TOTALLY INTEGRATED POWER

Integrative Planning and **digital Transformation**

SIEMENS

Content

1 **Digitalization** revolutionizes electrical planning

Digitalization has fundamentally changed traditional electrical planning in many respects and added new facets.

Where a few years ago it was still common practice to plan individual trades such as electricity, heating, ventilation, building and process automation, communication and IT technology separately and as a self-sufficient unit with a few interfaces to the neighbouring trades, an energy-efficient and trouble-free plant operation without deliberate component networking and a certain degree of automation is no longer in scope.

At the same time, considerations of a possible sector coupling in order to achieve maximum energy efficiency across all trades.

This makes planning more complex – but it pays off in the long run!

Digitalization, energy automation and the conscious exploitation of available potential to increase efficiency are no longer a matter for large energy supply companies – at the latest with the increased use of decentralized power-generating plant (PV roof systems), the laying of fibre optic cables or the modernization of heating systems including app control and remote maintenance, these technologies have successfully found their way into the infrastructure of individual existing buildings.

Changes that are seen as an opportunity encourage us to adopt new, creative approaches and the development of new solutions and technologies.

Holistic construction and electrical planning that incorporates these new digital possibilities are the basic building blocks for a lasting, sustainable and, above all, efficient use of our energy resources and therefore for the success of our society's desired energy transition.

This application manual shows electrical planners ways and options for a profitable integration of digital technologies into their existing planning strategy.

Using practical examples from everyday planning, concrete solutions are offered with products and systems from Siemens.

2 **Digital Aspects** in Electrical Planning

2.1 Sustainability

Sustainability is a key issue in the modern world – also in electrical planning.

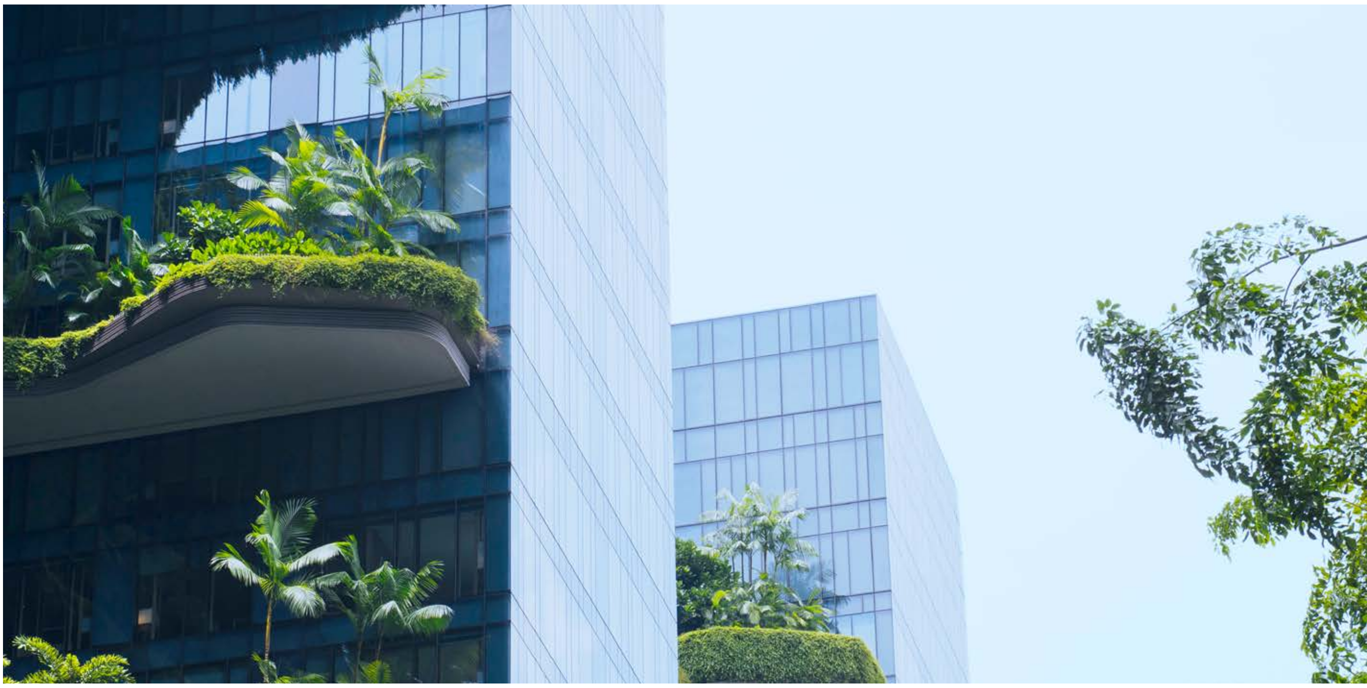
Sustainability is not limited to reducing energy consumption, but acknowledges social, ecological and economic aspects. Sustainable electrical planning aims to use natural resources in an environmentally friendly way and takes into account the needs of future generations.

Finite resources must be used sparingly, efficiently and, if possible, recurrently as part of a circular economy and, where possible, used on a recurring basis until suitable alternatives are found. This applies in particular to electrical energy. It ensures our high standard of living – worldwide and in almost all areas of life. And our demand for electrical energy is growing with the increasing integration of new, innovative technologies into our living environment.

The previous principle of centralized power generation from fossil fuels and radioactive elements in large power plants, with subsequent transportation and distribution across the country is no longer sustainable. The same applies to the almost careless use of electrical energy on consumers' side. Fundamental changes towards more efficient and responsible practices are required.

New, innovative planning approaches are needed for the construction or expansion of infrastructure facilities and industrial plants in order to make the use of electrical energy sustainable and efficient.

> **siemens.com/sustainability**



2.2 Transparency and Efficiency in Energy Consumption

In order to achieve sustainable targets in the use of electrical energy, transparency in consumption behavior is crucial. This clarity not only enables efficient use of electrical energy, but can also be easily transferred to other types of energy such as heat.

Consumers, whether private or in industrial manufacturing processes, need to understand their internal processes in order to create an accurate energy consumption profile.

