





9.1	Introduction	480
9.2	Network Consulting	481
9.3	Software Solutions	484

9 Network Planning

9.1 Introduction

Every society today is highly dependent on electricity – as becomes evident when blackouts or large disturbances occur. In our increasingly “digital societies,” almost all aspects of business and private life are based on the availability of electricity. The reliability of power supply systems cannot be taken for granted – especially not with a target reliability of 99.9 % or higher, a value not often met by any other technical system of comparable complexity.

The challenge to provide electricity – any amount required, at any time, at any customer’s premises, and with the appropriate quality – is achieved by a large and complex system of power plants and power systems. Building and operating the power supply system are comprehensive tasks of their own, and several trends in large parts of the world today require special attention:

- In several countries, the electricity sector has been liberalized, which means that the economic and legal framework has been thoroughly changed, and in many cases, it has caused a complete restructuring of power supply companies.
- Whether it be a consequence of liberalization or not, in most electricity markets the economic pressure on utilities has increased tremendously.
- The ecological awareness of societies is increasing, posing new questions for power utilities. Especially, the continuing growth of distributed generation and of generation from renewable energy sources requires also massive changes to the current network structure and configuration.
- E-mobility is a trend that on its own has the potential to spur substantial modifications to today’s power system architecture. The integration of a large number of e-cars and the related charging stations calls for analysis of network compatibility, of the required network reinforcement – and of new concepts for network operation, possibly making intelligent use of the storage capacity provided by the e-cars.
- Customer appliances are becoming ever more complex and thus sensitive to power quality issues, while at the same time the devices are also emitting ever more quality disturbances into the power supply systems.
- All these new requirements – together with new technologies and concepts for network equipment, network planning and network operation – motivate the transition of today’s power systems into smart grids. Increasing the power system’s capabilities for communication, control and automation is a key prerequisite for meeting the upcoming requirements. Detailed analysis of system performance and the designing of smart grid network structures will become key tasks for utilities.

Considering these trends and inherent requirements for changes in the power supply system, based on variations in customer structure (location and power demand), new technologies in generation (renewable generation by wind energy converters) and network equipment (devices based on power electronics) as

well as the age of system components, it is obvious that the power supply system is the subject of constant modification, redesign and extension. Despite the multitude of different requirements of power supply systems and their different states of development in different parts of the world, there is a typical high-level structure common to almost any power supply system, as shown in fig. 9.1-1.

- The typical hierarchical structure of power supply systems resembles a pyramid. The base is formed by the low-voltage (LV, up to 1 kV) distribution networks, to which most customers are connected. Starting from household customers requiring a few kW on average up to large commercial or industrial customers in the range of a few MW, the large number of customers demands a significantly wide range of power requirements and components in the LV system. Typically, highly standardized design concepts are used in very simple network structures (mostly radial networks) in order to cope with the large amount of equipment and with the economic constraints. While a large number of small generation units are installed at several different places (called distributed generation) – and many of those distributed generation (DG) units are being driven by renewable energy sources (RES) like solar or wind power – most of the power demand is supplied from the higher-level medium-voltage (MV, above 1 up to 50 kV) distribution network.
- The geographic distribution of the load demand defines the locations for the MV/LV substations commonly known as ring main units (RMU), and for the direct MV connection of larger commercial or industrial customers. The electrical configuration and overall network structure of the MV distribution system is mainly governed by these load requirements, and by the placement of larger DG units or groups of DG units, e.g., wind parks, or of small power plants.

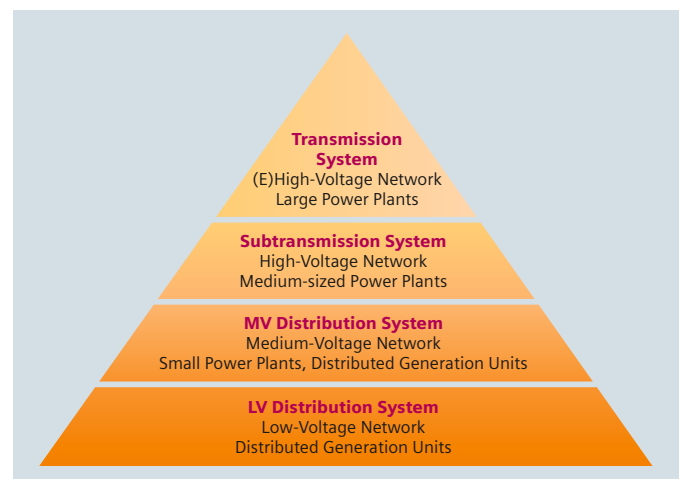


Fig. 9.1-1: Hierarchical structure of power supply systems

Standardized design concepts and simple network structures are primarily used; however, it is also common to use individual and more complex solutions for special areas like important HV/MV or MV/MV substations, or customers with special power quality requirements.

- The subtransmission system typically consists of regional high-voltage (HV, above 50 up to 200 kV) networks and medium-sized power plants. Power is supplied to the separate HV/MV substations feeding the subordinate MV networks. While failures in distribution networks often lead to individual or local supply interruptions for customers, failures in the subtransmission level can lead to more widespread, regional supply interruptions. Therefore, these networks are typically operated in a meshed structure.
- Finally, the transmission level contains HV and extra-high-voltage (EHV, 200 up to 750 kV and above) networks with interconnections to neighboring systems and countries, where possible. The networks are characterized by a comparably low number of components and by customized concepts. Large power plants providing the bulk of the power generation are connected to the transmission-level structure. Interconnected operation enables the system operators to make use of the balancing effects of different load patterns and different characteristics of power plants in different areas, e.g., pump storage hydro power plants in the Alps. Such an approach is a highly economical way to provide reserve generation capacity and support in emergency situations. Failures in the transmission system involve the risk of blackouts in large areas or even whole countries. Besides meshed operation, special attention is also paid to the substation design in transmission networks.

