisation, and optimal equipment placement.

A user-friendly time sweep simulation function facilitates analysis of the impact on the network infrastructure of both conventional generation and renewables, taking into account volatile distributed generation and storage systems with user-defined controls.



## RELATED FEATURES

### Models

Load models using standard load profiles or smart meter data

Models for PV systems based on solar radiation, electric vehicles, battery storage, etc.

Innovative equipment (distribution transformer with OLTC, voltage regulators, reactive power control schemes, etc.)

Dynamic and topologically dependent feeders, essential for many distribution system applications

### User Interface

Geographic diagrams with publicly available and custom map services as background

Voltage profile plots for feeders

### Analysis and Optimisation

Probabilistic Analysis with stochastic modelling of distributed generation and demand

Voltage Profile Optimisation for bi-directional power flows

Reliability Analysis and Optimal Power Restoration

Power Quality and Harmonic Analysis

Protection functions

Economic Analysis Tools

Connection Request Assessment

Quasi-Dynamic Simulation

Cable sizing and derating factor determination

Feeder load scaling

Hosting Capacity Analysis

Phase Balance Optimisation

Voltage Sag Assessment

Backbone Calculation

### Equipment Placement Functions

Optimal equipment placement for voltage regulators, batteries, remote controlled switches and capacitors



## PRODUCT APPLICATION

# INDUSTRIAL SYSTEMS

The design and operation of industrial networks is becoming increasingly challenging with the integration of more power electronics, sophisticated automation systems, and increased reliance on island mode operation. To face these challenges whilst ensuring continuity of production, electrical power quality, and the safety of personnel, proper modelling and analysis of the electrical networks is of the utmost importance.

PowerFactory provides a vast array of functionality perfectly suited to the industrial user's needs such as high precision load flow algorithms, flexible short-circuit calculation features, 4-wire and DC grid modelling, protection modelling and analysis tools, harmonic calculations and filter design options. In addition, PowerFactory provides up to date standards for short-circuit and arc-flash calculations, with clearly-presented results and a comprehensive and user-friendly interface.

The flexible data manager allows easy, tabular configuration of all input parameters and a spreadsheet-like export of results. To meet new challenges in industrial networks which require more detailed analysis in the time domain, PowerFactory offers the flexibility to analyse electro-mechanical and also electro-magnetic phenomena.



## TYPICAL STUDIES

As an integrated simulation tool with a rich spectrum of analysis functions, a variety of analyses may be carried out using the same data model.

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System analysis under different network configurations in relation to network topology, generation and load status

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Short-circuit calculations for AC and DC systems according to IEC/VDE, ANSI and IEEE standards

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HV & LV cable sizing according to IEC; NF and BS standards; ampacity, voltage drop, short-circuit capability

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Motor starting, re-acceleration and voltage drop analysis

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Protection scheme coordination (overcurrent, differential, distance and signalling)

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Harmonic distortion studies, resonance studies and filter sizing

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Network reliability analysis, scenarios and fault models

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Time domain simulation for stability and electromagnetic transient analysis

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Arc-Flash Analysis according to IEEE, NFPA and DGUV standards

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## PRODUCT APPLICATION

# POWER GENERATION

Reliability, efficiency and stable operation are essential features for the generation which forms the core of any power system. PowerFactory offers tools suitable for the electrical design of power plants and for planning their operation. The broad spectrum of solutions ranges from the analysis of the electrical and mechanical behaviour in steady-state and transient conditions, to the optimisation of generator dispatch.

Modern power systems bring new challenges to conventional power plants. Besides sub-synchronous resonances (SSR) typically related to series compensation, sub- and super-synchronous torsional interactions (SSTI) with

converter-based equipment are an increasing challenge. Proper analysis is essential in order to mitigate the risks of damage to equipment, and associated high costs, that can result from these phenomena.