Intelligent measuring devices and systems at central points of use provide the necessary information for this. Software solutions help to centrally collect, analyze and evaluate the consumption data collected, from which a future consumption forecast can be derived in the medium term. This makes energy requirements predictable and therefore plannable.

2.3 Sector Coupling

Sector coupling represents an extended approach to increase energy efficiency in building complexes and industrial plants across all sectors. The energy sectors – electricity, heat, transport and industry – are interconnected to exploit synergies and form a comprehensive energy system.

In the infrastructure sector, these synergy effects can be achieved, for example, by linking photovoltaic systems with heating rods surplus electricity from the solar systems is used to heat domestic water, which reduces the need for fossil fuels to generate heat.

In the industrial sector, combined heat and power plants (CHP) optimize energy use through the principle of cogeneration. They use the waste heat generated during power generation in the integrated turbines/motors to heat office buildings or feed it into district heating networks instead of releasing it unused into the environment. In this way, resources are used efficiently and fossil energy consumption is minimized.

2.4 Use of Automation Solutions

Real-time information and measurement data on grid utilization and energy consumption form the basis for the use of intelligent control and automation systems. Tailored to the specific needs and behavior, these systems independently ensure that electrical energy is brought to the right place, just at the moment it is needed.

Automated regulation and control processes are particularly essential when the focus is not only on the efficient use of energy, but also on availability of electrical energy due to the increased use of volatile energy sources which requires a dynamic adjustment of consumption.

Industrial plants and large infrastructure facilities often use different automation systems, including building automation systems, process and energy automation systems. Each system is specified and designed for different purposes.

Similar to sector coupling, overarching efficiency increases in energy use can be achieved: If automation systems are interlinked, a cross-system exchange of information is established, which enables cross-process control and extremely efficient plant operation.

2.5 Digitalization and Connectivity (IoT)

Digitization is the key enabler for highly efficient and emission-free plant operation. This involves far more than just converting analog information or system measurement data into digital formats.

Digitalization stands for increased communication, networking and interaction in conjunction with the application of the latest technologies, such as artificial intelligence or the Internet of Things (IoT), as well as an adapted working methodology.

Digitalization thus leads to a multidimensional transformation of information, working methods and processes as well as the structure of the systems used. This results in a multidimensional, much broader approach to the planning and design of electrical infrastructures, which enables the sustainable and efficient use of resources during operation.

2.6 Building Information Modelling (BIM)

Building Information Modeling (BIM) describes a cooperative working method for a networked planning, construction and operation of buildings with the assistance of intelligent software.

All building data is consistently recorded in digital models over the entire life cycle, managed and exchanged in transparent communication between project participants or transferred for further processing.

The process is based on four basic principles:

- At the beginning, you build twice – first, you create a digital representation of your building before you start building a real building.
- The second principle is to plan and build collaboratively, coordinating and approving design solutions already during the planning phase.
- The third principle states that data is generated only once. This means that the role that originally creates the data is the only one that really needs to create data, and other roles can reuse this data.
- The fourth principle is that BIM considers the entire life cycle of a building and takes all requirements into account.

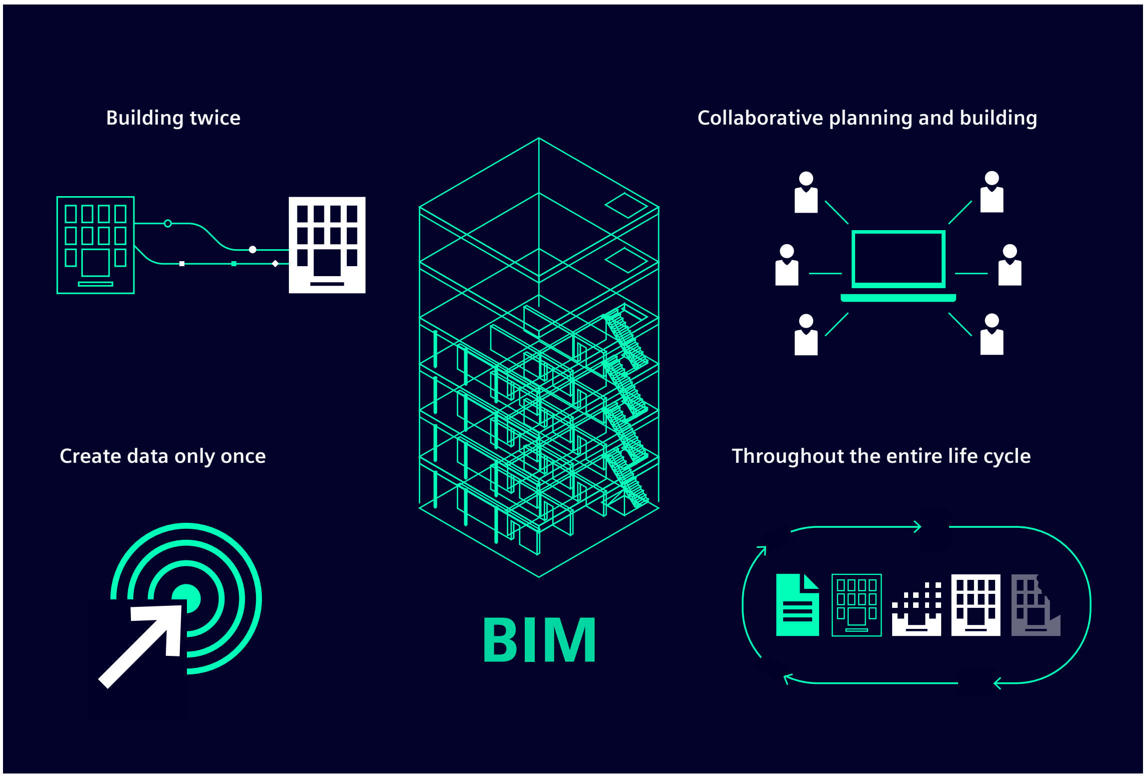


Fig. 2.1: BIM and its key principles

BIM is supported by various tools, technologies, and contracts.
In the electrical part of a BIM project, the SIMARIS planning tools are a good example to demonstrate this.