- Adequacy, the ability of the system to supply all customers in normal operation
- Safety, protection of people and equipment against harm and damage caused by electricity
- Security, the stability of the system, especially after disturbances like load shifts or electrical failures
- Power quality, continuous supply of electricity within constant frequency, voltage level and other quality parameters – also in disturbed operation
- Economical performance, keeping defined budgets and other economic performance criteria
- Ecological performance, preventing pollution and minimizing the impact of electrical equipment (e.g., lines) on the environment

Network planning is required to develop and support the strategic perspective of any renewal, extension or modification project in a power supply system, and it links to all steps in the life cycle of such projects (fig. 9.2-1). Initially, it is obvious that network planning assists in the development of the general project idea and in feasibility studies, as well as in the subsequent planning phase. During operation of the equipment, issues like failure investigations, performance analyses and definition of maintenance strategies call for network planning support. Finally, the requirement for modification, extension or renewal closes the life cycle and/or triggers new projects supported by the input of network consulting.

The complexity of network planning does not only arise from the significant geographic extent of power supply systems and the different hierarchical levels of their distinctive functions. It is also complex because of the fact that different objectives are often contradictory, e.g., technical performance vs. economical performance. Network planning covers a wide range of different time horizons – far future, near future and the next few days, hours or minutes.

9.2 Network Consulting

Network planning process

The key characteristic of network planning is always the system context. The power supply system is more than just a combination of switchgear, transformers, overhead lines, cables, and secondary equipment for protection, control and communication. It is the integration of all these components in an overall solution meeting the customers' requirements with respect to load demand and power quality. While there are highly complex and important tasks to be addressed in the detailed planning and design work on the equipment level, it is the task of network planning to define the functional specifications for each separate component and to ensure the safe and secure operation of the system as a whole.

The complexity of the power supply system requires very thorough and precise planning in order to meet the following requirements:

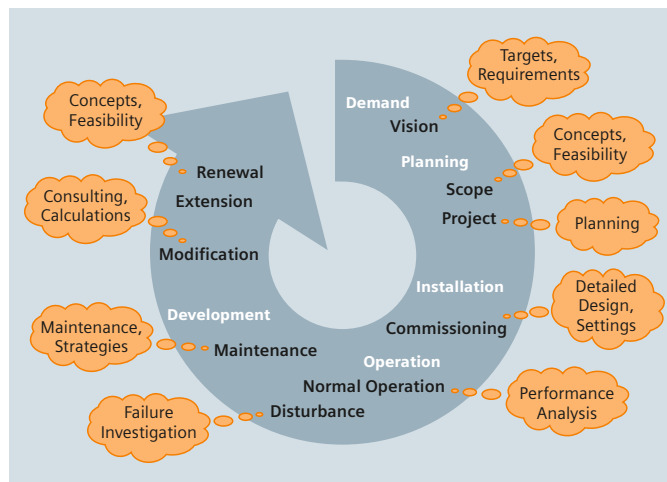


Fig. 9.2-1: Project life cycle and network planning tasks

In a running system, time and cost constraints are often the most relevant targets in planning the required modifications and updates. Typically, each of those cases will involve smaller changes to the network – but there is a continuous demand for such projects. Often the system develops into more and more complex network structures and operating principles.

Strategic network planning projects are required at regular time intervals. The goal is to re-assess the load demand and quality expectations to be met by the system, to integrate the latest developments in equipment technology and system design principles and to trim the expected technological and economical performance of the network to the current requirements and budget – that is, to make the network “fit for the future.” In this context, the development of suitable long-term concepts is a key requirement, and typically this is the first task requested in planning projects – following initial data collection and analysis of the existing system model (fig. 9.2-2), which may reveal certain weak points requiring immediate action. Actual network planning needs to start with the long-term view to be able to develop the strategic perspectives that then act as guidelines for the development of short- and medium-term concepts, as appropriate for all concepts following the defined planning criteria.

The development and analysis of such network concepts are the core tasks of strategic network planning (fig. 9.2-3). As indicated, this process starts with the compilation of the system model, which in most cases is the model of the system in its current condition. This network planning model has to consider at least the topological and electrical data of the equipment, and may be extended to several other data items as required for technical analyses to be conducted in the study. In practice, the condition and availability of data are often the most critical aspects in network planning, especially for more sophisticated analysis and the corresponding data requirements.

Based on this network model for a precisely defined base scenario, new variants are developed. This process defines the basic system architecture, considering planning criteria and standard equipment configuration as identified by separate investigations of, for example, pilot areas of the system or abstract network models. This process covers very basic questions, such as those relating to voltage levels and network structures, and also very detailed aspects of individual solutions where needed. Several different system variants – each meeting the relevant requirements with respect to overall network structure and equipment types – result from this step.

In order to arrive at a final solution, a detailed technical and economical analysis of these different system variants is required. Here, various technical network calculations and economic evaluations are performed, such as:

- Power flow calculation and reactive power analysis, identifying, for example, voltage levels at all busbars, the loading of lines and transformers, transformer tap changer settings, losses
- Short-circuit current calculation, evaluating, for example, indices for maximum and minimum short-circuit currents for different failure types in various failure locations