## HIGHLIGHTED POWERFACTORY CAPABILITIES AND TYPICAL STUDIES

Models of generators, governors (steam, gas, diesel, hydro), automatic voltage regulators (AVR) and power system stabilisers (PSS)

Voltage-dependent PQ capability curves

Harmonic Load Flow

Models of motors, protection relays, power electronic converters and DC equipment

Calculation of short-circuit currents

- in AC grids according to IEC 60909 and ANSI
- in DC auxiliary supply grids according to IEC 61660 and ANSI/IEEE 946

Unit Commitment and Dispatch Optimisation, including grid and security constraints

Stability and EMT simulation

- Behaviour during short-circuits and load changes
- Frequency control
- Transient stability
- Transformer inrush
- Sub-synchronous resonances (SSR)
- Sub- and super-synchronous torsional interactions (SSTI)

Model frequency response analysis (Bode and Nyquist Diagrams)

System Parameter Identification for dynamic models

Power Plant Energy Analysis for an economic assessment of wind or solar power parks





## PRODUCT APPLICATION

# DISTRIBUTED GENERATION

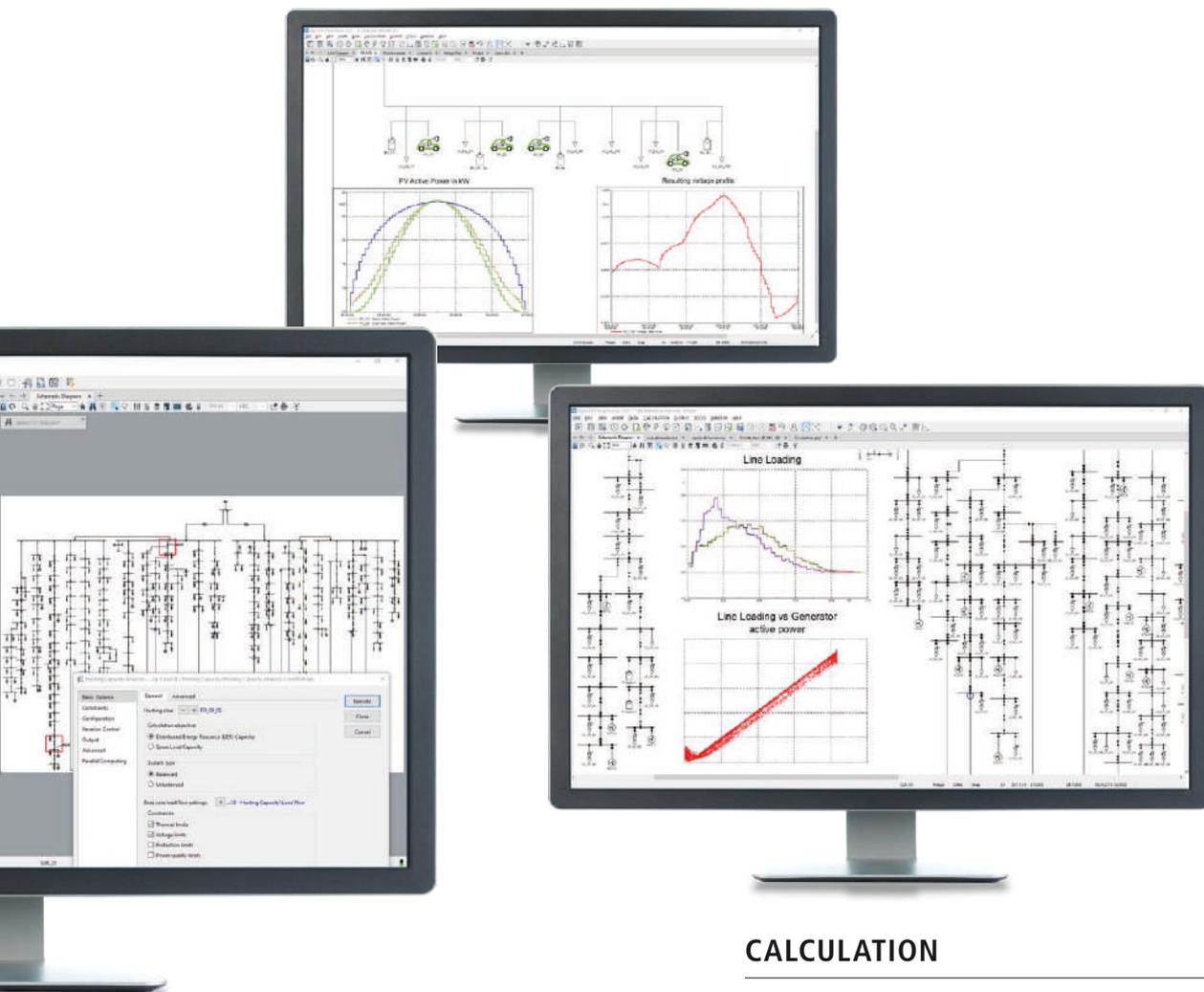
Power system phenomena such as reverse power flows, voltage dips and swells, varying fault levels and equipment loading are some of the major challenges associated with distributed generation in electricity systems.