> **siemens.com/simaris**

The data exchange of BIM objects takes place in the IFC (Industry Foundation Class) file format. Its scope is defined by criteria called LOIN (Level of Information Need) and by categories:

- LOI – Level of Information
- LOG – Level of Geometry
- DOC/LOT – Level of Technical Documentation.

The data extent of BIM objects depends on the respective project phase, the role of the project partner from whom the data is required, and the respective BIM use case (Fig. 2.2).

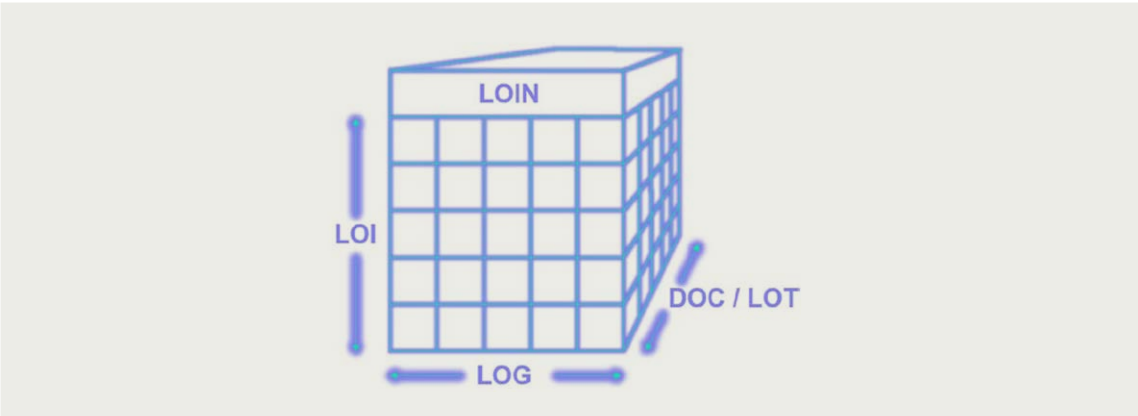


Fig. 2.2: Data extent of a BIM object defined by LOIN (Level of Information Need)

As construction progresses, the BIM object approaches the "As-built model", which steadily increases the amount of data and its accuracy (Fig. 2.3).

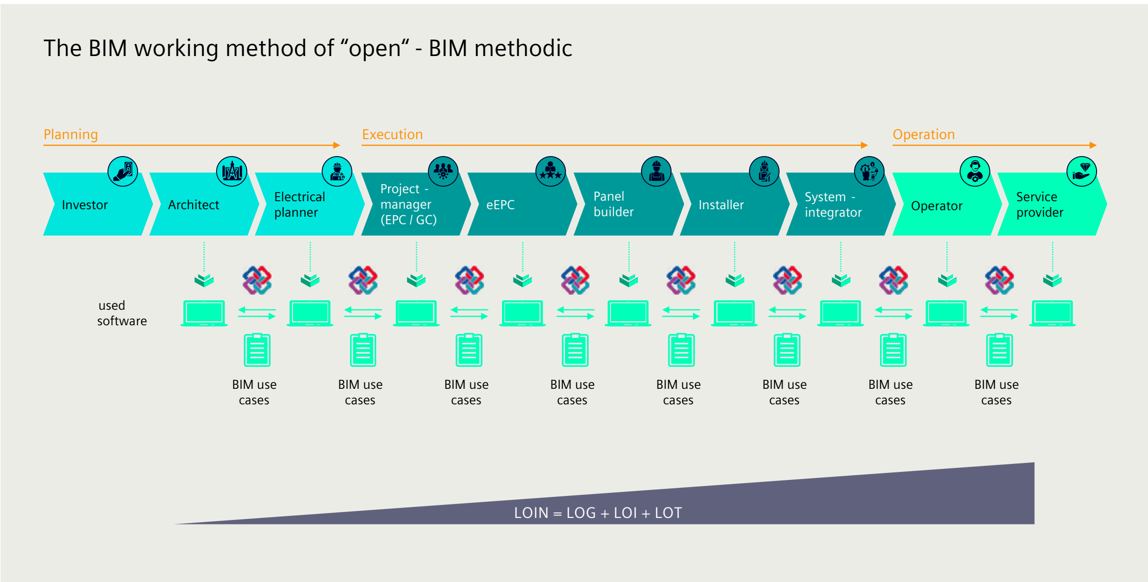


Fig. 2.3: Step-by-step model of a BIM-object

3 Products and Software Solutions
for the digital Transformation

3.1 Electrification X, SaaS, Xcelerator Marketplace

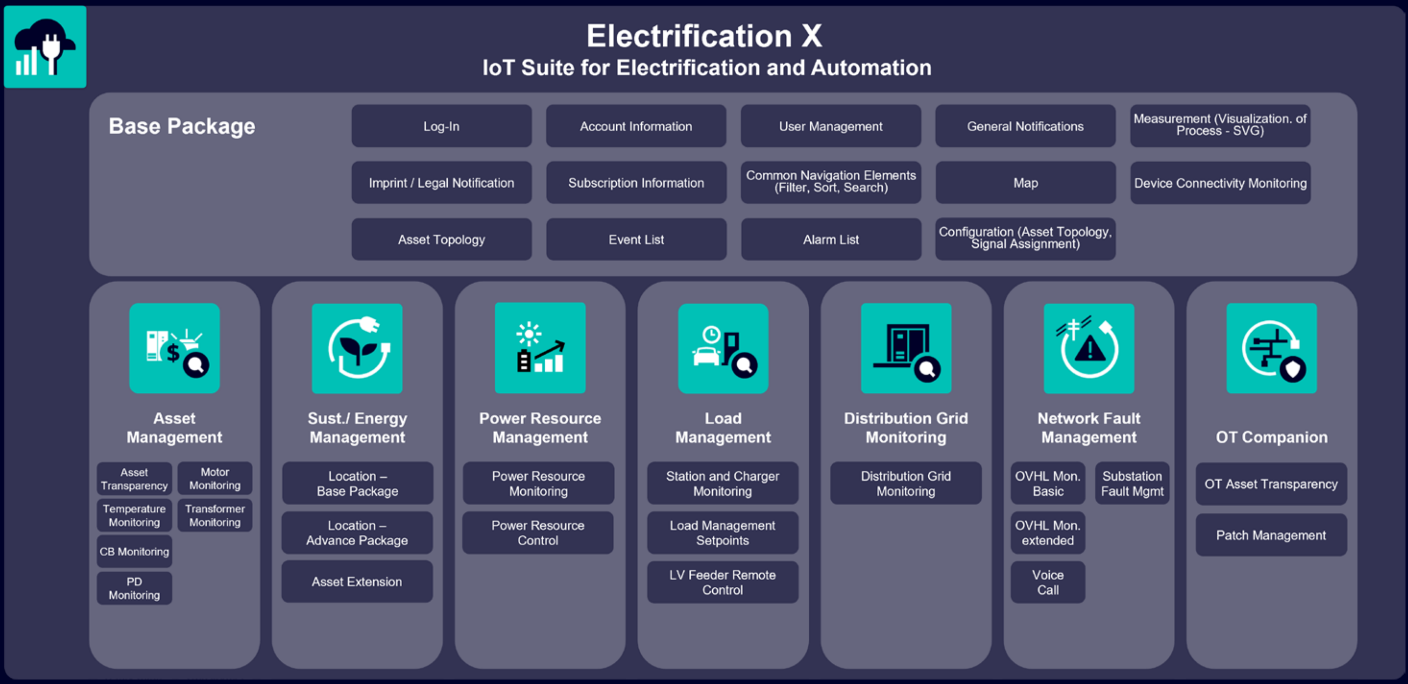
Electrification X is an IoT suite that combines the real and digital worlds in a scalable Software-as-a-Service (SaaS) offering.