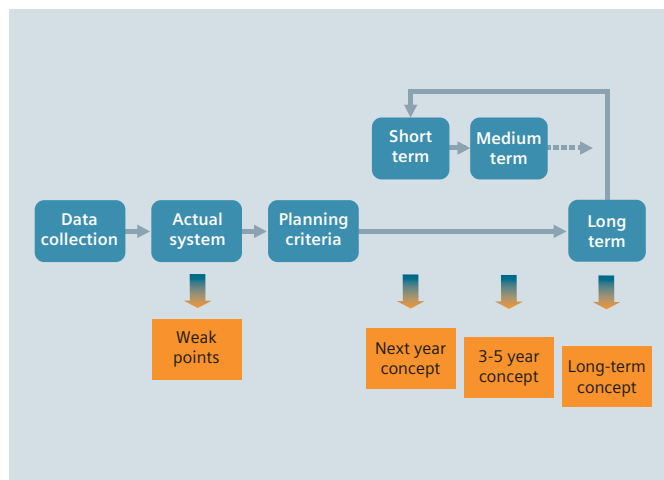


Fig. 9.2-2: Strategic network planning loop

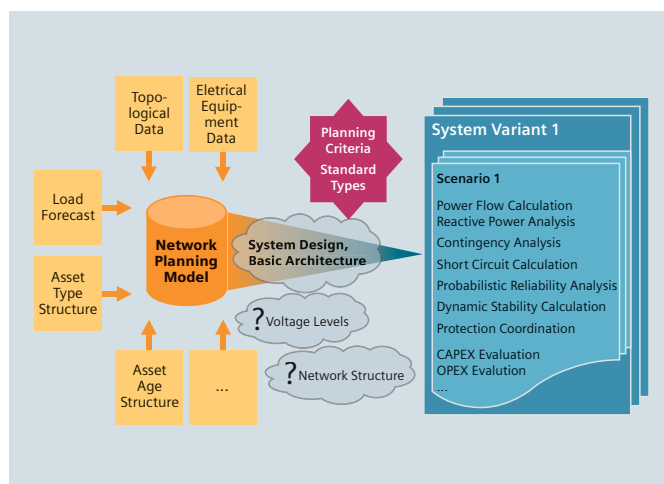


Fig. 9.2-3: Schematic overview of network planning process

- Probabilistic reliability calculation, delivering the expected values of reliability indices such as SAIDI (system average interruption duration index), and frequency of interruption
- Dynamic stability calculation, investigating, for example, the effect of failures on the stability of generators in the system
- Protection coordination, defining concepts and suitable parameters for selective and fast disconnection of electrical failures
- Economic analysis, assessing, for example, the required CAPEX (capital expenditure) and OPEX (operational expenditure) for a network
- Development of automation and control concepts, ensuring that operational performance requirements are met
- Other investigations and calculations, depending on the scope of study

The technical calculations have to follow the international and national standards relevant to the respective project, as well as

customer-specific standards and requirements. It might not be sufficient to execute the defined set of calculations only once – typically, several different system scenarios need to be analyzed for each variant. Different system scenarios are characterized by, for example, different load situations (winter/summer) or operating conditions (normal/disturbed operation), or as different phases in the transition of the present network state into the desired target state. In the end, comprehensive information on the technical and economic performance of the various network variants is available. Assessing these results will lead to the final solution, or recommendation, for the problem addressed in the study.

Typical issues addressed in a network planning project

Network planning projects are highly individual, because in each case the special conditions of the supply area, load demand and geographic distribution, technical standards and requirements, current status of the existing system, etc., have to be considered. The actual scope and goal of each project are different as well. Typical topics that may be addressed in network planning include:

- **Strategic network planning**
Completely new structures, modifications or extensions are to be developed for individual plants, certain areas within the system, or even for whole power supply systems need to be examined. The project scope can comprise anything from the selection of general network structures and voltage levels down to detailed functional specifications for substation design. The typical aspects of the system level under consideration – transmission network, distribution network or industrial network – need to be considered as well.
- **Dynamic performance of generators and transmission networks**
Transmission networks are responsible for the secure operation of the power supply system in large areas. A major concern is system stability, including several different aspects such as inter-area and intra-area oscillations of generators, transient stability or voltage stability. In large power systems, several generators or groups of generators may start to oscillate against each other as a result of operational changes or system disturbances. These inter-area oscillations need to be damped effectively in order to prevent system instability. By suitable calculations, the oscillations are analyzed and the optimal placement and settings of damping devices is evaluated.
- **Dynamic performance of industrial networks**
In industrial networks comprising local generation, the dynamic performance is of crucial importance. Besides the requirement to run the local generation in operation, special scenarios like decoupling from the public network, island operation, or system recovery after voltage dips need appropriate planning. In addition, the start-up of large motors may pose challenges to the dynamic performance of the system.
- **Protection design and coordination**
Electrical failures in power supply systems occur rarely, but nevertheless regularly, e.g., lightning strikes. They need to be cleared as fast and as selectively as possible in order to minimize safety risks and disturbances of system operation. The design of suitable protection systems, considering also

backup protection functionality, and the calculation of appropriate functional parameters for each protection relay ensure that these requirements are met.

- **Asset management**
The systematic and comprehensive consideration of technical and economic performance indicators of both individual equipment and the entire system over the complete life cycle requires detailed data. Certain information can only be provided by appropriate network calculations and supports, e.g., the prioritization of equipment in maintenance schedules or renewal programs, or the prognosis of expected technical system performance.
- **Power quality**
Today, many electrical appliances are becoming increasingly sensitive to power quality issues, like harmonics, voltage fluctuations or voltage dips. It is important to identify the current status of such power quality aspects in the system through evaluation, and to include these facets in the system model in order to derive suitable mitigation measures, such as filters. Harmonics are becoming an even more widespread problem, because new kinds of electrical appliances often generate significant levels of harmonics. As a result, the total harmonic distortion is increasing, and certain network configurations may even lead to resonances.
- **Earthing and interferences**
Earthing is an important aspect of power supply systems and highly relevant for safety issues. Appropriate earthing has to ensure that fault currents are limited to acceptable levels, and in the design of earthing systems the local geological features have to be considered. Fault currents or magnetic fields may also cause disturbing interferences with other technical networks. Such interferences on other electricity, pipe or communication networks, for example, need to be studied in order to delineate suitable mitigation and protection measures (called electromagnetic compatibility, EMC).
- **Insulation coordination, switching transients**
Electrical phenomena related to switching and lightning strikes, for example, can lead to high transient overvoltages in power supply systems. In order to prevent significant equipment damage, a suitable insulation level for all components is required. Related studies can include measurements of such transient phenomena, suitable modeling in special network analysis tools and the placing and rating of surge arresters and other mitigation equipment.
- **Special power supply systems**
Alongside the generally known networks for public and industrial power supply, special power supply systems are employed for exceptional tasks, such as oil-drilling or pumping platforms and vessels, underwater systems in wind parks or oil and gas plants, or isolated supply of ore mines. For all these systems, different planning tasks need to be defined and performed in order to ensure a safe and reliable operation despite the many components and aspects involved.

Siemens network consulting competences

Siemens Power Technologies International (Siemens PTI), the provider of network consulting, software solutions and T&D training within the Smart Grid Division of the Siemens Infrastructure & Cities Sector, offers network consulting services for any aspect relating to the planning and operation of power supply networks. With more than 100 dedicated consulting engineers employed in various international locations, there are experienced and internationally recognized experts available for any project.