Of particular note are the challenges arising from the interaction between highly volatile generation from renewable sources and an increasing variability in consumption.

The extensive model library in PowerFactory offers users the possibility to use ready-made load flow and dynamic models for generators and converters, PV systems with integrated power calculation based on solar radiation, fuel cells, wind generators and battery storage (according to IEC and WECC).

To account for the interaction between consumption and generation in the network, models for single and three-phase loads, consumption energy profiles and models for electric vehicles can be used.

This provides the perfect basis for all the necessary analysis, from unbalanced network assessments and voltage drop/rise calculations, to Quasi-Dynamic Simulation and Voltage Profile Optimisation. Using the Hosting Capacity calculation, the remaining capacity for renewable energies can be evaluated, whilst Probabilistic Analysis and Reliability Analysis can be performed in order to determine the risks of uncertainty.



## SELECTED FEATURES

### MODELLING

PV system model with integrated power calculation based on solar radiation (1 and 3-phase technology)

Wind generator model with power calculation based on wind speed distribution or time-series input

Dynamic models of wind turbine generators, PV systems, battery storage and distributed energy resources (DER\_A) including FRT-capability, as well as of composite loads

Various reactive power control schemes for single generators or wind farm / PV park master controllers

On-load-tap-changer capability with various control schemes including line-drop-compensation for transformers and voltage regulators

Symmetrical and unsymmetrical network representation

### CALCULATION

Harmonic analysis, impedance sweep and Flickermeter calculation for power quality assessment

Medium to long term Quasi-Dynamic Simulation accounting for variable generation and battery storage applications

Optimisation of distribution transformer tap positions for bi-directional power flows in systems with a high level of distributed generation, for optimised voltage profile

Short-Circuit Calculation according to IEC 60909

Hosting-Capacity Analysis tool for the evaluation of spare generation or load capacity in predefined network areas

Probabilistic Analysis of load flow and optimal power flow

Reliability Analysis to identify the loss of generation and loads including optimal restoration schemes

Cable Sizing for distribution networks, derating factor and Cable Ampacity calculation

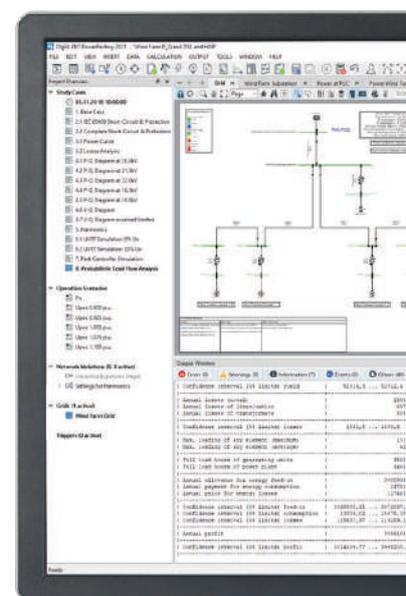


## PRODUCT APPLICATION

# RENEWABLES

Complex studies for the integration of renewable generation into electrical networks are an integral part of network planning and analysis. PowerFactory combines extensive modelling capabilities with advanced simulation algorithms. Network and park models are easily created using an intuitive drawing tool-box, while the use of model templates and an extensive model library allow complete plant models to be constructed efficiently.