The IoT suite supports industrial and infrastructure customers as well as transmission/distribution grid operators in comprehensively managing their energy grids and ensures maximum availability, efficiency and safety in system operation.

- Reduction of energy costs and CO_2-emissions
- Optimization of operating expenses by reducing operating and maintenance costs
- Increasing operating times and reliability, extending the service life of the systems
- Improving the availability and reliability of energy automation components in energy automation such as relays and RTUs
- Handling of low-voltage consumer loads to stabilize the power supply grid
- Maintaining and stabilizing grid quality despite the growing share of decentralized generation and the charging of electric vehicles
- Reliable protection of systems against cyber threats
- Continuous software updates to ensure cyber security

> **siemens.com/Electrification X**

Electrification X: Scope



The IoT suite Electrification X and other SaaS offerings from Siemens are available on the Xcelerator Marketplace. As an open digital business platform, it supports customers with a comprehensive portfolio of connected hardware and software solutions to drive their digital transformation easier, faster and at scale.

As a powerful partner ecosystem, this platform thus serves as a pioneer for digitalization solutions and enables companies to increase their productivity, improve their competitiveness and scale innovation.

siemens.com/Xcelerator

3.2 SIMARIS Suite & SIMARIS Planning Tools

Planning the electric power distribution for industrial plants, infrastructure, and buildings is becoming more and more complex. To help you as an electrical planner work faster and better, the SIMARIS Suite supports you with its valuable collection of software tools and information material on technical topics.

› **siemens.com/simaris**

The NEWS section provides daily information about updates, additional functions, and all kinds of news relating to electrical planning. This also includes the availability of new webinars, which you can register for via the suite.

The SOFTWARE section contains the latest versions of the respective SIMARIS planning tool and shows the availability of new versions. New versions can be installed or started here. If you have worked on older projects with a previous version, you can also start these easily using the SIMARIS Suite.

In addition to the SIMARIS planning tools, with SIMARIS Web Tools the suite also offers a range of highly interesting standalone tools for electrical planning.

The SUPPORT section contains a valuable compilation of worldwide TIP contact partners as well as available information and innovations relating to BIM or the SIMARIS planning tools.

SIMARIS Planning tools

SIMARIS design

With the SIMARIS design software you can perform the network calculation, including the calculation of short-circuit currents, based on real products with minimum input effort.

SIMARIS project

Free planning tool that allows you to plan electrical distribution systems easily, quickly and clearly, including budget pricing, tender specification texts, and generation of BIM-files.

SIMARIS curves

For graphical display or comparison of characteristic curves of the switching and protection devices used (current-time, let-through current, let-through energy).

SIMARIS busbarplan

With this tool, available as a plug-in for Autodesk Revit®, you can carry out the 3D planning of SIVACON 8PS busbar trunking systems.

SIMARIS sketch

This free software is a standalone solution for the 3D planning of SIVACON 8PS busbar trunking systems in the context of BIM.

SIMARIS Web Tools

SIMARIS curves web

A web-based version of SIMARIS curves with identical functionality, without the need for installation. This enables more flexible access and use on different end devices..

Tender specification texts

Central platform for provision and download of tender specification texts for Siemens products and systems.
The main topics include:

- Electrical power distribution
- Industrial switching technology
- Building technology
- Drive technology
- Automation technology
- Safety technologies

Optionally, data export in the formats .TXT, .RTF, or GAEB (.X81, .D81)

> **siemens.com/tender-specifications**

SIMARIS ecoguide

Tool for visualising sustainability and costs as a decision-making aid for SIVACON S8 configurations.

Efficiency Guide

A free tool for energy efficiency assessment of buildings according to DIN VDE 0100-801.

EMC Busbar

Tool for calculating the magnetic radiated disturbance for SIVACON 8PS busbar trunking systems according to the distance to the busbar run.

Selectivity & Backup Manager

Tool for creating individual selectivity or backup limit value tables for specific device combinations (low-voltage).