Such projects vary from small studies, e.g., determining the functional parameters for one protection relay to be installed in a container crane – to very large projects, e.g., developing a master plan for the transmission system of a complete country, and to long-term partnerships with clients. The common thread is the high quality of the technical results and the high level of professionalism and objectivity in the execution of the consulting project.

The Siemens PTI scope of competences is illustrated in fig. 9.2-4:

- Expertise and experience in any system level, from LV distribution networks to EHV transmission systems – in three-phase AC systems, of course, but also in single-phase AC or DC systems and in the integration of DC devices like HVDC lines or FACTS
- Familiarity with the special requirements of both public utilities in distribution as well as transmission levels, and of industrial or commercial customers in any branch and of any size
- Consideration of both primary equipment, i.e., network structure and functional requirements for switchgear, transformers and lines, and of secondary equipment, i.e., protection system design, relay coordination, or network automation

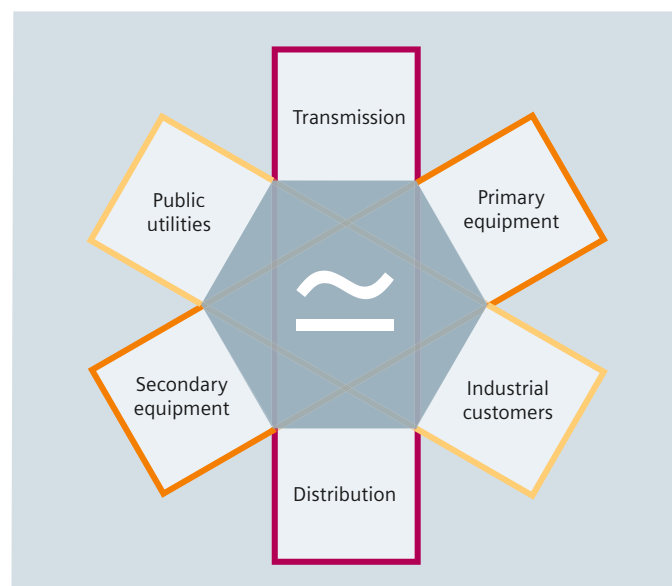


Fig. 9.2-4: Siemens PTI network consulting competences

More information on Siemens Power Technologies International visit:
www.siemens.com/power-technologies

9.3 Software Solutions

Various calculations of technical and economic characteristics of the actual system or of planning variants are part of the network planning process. The availability of suitable tools is highly important. Besides the obvious requirement that calculation results should be as accurate and reliable as possible, particularly with regard to the quality of both calculation tools and input data, several other aspects are also relevant for the successful and efficient use of network planning tools:

- Network model

The quality of calculation is dependent, above all, on the quality of the input data. The structure and complexity of the data model must support the various calculations, including those for very large network models. In large systems, the question of how the network and the data are structured and presented to the user is of crucial importance for the effective use of the software tools.

- User interface

Calculation algorithms implemented in the software tools have reached a very high level of complexity and are controlled by a multitude of different parameters. The handling and management of large network models is a complex task on its own. Therefore, an intuitive but comprehensive user interface is a key requirement for modern software tools.

- Management of calculation results

After the actual calculations have been performed, the results need to be analyzed and presented. In many cases, this means more than printing tables or network diagrams with certain result values attached to the respective components. The compilation of comprehensive graphical representations, tables and reports – both according to predefined and user-defined structures – provide significant support in the execution of network planning projects and should be supported by the software tools.

Siemens has used its great experience and know-how in network planning to develop powerful system simulation and analysis tools to assist engineers in their highly responsible work. The software tools of the Power System Simulator PSS®Product Suite are leading products with respect to technical performance and user-friendliness. Comprehensive interfaces enable the interaction of all PSS®Product Suite tools, and also support the integration with other IT systems.

PSS®E

With over 800 customers and 10,000 users in more than 100 countries, PSS®E (Power System Simulator for Engineering) is the premier software tool used by electrical transmission utilities and consultants worldwide.

PSS®E is an integrated, interactive program for simulating, analyzing, and optimizing power system performance – providing transmission planning and operations engineers a broad range of methodologies for use in the design and operation of reliable networks.

PSS®E has a modern, easy-to-use, graphical user interface (GUI). The GUI contains command recording capability to aid the user in building macros, which can be used to automate repetitive calculations. PSS®E has been used in production mode on the largest network-size models being simulated. Common reports in readable formats are standard. Most data can be entered and modified via the one-line diagram (fig. 9.3-1).

PSS®E Program Sections:

- Power flow
 - PV/QV Analysis
 - Sensitivity Analysis
 - FACTS/HVDC Modeling
 - Advanced Contingency Analysis with Corrective Actions and support of Multi-Processors
- Dynamics
 - Graphical Model Builder (GMB)
 - Small Signal Analysis
 - Wind Turbine Modeling
 - Eigenvalue Analysis (NEVA)
- Reliability
- Short Circuit
- Optimal Power Flow (OPF)
- Preventive Security Constrained OPF
- Python Scripting
- Scenario Manager
- Interactive Data Checking

PSS®SINCAL

PSS®SINCAL (Siemens Network Calculation) is a high-performance planning tool for the simulation, evaluation and optimization of supply systems. It is successfully applied by more than 300 municipal utilities, regional and national power supply companies, industrial plants and consultants worldwide.

PSS®SINCAL offers state-of-the art software technology and a fully featured scope of analysis methodologies for electrical networks as well as gas, water and district heating / cooling networks – integrated in one powerful and intuitive user interface (fig. 9.3-2). Using a commercial data base as data repository allows easy integration into the customer's IT environment. High-end automation features based on COM-server technology allow for the implementation of user-specific solutions. The availability of many ready-to-use interfaces facilitates the integration into existing IT architectures. PSS®SINCAL also serves as the foundation for the main database of all Siemens power system analysis products. Its fully unbalanced network model makes it the perfect tool for the simulation of distributed generation and wind modeling.