A full set of tools is provided to undertake the wide range of studies required for grid connection and grid impact analysis of wind parks, PV generation and all other renewable energy power plants. Recurring tasks can easily be automated using scripting tools, to streamline the analysis process.



## SELECTED KEY FEATURES

Economic assessment using the Power Park Energy Analysis tool

Steady-state load flow calculations taking into account voltage-dependent reactive power capability limits, power park controllers with set-point characteristics, etc.

PV system model with integrated power calculation based on solar radiation (1 and 3-phase technology)

Short-circuit calculation according to IEC 60909 and ANSI, and complete method with dynamic voltage support according to k-factor settings

Medium to long-term Quasi-Dynamic Simulation

Stochastic wind models and probabilistic analysis tools

Balanced and unbalanced stability and EMT simulation, e.g. for UVRT and OVRT analysis

Multiple domain co-simulation (RMS/EMT)

Models for all established wind turbine and generator/converter types, photovoltaic systems, battery energy storage, STATCOMs and HVDC systems

Dynamic models according to IEC 61400-27-1 and WECC

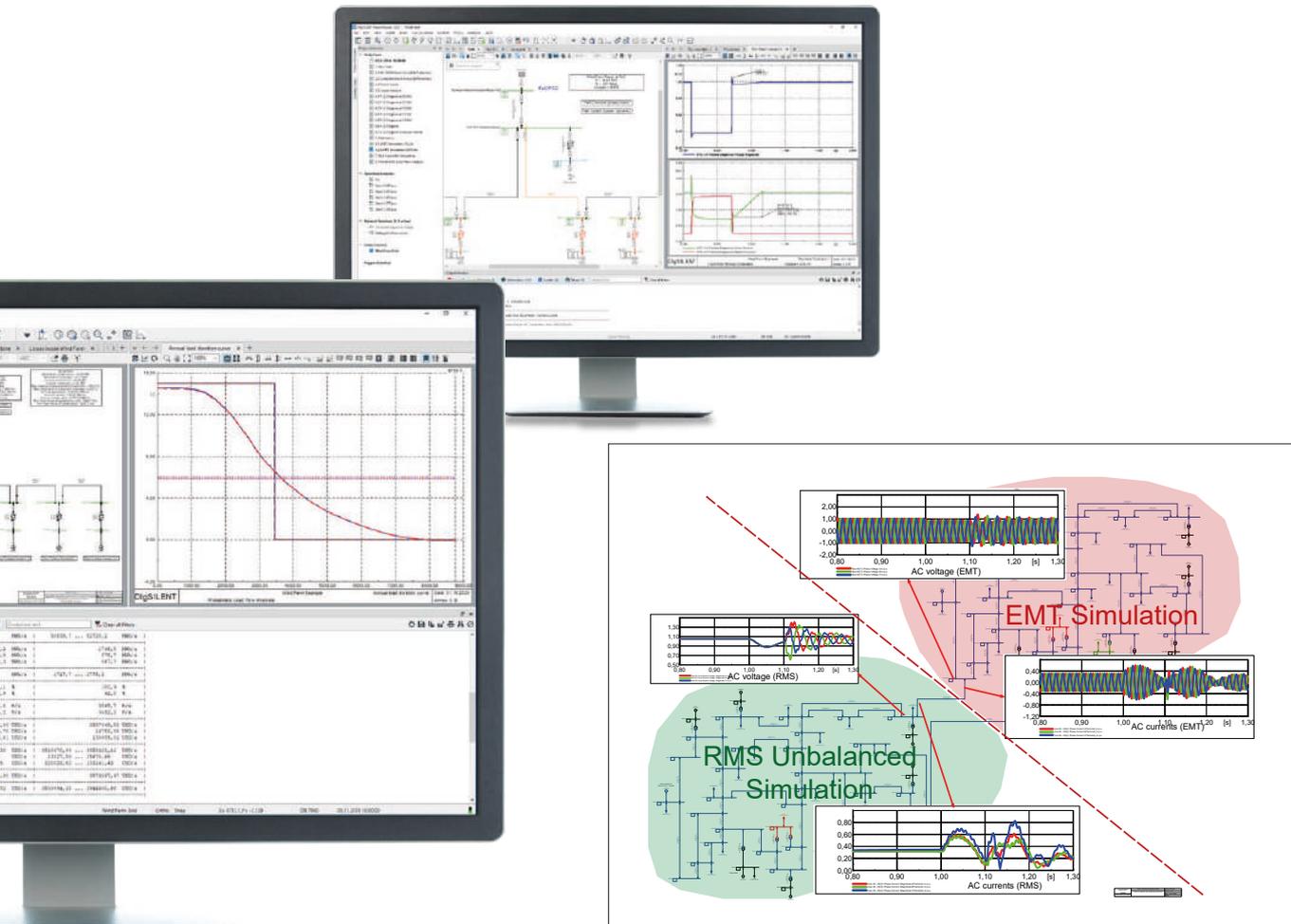
Interface for external models according to IEC 61400-27-1