Sitrato

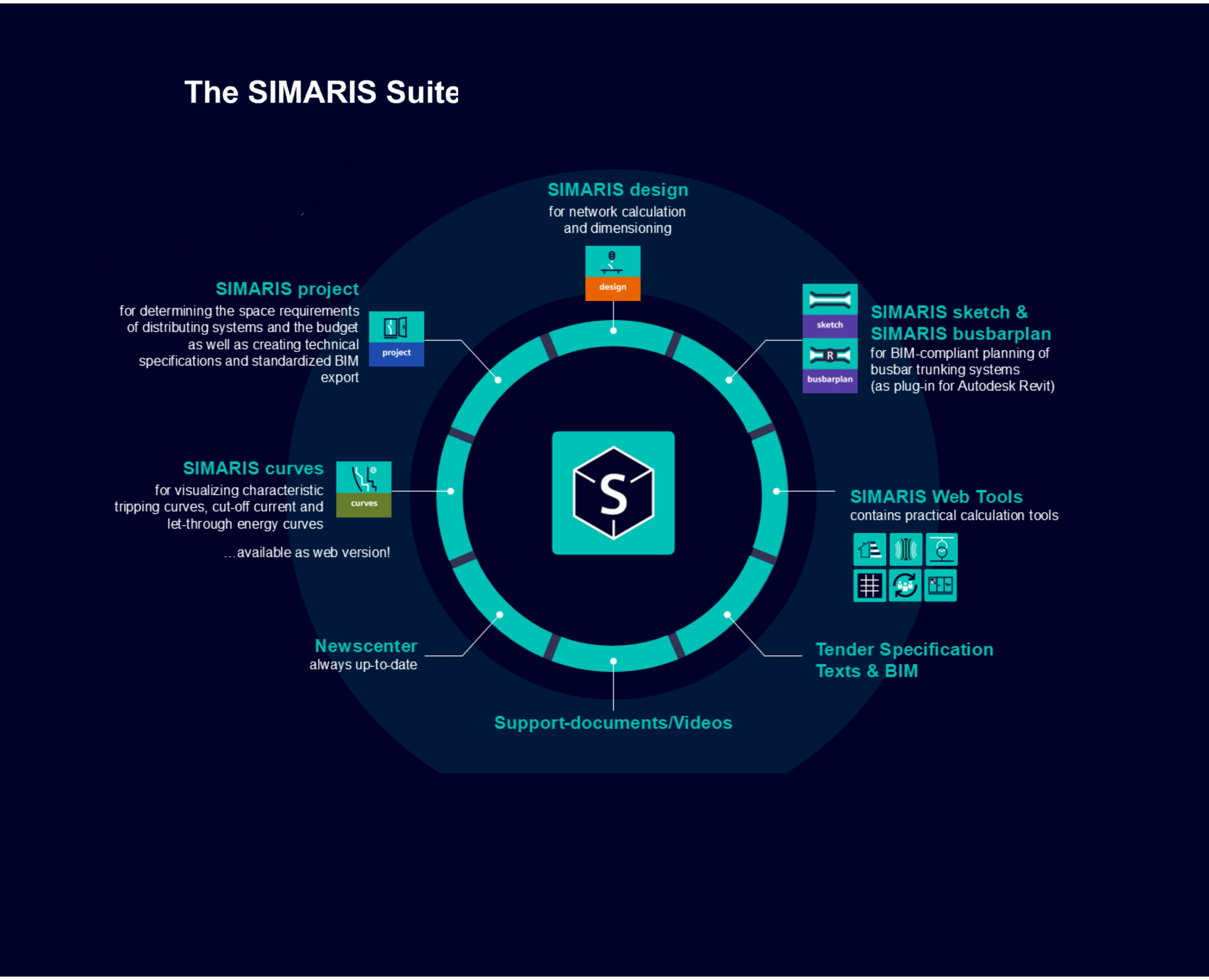
Tool for spatial pressure calculation for GEAFOL transformers in case of an arc fault.

SIMARIS xchange

Cloud-based platform for collaboration and visualization of BIM and 3D files.

With regard to the context of BIM working methods (**Chap. 2.6**), data and interim results from the SIMARIS planningtools can be exchanged digitally between the individual modules, automatically updated or transferred digitally to other trade planners.

> **siemens.com/simaris**



The integrated IFC data export in SIMARIS configuration and SIMARIS project enables electrical planners to participate in open or closed BIM projects, as required.

CLOSED-BIM

In the so-called CLOSED BIM concept, the data is exchanged according to a proprietary information model of a software manufacturer and the Common Data Environment (CDE) is integrated. The proprietary information model is based on a schema of the software manufacturer, the structure of which is not disclosed ("closed").
With a closed BIM approach, the software used should be tailored to several specialist planning disciplines and the project team should be put together in such a way that as many specialist planning disciplines as possible can work with this software.

OPEN-BIM

With the Open BIM concept, data is exchanged using open information models. An open information model is based on an open schema, such as the IFC schema from buildingSMART International.

Software applications from different manufacturers must be able to import and export data according to the agreed, open information model.

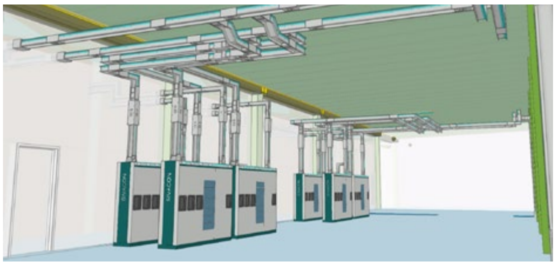
Tool-specific information exchange (closed ecosystem)

Standardized information exchange

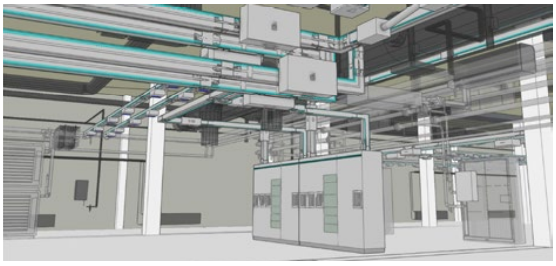
The integrated IFC data export in SIMARIS configuration and SIMARIS project enables electrical planners to participate in open or closed BIM projects, as required.

The As-built BIM data from SIMARIS configuration are more detailed comparing to As-planned data from SIMARIS project:

- System and enclosure dimensions as well as degree of protection, rated currents, ambient conditions, power loss, etc. includes the mapping of the exact system layout including the field structures and functional units.
- Main devices in the doors and covers are shown with their exact positions and with high graphical details.
- Visible door opening directions to be following escape route planning.
- Exact footprint considering switchgear shape with corner cubicles and roof plates.
- Required clearing zone around the switchboard for installation, operation and maintenance.
- Reference points for connection with cable or busbar trunking systems.
- Level of technical data includes basic articles of the mounted main devices, plant and cubicles dimensions as well as degree of protection, rated currents, environmental conditions, power losses and more.