PSS®SINCAL Program Sections:

- Electrical networks (balanced and unbalanced)
 - Power flow
 - Smart power flow interfacing with metering database systems
 - Short circuit according to main standards and pre-fault loading
 - Modules for protection coordination, simulation and setting calculation, arc flash hazard

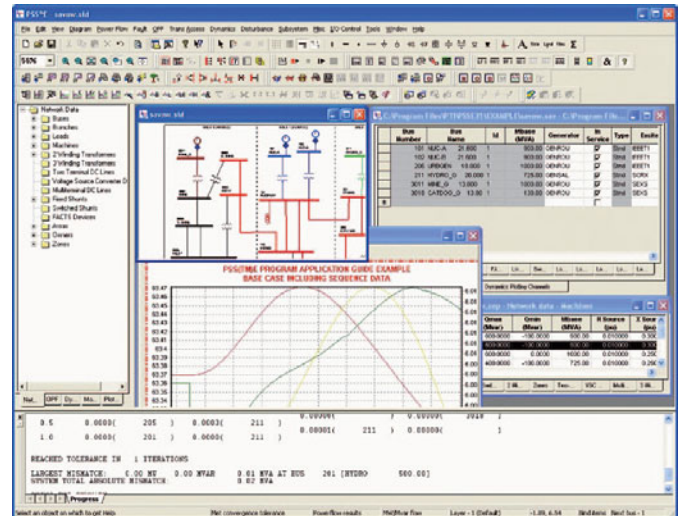


Fig. 9.3-1: PSS®E for electrical transmission system planning tasks

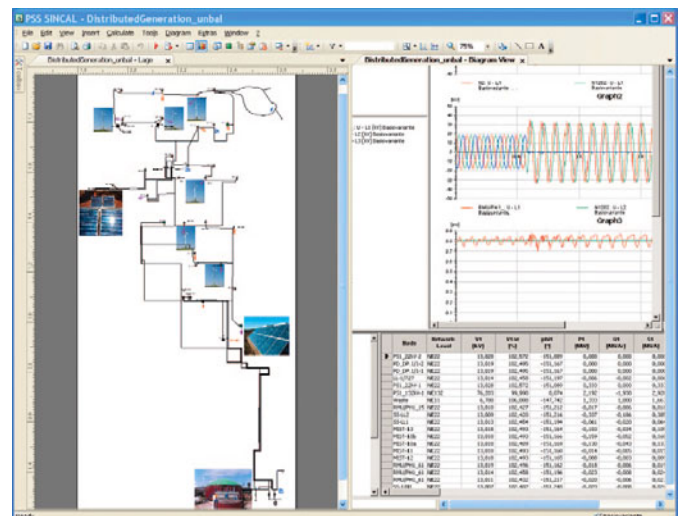


Fig. 9.3-2: PSS®SINCAL for utility and industry network planning tasks

- Modules for optimal power flow, optimal branching and compensation optimization
- Strategic network development
- Optimization and automatic design of network structures
- Economic calculation
- Modules for harmonics and ripple control
- Contingency Analysis with outage scenarios
- Modules for system dynamics including motor start, transient stability, electromagnetic transients, eigenvalue and modal analysis (NEVA) as well as graphical model builder (GMB), model libraries
- Probabilistic reliability calculation
- Pipe networks
 - Gas / water / heating / cooling steady state calculations
 - Gas / water / heating / cooling contingency analysis
 - Gas / water / heating / cooling quasi-dynamic simulation
 - Fire water simulation
 - Water tower filling
- Multi-user project management

PSS®PDMS – Protection Device Management System

PSS®PDMS (Protection Device Management System) is a universal program to centrally manage protection devices and their settings. All data is stored in a central relational database and is available for data exchange with other programs, such as relay parameterization software, network planning tools and asset management systems.

Numerous settings are needed to parameterize different functions of modern protection devices (impedance, differential, (back-up/directional) overcurrent time, overload, standby earth-fault protection, monitoring measurements, etc.). At any point in time – from setting calculation, to parameterization and testing – settings and accompanying documents must be traceable and the workflow state clearly indicated. PSS®PDMS is designed to facilitate the complex protection data management process comprising the involvement of different staff members, the management of different parameter sets for changing network configurations as well as the handling of different firmware. Fig. 9.3-3 shows the PSS®PDMS user interface and fig. 9.3-4 illustrates the typical protection data flows in a utility.

PSS®PDMS key features

- Multi-user enterprise application
- All data stored in one central relational database (either Microsoft® Access®, Oracle® Database or Microsoft® SQL Server®)
- Modern Microsoft® Windows® user interface for optimal data management
- Protection devices modeled comprehensively with all functions and settings, including different parameter sets for each relay
- Settings are checked against available setting ranges
- Straightforward creation and management of protection device templates
- Easy connection to external documents (parameter files, protection devices manuals etc.)
- Extensive functions for relay import and export
- Specification and customization of user roles and access rights
- Supports user defined workflows (e.g. planned, approved or active settings), including historical settings
- Data exchange with power system simulation software PSS®SINCAL enables protection engineers to verify the settings through simulation directly in the network model.

PSS®NETOMAC

The deregulation of the energy market is creating new demands on system planning engineers and system operators in power utilities and industrial companies. Traditional areas of activity have to be rethought and new ones acquired. In order to succeed in the open competitive markets of today, it is extremely important to have all required information available at the right time and in the right place. Also the protection against wide-area black-outs becomes more and more important (fig. 9.3-5).