User-defined modelling for Quasi-Dynamic, RMS and EMT simulation

Encryption option for user-defined models and compilation option (DLL model interface)

Power quality assessment including harmonic analysis with frequency-dependent Norton equivalents, impedance frequency sweeps and Flickermeter calculation

Model Frequency Response analysis (Bode and Nyquist Diagrams)





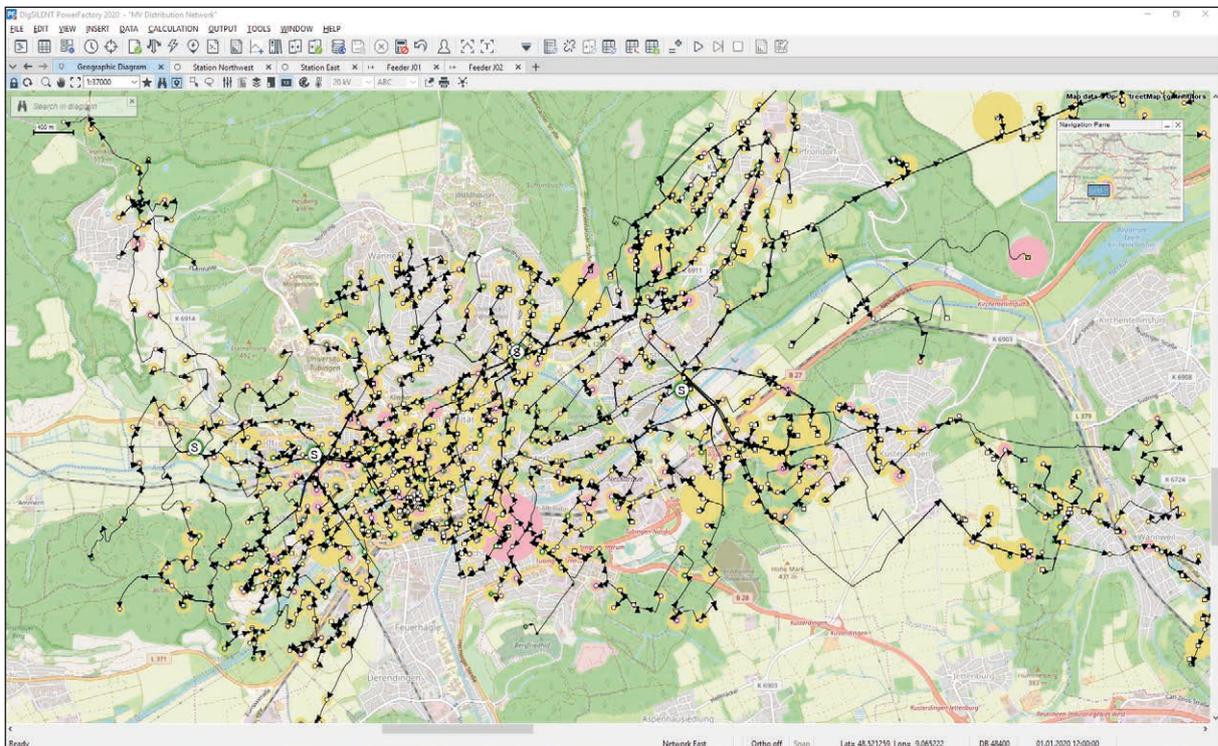
## SYSTEM INTEGRATION

# GIS INTEGRATION

Geographic Information Systems (GIS) together with Asset Management Systems are the main sources of network topology and equipment data. Many utilities use GIS exports as a basis for the PowerFactory network model. These exports may comprise detailed substation data including topology, line/cable data, load/generation data and GPS coordinates/schematic diagram information, etc.

The symbols of stations, line style and colouring can be customised according to technical properties of the objects. The built-in Compare & Merge Tool and the versioning mechanism perfectly support frequent data exchange with GIS.

PowerFactory engines can directly be integrated into GIS systems providing calculation functionality such as evaluation of renewable generation connected to the low voltage grid.