Sample grafic 1:
BIM-process supported by the SIMARIS planning tools



Sample grafic 2:
BIM-process supported by the SIMARIS planning tools

6.1 BIMPOWER™

BIMPOWER™ is a robust and user-friendly Revit-Plug-in for electrical planing of buildings according UL- and ANSI-standard. It enables BIM designers to configure dynamically model-based electrical power distributions.

Based on Siemens products, the plug-in generates configuration-specific device models. All models can be adapted at any time, which allows to integrated third-party components easily.

The resulting BOM-list can be exported or directly transferred to Siemens' quotation platform (COMPAS).

For further informations
usa.siemens.com/bimpower

Key Benefits

Ensuring constructability

- Quickly and accurately convert system requirements into models with verified 3D-dimensions
- Models dynamically update in case of design change

No software licensing fees

- BIM-stakeholders can use SIMARIS xchange platform for collaboration and data-exchange for project documents as well as BIM and 3D-models
- Professional planning and project-support from Totally Integrated Power worldwide

Time saving

- Auto-create a bill of material (BOM) for all electrical components
- Expedited timeline for project workflow, review and approval timeline
- Voltage-drop calculation and budget pricing

Open for Third-party components

- Customizable model dimensions
- Dimensions from Siemens products can be adapted at any time

3.3 Measuring Devices for Power Quality, Energymonitoring and consumption

Low-Voltage Measurement Technology PAC-Measuring devices – 7KM/7KT

The SENTRON PAC product family is a series of multifunctional measuring devices for the precise recording and analysis of electrical measurands in low-voltage networks.

Ideal for use in industrial plants, functional buildings, offices, homes and critical infrastructures, they enable reliable monitoring and integration into existing automation and energy management systems. Their diverse communication options support efficient and reliable monitoring and analysis of energy distribution.

PAC 4220

The SENTRON 7KM PAC 4220 power analysis measuring device is used to precisely record typical electrical measurands to assess system statuses and power quality, especially in the process and manufacturing industries as well as in critical infrastructures such as hospitals and data centers. With a wide range of communication options, the device can be easily integrated into automation and energy management systems, supported by Modbus TCP, PROFINET, PROFIBUS and Modbus RTU. Additional modules offer digital and analog interfaces, N-wire direct measurement, residual current measurement and RS485 gateway functionality. The 7KM PAC measuring devices are available in variants with different auxiliary power supplies.

PAC 3220

The SENTRON 7KM PAC 3220 multifunction meter offers basic functionality comparable to the PAC 4220. It is well suited for basic energy consumption measurements in less critical applications where the functional depth, communication and analysis capabilities of the standard version are economical and practical.

PAC 2200

The SENTRON 7KM PAC 2200 energy meters are designed for the calibrated measurement of energy consumption in single-phase and three-phase networks. They are suitable for use in industrial plants, functional buildings, offices and apartment buildings. Equipped with a certified load profile that complies with the calibration law requirements in accordance with PTB-A50.7, these meters are particularly suitable for billing purposes. The SENTRON 7KM PAC 2200 energy meters offer an extended range of functions with regard to precise and reproducible energy value recording for feed-ins, electrical outgoing circuits or individual consumers, either via transformer or direct measurement up to 65 A.

PAC 3200T

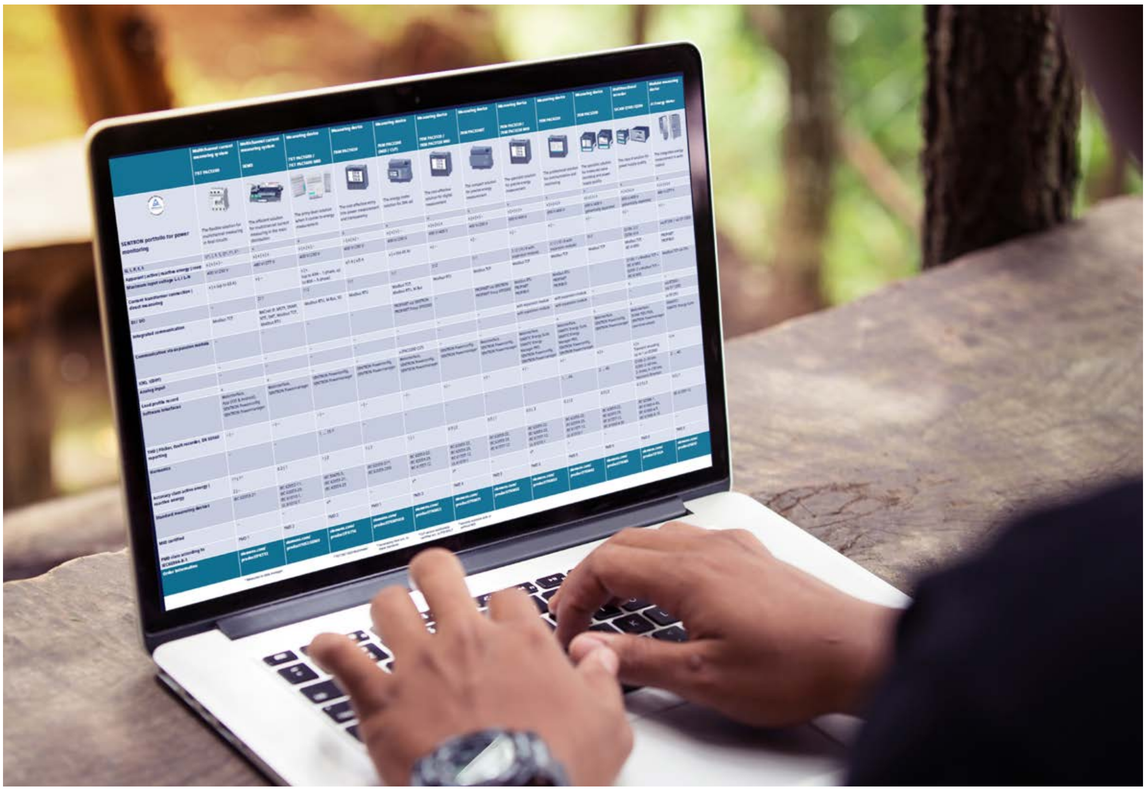
The SENTRON 7KM PAC 3200T is a measuring device for the precise measurement and monitoring of electrical energy consumption data in industrial and commercial applications. It offers comprehensive functions for recording electrical variables and fulfills the requirements of PMD-III, enabling a detailed analysis of the energy flow. The PAC 3200T can be seamlessly integrated into existing automation systems and energy management solutions via Modbus TCP. The PAC 3200T does not have an integrated display and is designed exclusively for DIN rail mounting, which, together with its compact design, makes it ideal for use in control cabinet applications. Thanks to their versatile communication options, the devices can be easily integrated into higher-level automation and energy management systems via Modbus TCP and PROFINET for further processing of the measurement data.
The SENTRON 7KM PAC 3200T measuring devices are available in different versions to suit to the scope of your requirements, also in non-calibrated form.