PSS®NETOMAC (Network Torsion Machine Control) is a professional network planning tool designed to address any kind of steady-state and dynamic analysis of a power system. A variety of preprocessing options are provided, such as the parameter-

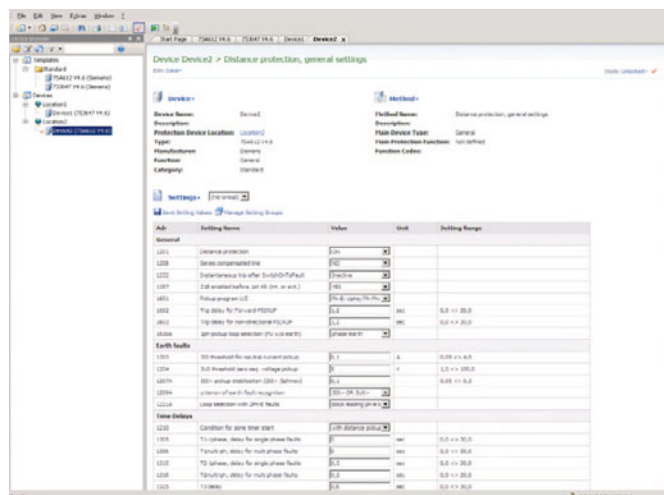


Fig. 9.3-3: PSS®PDMS user interface

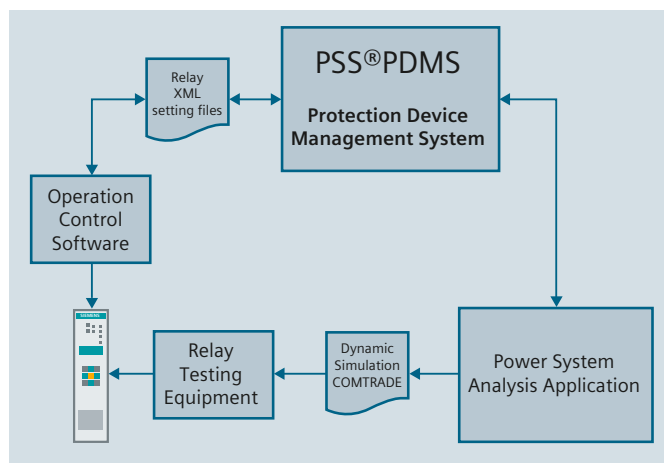


Fig. 9.3-4: Protection data flows

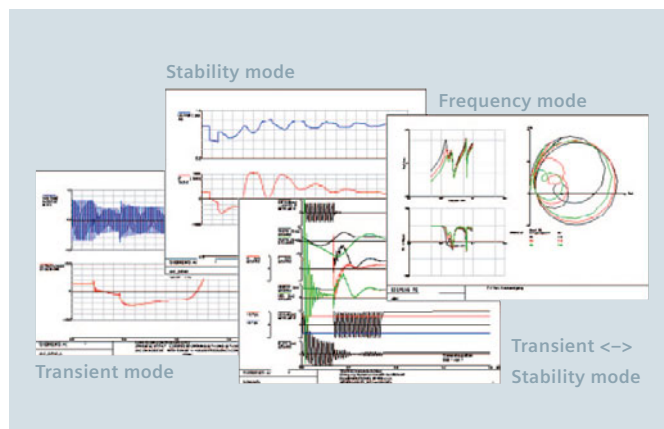


Fig. 9.3-5: Results from Time- and Frequency Domain calculations

izing of overhead lines, cables or motors and the identification of model parameters. The system analysis facilities are supplemented by user definable methods for optimization.

As a result, PSS®NETOMAC offers a great variety of possibilities:

- Simulation of electromagnetic and electromechanical transient phenomena in the time domain
- Handling of balanced / unbalanced and d.c. networks
- Steady-state load-flow and short-circuit current calculations
- Frequency range analysis
- Eigenvalue and modal analysis (NEVA)
- Simulation of torsional vibration systems
- Parameter identification and optimization
- Reduction of passive and active networks
- Interactive network training simulator
- Real-time simulation (DINEMO)
- Extended user interface for the graphical input of network and controllers structures and results documentation
- Data import and export from and to other planning packages, e.g. PSS®E, PSS®SINCAL, etc.
- Graphical Model Builder (GMB)
- Interface to dynamic models built with Simulink®

DINEMO

DINEMO (Digital Network Model) is an intelligent signal treating device that works as a real-time transceiver between protection relays or turbine controllers and simulation programs for electrical power systems like PSS®NETOMAC. DINEMO runs on a standard Windows® PC and allows real-time simulation with up to sixteen analog output signals that are continuously calculated in PSS®NETOMAC. Four analog or sixteen digital feedback signals of the equipment under test can be treated, allowing a closed-loop interaction between protection relays or controllers and the simulation program. Such real-time tests, with round-trip times of up to 0.15 ms, are possible using PSS®NETOMAC with its high-speed calculation algorithms running on Dual Core CPUs. DINEMO is used for tests with analog controllers with input voltages of max. ± 10 V and with frequencies of up to 5 kHz. With additional power amplifiers, close-to-reality tests can be accomplished with standard protection relays. DINEMO allows extensive tests on protection relay configurations using detailed models of all network elements (fig. 9.3-6).

SIGUARD®Solutions

SIGUARD®Solutions offer a combination of software, training and consulting to prepare the customer for the new challenges and the upcoming security requirements in power system operations. Applying SIGUARD®Solutions provides the following benefits:

- Blackout prevention
- Increase of power system utilization
- Improvement of situational awareness

SIGUARD®Solutions support the decision making process of the power system operator. The basic idea is to increase the observability and the controllability of the system and to perform an automatic, intelligent security assessment. An overview of SIGUARD® software tools is given in fig. 9.3-7.