Geographic representation of a fictitious medium voltage grid in PowerFactory. Yellow circles indicate load; pink shows installed production.



PowerFactory can interface with SCADA systems as a calculation engine.

## SYSTEM INTEGRATION

# SCADA INTEGRATION

The PowerFactory OPC interface is utilised worldwide for real-time integration of PowerFactory with SCADA systems. The applications range from online state estimation, simulation mode functions (dispatcher load flow, contingency analysis, switching validation) to dispatcher training simulator with real-time transient grid simulation. Controller manufacturers use the PowerFactory OPC interface for controller development and hardware-in-the-loop tests, e.g. for smart grid controllers, PV or wind park control schemes.



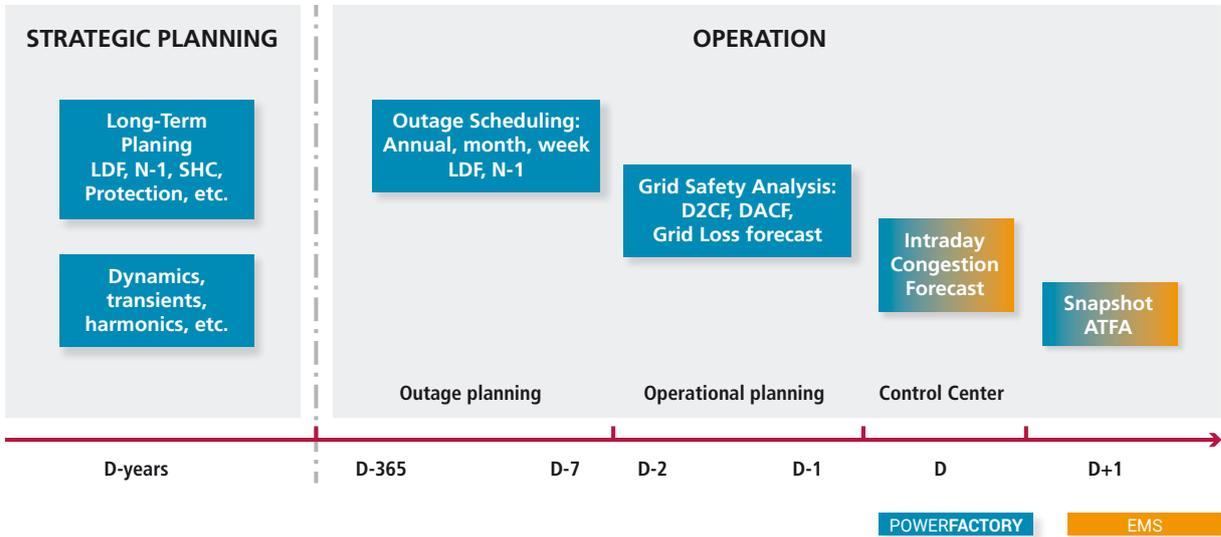
## SYSTEM INTEGRATION

# BUSINESS PROCESS AUTOMATION

PowerFactory supports standard ENTSO-E operation planning processes such as D2CF, DACF and IDCF (Intraday). The Intraday process runs as a fully-automated, parallelised process. The ESB interface adapter features message-based data exchange such as load forecast, planned generator dispatch, day-ahead cross-border exchange programs, UCTE-DEF files, EMS snapshots, dynamic line ratings and market coupling data.