PAC 1200/PAC 1261

The SENTRON 7KT PAC 1200/PAC 1261 multi-channel current measuring device enables a high level of transparency in the application. It measures the current values using sensors that are mounted above the circuit breakers. This precise recording of current values by sensors is ideal for monitoring and analyzing current distributions in various applications. The measured data can be integrated into higher-level systems for further processing and analysis. The system is easy to install and enables detailed monitoring of power distribution. These devices are particularly useful for applications where accurate and reliable power monitoring is required, helping to improve energy efficiency and operational safety. Thanks to their versatile communication options, the devices can be easily integrated into higher-level automation and energy management systems via Modbus TCP and PROFINET for further processing of the measurement data.

The SENTRON 7KT PAC 1200/PAC 1261 measuring devices are available in various design versions, either in calibrated or non-calibrated form.

A complete overview of the PAC measuring device family, technical specifications and areas of application can be found in the Quick Selection Guide



> **Quick Selection Guide**

Medium-Voltage Measurement Technology

SICAM Q100/Q200

The SICAM Q100 and SICAM Q200 power quality instruments are suitable for precisely recording, monitoring and analyzing electrical measurands and power quality. Typical applications include harmonic analysis, transient recording or determining the direction of disturbances. Both measuring device types meet the requirements of class A in accordance with IEC 61000-4-30.

The SICAM Q200 power quality analyzer is an extended, highly sensitive version of the Q100 for demanding applications in which high-frequency transients or pulse disturbances are to be expected.

MV/LV Switching/Protection Devices with integrated measurement and communication functions

SENTRON low-voltage switching and protection devices offer reliable protection for people and systems as well as integrated measurement and communication functions. These functions enable consistent engineering, precise energy data acquisition and seamless integration into digital environments.

The use of switching and protection devices with integrated measurement and communication functions is particularly advantageous when space-saving installation is required or when the connected load feeder requires independent data acquisition and control due to its power rating.

The integrated measurement and communication functions in SENTRON switching/protective devices are equivalent to those of the PAC measuring device family.

3WA/3VA COM

The SENTRON 3WA/3VA circuit breakers enable real-time monitoring of characteristic values such as voltage, current and phase imbalances. For this purpose a so-called communication module (COM) is used for this purpose.

Communication takes place either via Modbus TCP/RTU or Profinet IO and enables simple integration into existing networks and communication with other devices. This also enables remote monitoring and control of the circuit breaker.

Further information on the measuring functions of SENTRON circuit breakers:

- **Equipement Manual 3WA 08/2025**
- **System Manual 3VA Communication**

SENTRON Miniature Circuit Breaker

Die SENTRON miniature circuit breaker 5SL6 COM combine switching and protection functions with integrated communication and measuring functions and bring transparency to the energy consumption behavior of the final circuit.

Information on the switching status enables predictive maintenance. It is also possible to retrofit these series with communication and measurement-capable auxiliary/fault signal switches.

These devices record parameters such as temperature, tripping and switching cycles. All measured values are transmitted via a wireless protocol to the 7KN Powercenter 1100 and then forwarded to higher-level systems via an Ethernet interface (Modbus TCP).

Detailed information on the measuring functions of SENTRON circuit breakers can be found in the system manual for circuit breakers with communication and measuring function.

- **System Manual – Circuit protection devices with communication and measuring function**

SENTRON Fuse Systems

3NA6 COM fuses with gG-characteristic and framesize 2 are ideal for low-voltage systems with a rated current of 100 to 315 A@400 V. They offer a breaking capacity of 100 kA in accordance with IEC 60269 and have insulated grip tabs for safe handling.