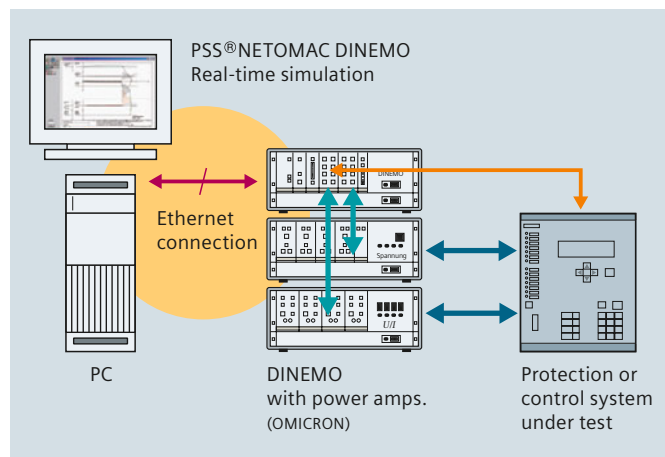


Fig. 9.3-6: Principle of DINEMO application

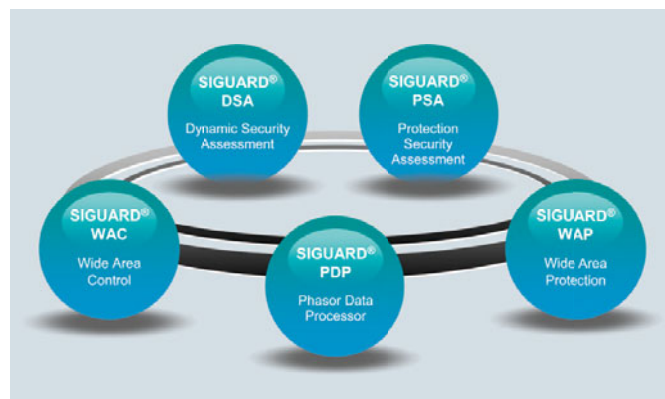


Fig. 9.3-7: Illustration of single software parts of SIGUARD®Solutions

SIGUARD®PDP – Phasor Data Processor increases the observability of power systems with the help of time synchronized, highly exact measurements (PMU – Phase Measurement Units).

SIGUARD®DSA – automatic and intelligent Dynamic Security Assessment for calculation of the stability margin and validation of remedial actions.

SIGUARD®PSA – automatic and intelligent Protection Security Assessment for finding weak points in the protection system.

SIGUARD®WAC – Wide Area Control system for realization of the optimal remedial actions, which were validated in SIGUARD®DSA.

SIGUARD®WAP – Wide Area Protection system for realization of adaptive settings and special protection schemes, which were validated in SIGUARD®PSA.

The SIGUARD® team offers a combination of software, training and consulting to our customers. The software forms the basis of SIGUARD. We provide the following services:

- On-site commissioning of all or single parts of the SIGUARD®Solutions,

- Adaptation to the control room applications of any vendor,
- Adaptation of the power system models of any vendor to the SIGUARD® format,
- Adaptation to the power system specific requirements (e.g. grid code).

Within the SIGUARD®Solutions trainings on the following topics are offered:

- Power system dynamics
- Voltage stability assessment
- Transient stability assessment
- Small signal stability assessment
- Handling of the SIGUARD® software components

In addition, as consultants we provide ongoing support when it comes to system studies regarding special protection schemes, remedial actions, power system and protection planning.

PSS®ODMS

PSS®ODMS is a data management and network applications suite centered on the international standards Common Information Model (CIM) and Generic Interface Definition (GID). Siemens PTI's Operational Database Maintenance System (ODMS) and Power System Simulator for Operations (PSS/O) have been integrated into PSS®ODMS, making this product one of the most advanced network modeling and applications tools for network operation and network planning (fig. 9.3-8).

PSS®ODMS is designed to create or install into a CIM environment, and optionally to either create or install into a GID-based enterprise platform. It offers the user tools to:

- Decipher models from many different sources
- Import and export a full model, partial models and incremental models
- Aggregate the models
- Create future study scenarios
- Apply an extensive set of business rules to increase the accuracy of the resulting model
- Store that model in an open, industry-standard database structure that may be used by many current and future applications
- Convert operations models to planning models.

The integrated PSS®O functionality comprises:

- Topology processor
- State estimation
- Real-time power flow
- Contingency analysis
- Outage ranking
- Real-time mode and study mode.

MOD®

MOD® (Model On Demand) significantly extends the capabilities of PSS®E by enabling the user to manage a great number of change cases for PSS®E. MOD® assembles sets of model changes into "projects" (fig. 9.3-9). Projects can then be managed and organized in various fashions depending on the needs of the PSS®E user.

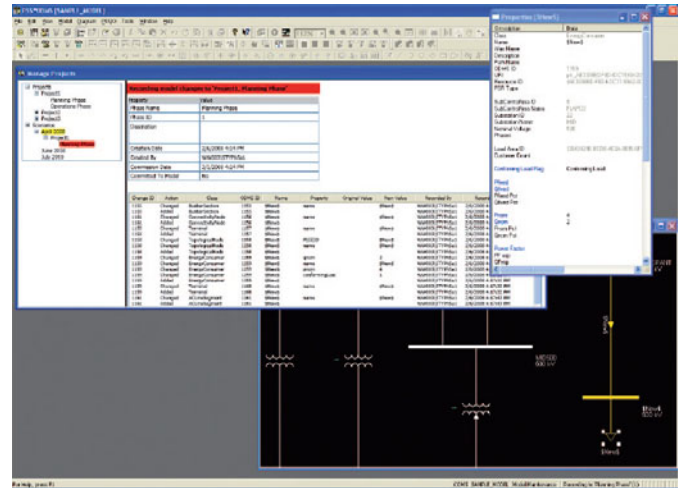


Fig. 9.3-8: PSS®ODMS data management and network applications suite

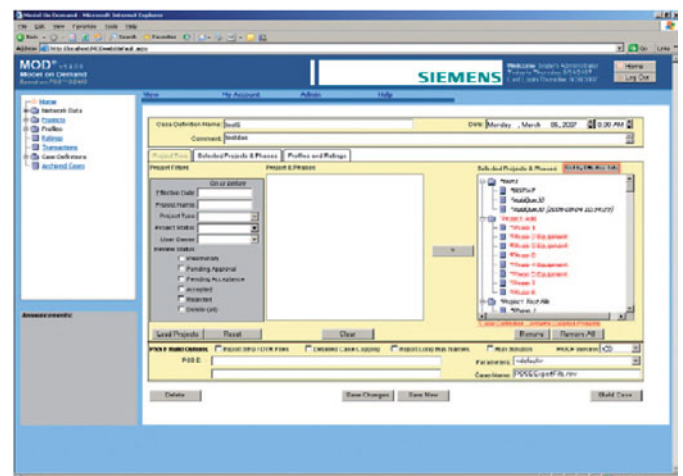


Fig. 9.3-9: MOD® extension for PSS®E

These modeling projects are coupled with MOD® seasonal and annual profiles to provide the PSS®E user with a procedure for organizing and reorganizing system investigations. All this can be done without generating a great number of PSS®E base cases or repeatedly rerunning PSS®E cases when planning sequence changes.