Likewise, PowerFactory is the product of choice for business process automation in distribution planning and operation. As an example, the combined MV/LV calculation for the distribution grid of a whole country

(>2 000 primary substations and > 25 000 MV feeders and > 845 000 LV grids) has been automated using PowerFactory and bulk exports of GIS data.



Processes in strategic and operational network planning that are well supported by DlgSILENT PowerFactory in customised automated solutions.



## SYSTEM INTEGRATION

# INTEGRATION COMPONENTS

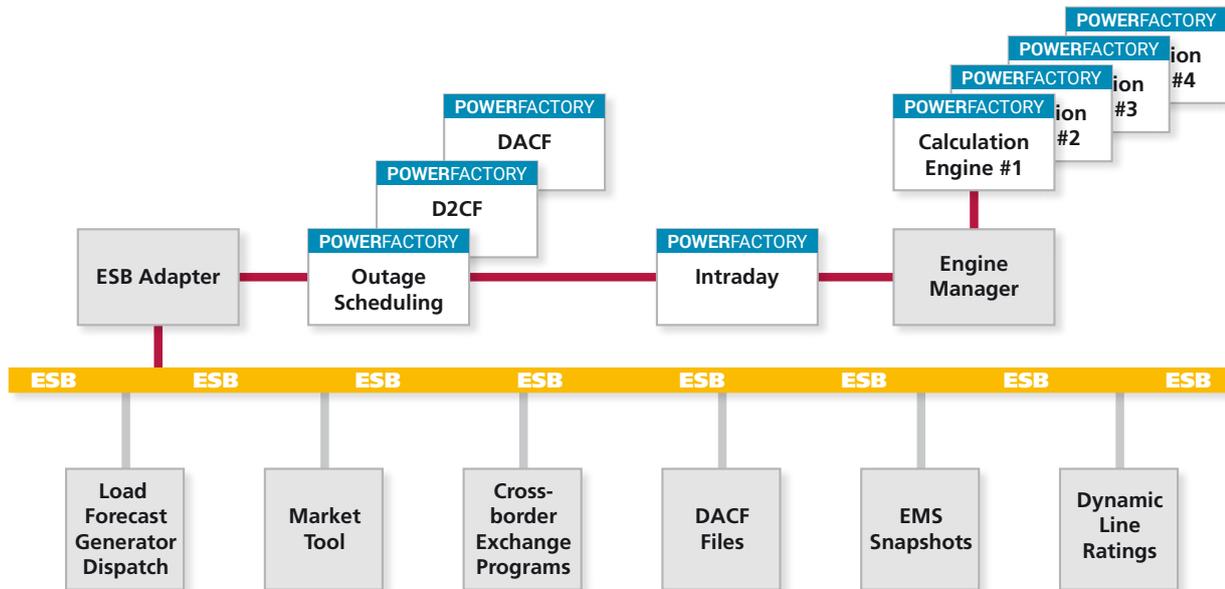
PowerFactory operated in engine mode provides complete PowerFactory functionality for external systems. The engines can be controlled via a PowerFactory Engine Manager, PowerFactory API, DPL or Python scripts. Various interfaces such as CIM, UCTE-DEF, OPC and DGS support bi-directional data exchange with different systems.

The ESB interface adapter connects to an enterprise service bus enabling modern message-based data exchange.

The built-in queuing and scheduling simplifies the integration of the PowerFactory engine into other applications.