MOD® delivers PSS®E formatted power flow models which can be processed and utilized by the full PSS® Product Suite. MOD® revolutionizes transmission planning data manipulation and the generation of major study data sets.

MOD® allows the system study engineer to:

- Organize and reorganize study cases without the need to generate a multitude of PSS®E "base cases"
- Store a single master network model
- Accommodate seasonal and annual profile data sets

- Treat projects as sets of data changes that are applied serially in any order specified by the user
- Export a PSS®E file with equipment commissioning/decommissioning dates, out-of-service and in-service dates
- Provide an unlimited number of ratings to be applied as Rate A, B, C in the exported PSS®E case

SIGRADE

SIGRADE (Siemens Grading) is a software program for overcurrent protection coordination of high, medium and low-voltage networks. It allows the selection of grading paths and drawing of tripping characteristics of fuses and protection relays into a log-log current-time diagram. SIGRADE guides the user from the initial simple sketch of the project through the collected information and data to short-circuit calculations, supports the user in developing a protection concept, and documents the complete relay coordination of overcurrent protection devices (fig. 9.3-10).

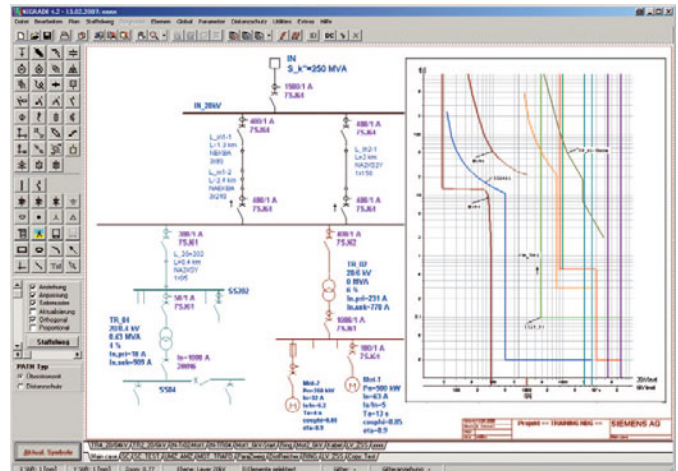


Fig. 9.3-10: SIGRADE for overcurrent protection coordination

CTDim

CTDim (Current Transformer Dimensioning) is a software program for current transformer (CT) dimensioning, dynamic simulation of CT behavior and drawing of saturation curves (fig. 9.3-11). Reports are prepared automatically. The optimization of current transformers with regard to technical requirements and economic aspects is becoming more and more important. CTDim makes current transformer dimensioning more efficient. CTDim saves engineering and production costs by optimizing the current transformer data.

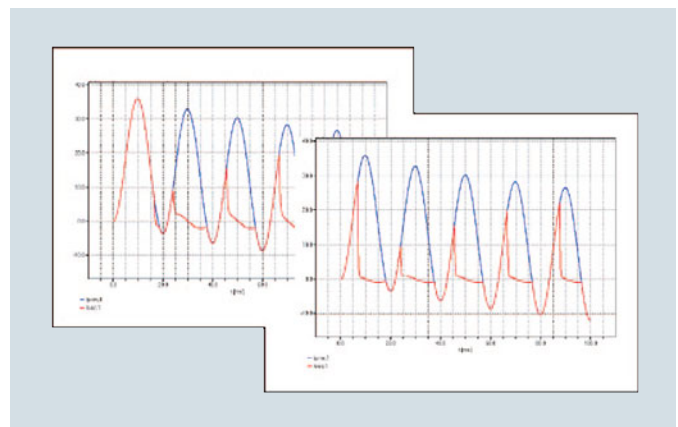


Fig. 9.3-11: CTDim for current transformer dimensioning

CTDim comprises the following features:

- Easy dimensioning of CT data
- Dynamic simulation of saturation curves
- Input of CT data according to IEC, VDE, BS and ANSI standards
- Database of protection device-specific CT requirements
- Automatically customized documentation

PSS®MUST

The capability to move power from one part of the transmission grid to another is a key commercial and technical concern in the restructured electric utility environment. Engineers determine transmission transfer capability by simulating network conditions with equipment outages during changing network conditions. Many uncertainties remain in the process.

The purpose of the PSS®MUST (Managing and Utilizing System Transmission) software is to efficiently calculate:

- Transaction impacts on transmission areas, interfaces, monitored elements or flowgates
- Generation redispatch factors for relieving overloads
- Incremental transmission capability (FCITC)
- FCITC variations with respect to network changes, transactions and generation dispatch
- The impact of transmission element outages on power flow by both DC and AC contingency analysis

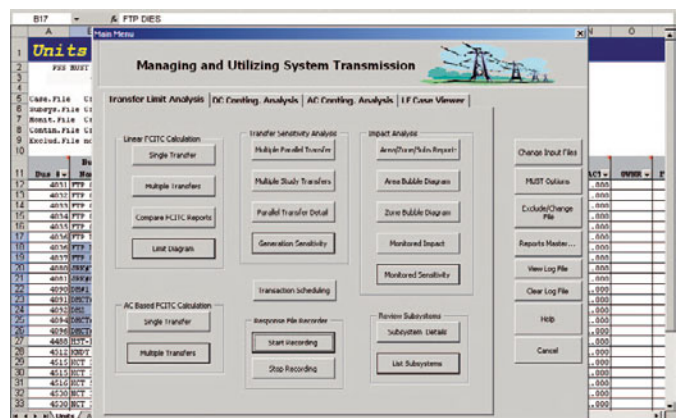


Fig. 9.3-12: PSS®MUST for transmission transfer capability analysis

PSS®MUST complements PSS®E data handling and analysis functions with the most advanced linear power flow and user interface available (fig. 9.3-12). The program's speed, ease-of-use and

versatile Microsoft Excel interface, coupled with the ability to run automated scripts, simplifies and reduces data setup time, and improves both results display and understanding.