The PowerFactory Engine Manager component provides access to multiple PowerFactory engines via web services.

## SOLUTION ARCHITECTURE



System architecture automation for operational processes.



## MAINTENANCE & SUPPORT SERVICES

- Continuous product maintenance and development
- Free version upgrades as well as regular software updates
- Professional support via customer portal or hotline
- Detailed manual and tutorial with comprehensive examples
- Knowledge Base including FAQs, application examples and demonstration videos
- Regular newsletter containing information about PowerFactory releases and seminar schedules

## TRAINING COURSES

- Modular training concept covering all PowerFactory functions
- Standard and user-specific training courses, including
  - Load flow and short-circuit
  - Power system stability
  - Dynamic modelling workshop (DSL)
  - Harmonic analysis
  - Electromagnetic transient analysis
  - Grid connection of renewable generation
  - Protection in PowerFactory
  - Scripting in PowerFactory with Python
- Training courses are offered online and in-house at DlgSILENT offices, as well as at users' own sites.

### SALES CONTACT

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Availability of support services depends on existing licence agreement. For more details, see our PowerFactory Maintenance and Support Services Flyer that is available in the Download Area of our website.

# ABOUT DIGSILENT

DIGSILENT was founded in 1985 and is a fully independent and privately owned company located in Gomaringen close to Stuttgart, Germany. DIGSILENT continued expansion by establishing offices in Australia, South Africa, Italy, Chile, Spain, France, the USA and Oman, thereby facilitating improved service following the world-wide increase in usage of its software products and services. DIGSILENT has established a strong partner network in many countries such as Mexico, Malaysia, UK, Switzerland, Colombia, Brazil, Peru, China and India. DIGSILENT services and software installations are used in more than 150 countries.

## POWERFACTORY

DIGSILENT produces the leading integrated power system analysis software PowerFactory, which covers the full range of functionality from standard features to highly sophisticated and advanced applications including wind power, distributed generation, real-time simulation and performance monitoring for system testing and supervision. For various applications, PowerFactory has become the power industry's de-facto standard tool, due to PowerFactory models and algorithms providing unrivalled accuracy and performance.

## STATIONWARE

StationWare is a central asset management system for primary and secondary equipment. In addition to handling locations and devices in a user-definable hierarchy, the system allows manufacturer-independent protection settings to be stored and managed in line with customer-specific workflows. It facilitates the management of a wide variety of business processes within a company and centralises the storage of documents. StationWare can be integrated seamlessly into an existing IT environment and the interface with PowerFactory enables the transfer of calculation-relevant data for protection studies.

## MONITORING SYSTEMS

Our Power System Monitoring PFM300 product line features grid and plant supervision, fault recording, and power quality and grid characteristics analysis. The Grid Code Compliance Monitoring PFM300-GCC system also offers compliance auditing of power plants with respect to grid code requirements. This monitoring and non-compliance detection provides the complete transparency and assurance required by both plant operators and utilities.

## TESTING AND CERTIFICATION

The DIN EN ISO/IEC 17025 accredited DIGSILENT Test Laboratory for NAR Conformity carries out measurements in accordance with FGW TR3 on the operational type 1 generation plant (directly coupled synchronous machines). These measurements are carried out in accordance with the "individual verification procedure" as required by the German grid connection guidelines VDE-AR-N 4110/20/30. DIGSILENT has many years of international expertise in the field of generation and consumption/load systems testing. The in-house developed and produced measuring systems enable the testing laboratory to offer customised measuring solutions for a wide range of power plants and applications.

## SERVICES

DIGSILENT GmbH is staffed with experts of various disciplines relevant for performing consulting services, research activities, user training, educational programs and software development. Highly specialised expertise is available in many fields of electrical engineering applicable to liberalised power markets and to the latest developments in power generation technologies such as wind power and distributed generation. DIGSILENT has provided expert consulting services to several prominent PV and wind grid integration studies.

# SERVING MORE THAN 150 COUNTRIES



For more information, visit  
[www.digsilent.de](http://www.digsilent.de)



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