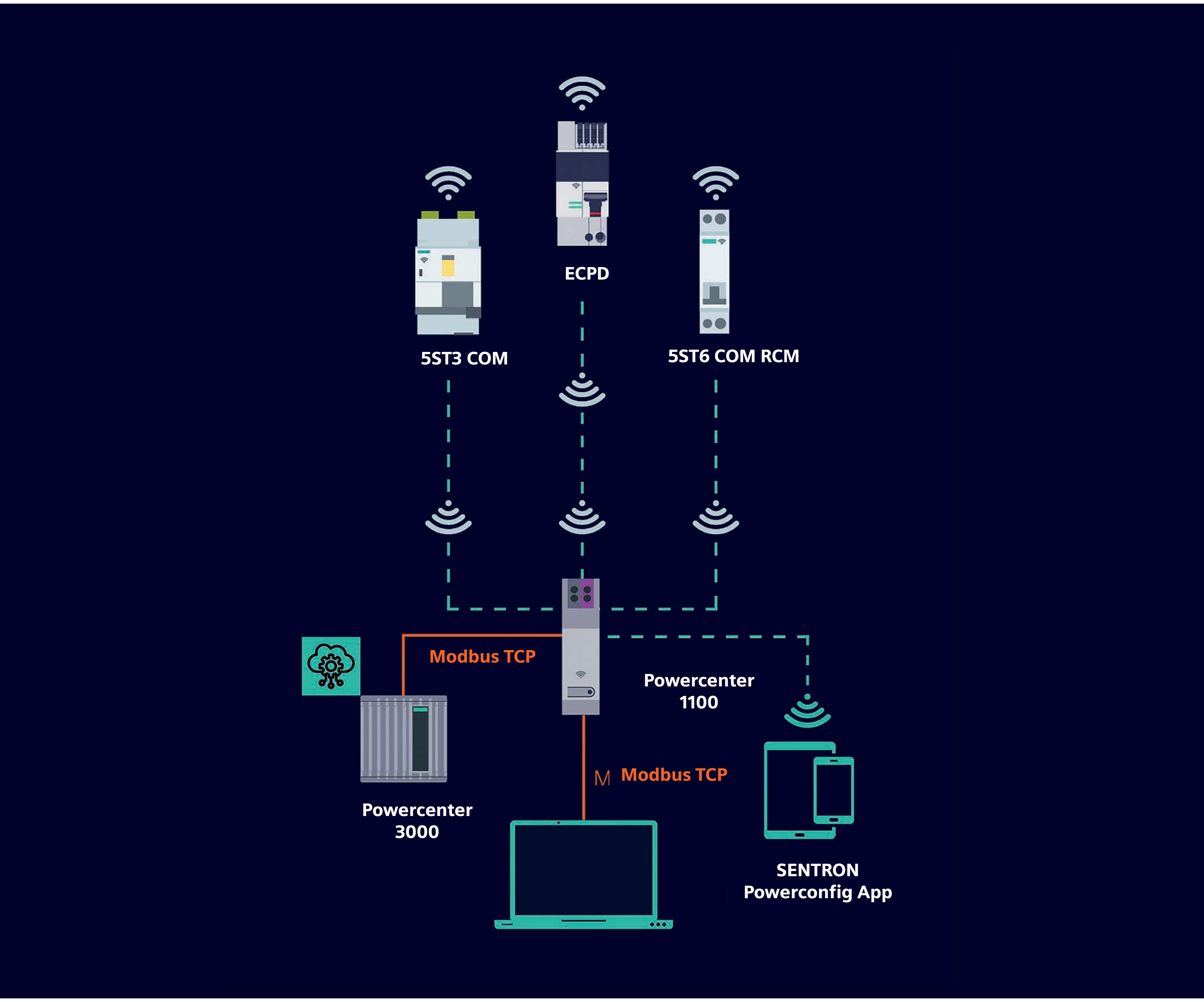
In combination with SICAM EGS, they record the effective value of current and temperature as well as the direction of energy flow. Integration is facilitated by the paring and export function via SENTRON Powerconfig.

Thanks to the wireless communication interface, data can be reliably transferred to SICAM EGS without complicated conversions, making it easy to retrofit existing systems.

ECPD – 5TY1

The Electronic Circuit Protection Device (short: ECPD) combines the proven reliability of classic electro-mechanical switching technology with the speed and precision of state-of-the-art power electronics, while at the same time offering a wide range of intelligent additional functions for networking and integration.

> TS21-ECPD



SIPROTEC Protection Devices

At medium-voltage level, the SIPROTEC devices from Siemens offer a wide range of measuring functions that are relevant for the monitoring and protection of power grids in industrial applications.

- Voltage and current measurement: SIPROTEC devices can measure voltages and currents in different areas of the power grid to ensure accurate recording of the grid parameters. This includes the measurement of phase and neutral voltages as well as phase and neutral currents.
- Power measurement: SIPROTEC devices offer the option of measuring active and reactive power to monitor and control the energy flow in the power grid. This includes the measurement of active power, reactive power and apparent power and the calculation of power factors.
- Frequency measurement: SIPROTEC devices can measure the frequency of the electricity to ensure that it remains within the permissible limits. This is important for the stability and synchronization of the power grid.
- Analysis of harmonics: SIPROTEC devices support the analysis of harmonic distortions in the power grid in order to assess the quality of the grid supply and identify problems such as resonances and harmonics.
- Symmetry and asymmetry measurement: SIPROTEC devices can measure the symmetry and asymmetry of voltages and currents in the power grid in order to detect imbalances and take appropriate measures to stabilize the grid.
- Power factor correction: Some SIPROTEC devices offer functions for measuring and control of reactive power in order to improve power factor correction and energy efficiency in the power grid.

Energymonitoringsoftware/Data Concentrator

The SENTRON Powercenter 3000 module simplifies the entry into operational energy management and offers an intuitive solution for monitoring and optimizing energy consumption, specially developed for low-voltage power distribution.

As a plug-and-operate system, the SENTRON Powercenter 3000 is designed to record, store, export, visualize and transmit data from connected SENTRON measuring and protection devices or any generic Modbus devices.

At sensor level, the system allows the connection of up to 212 devices, whose values are queried, calculated and stored in the integrated database. The integrated web interface enables visualization, analysis and commissioning tasks to be carried out. 15-minute energy values can be stored for up to 14 months and exported for further analysis using an export function.

It is also possible to transfer the values to the Siemens cloud application SENTRON Powermind or to other cloud systems via an MQTT interface.

The system offers numerous setting options with regard to industrial cybersecurity and serves as the basis for an energy management system (in accordance with ISO 50001), an energy audit (in accordance with DIN EN 16247-1) or the creation of energy performance indicators (in accordance with ISO 50006).
The exported data can be further processed with external tools such as MS Excel.

SENTRON Powercenter 1100

The SENTRON Powercenter 1100 Module offers comprehensive data acquisition of communication and measurement-capable switching and protection devices, ensuring a high level of transparency in the final circuit and making it easy to derive measures.

It enables the connection of up to 24 terminal devices and the temporary storage of selected data, resulting in comprehensive data availability.

An integrated Bluetooth interface enables mobile data readout on site via the SENTRON Powerconfig mobile app.

The integrated Modbus TCP interface enables a connection to the SENTRON Powerconfig software and the energy monitoring software SENTRON powermanager.

It is also possible to integrate the system into cloud solutions, to perform data analyses with SENTRON Powercenter 3000 or other cloud gateways to carry out data analyses. The compact design of the system ensures minimal space requirements in the distribution board (1 TE).

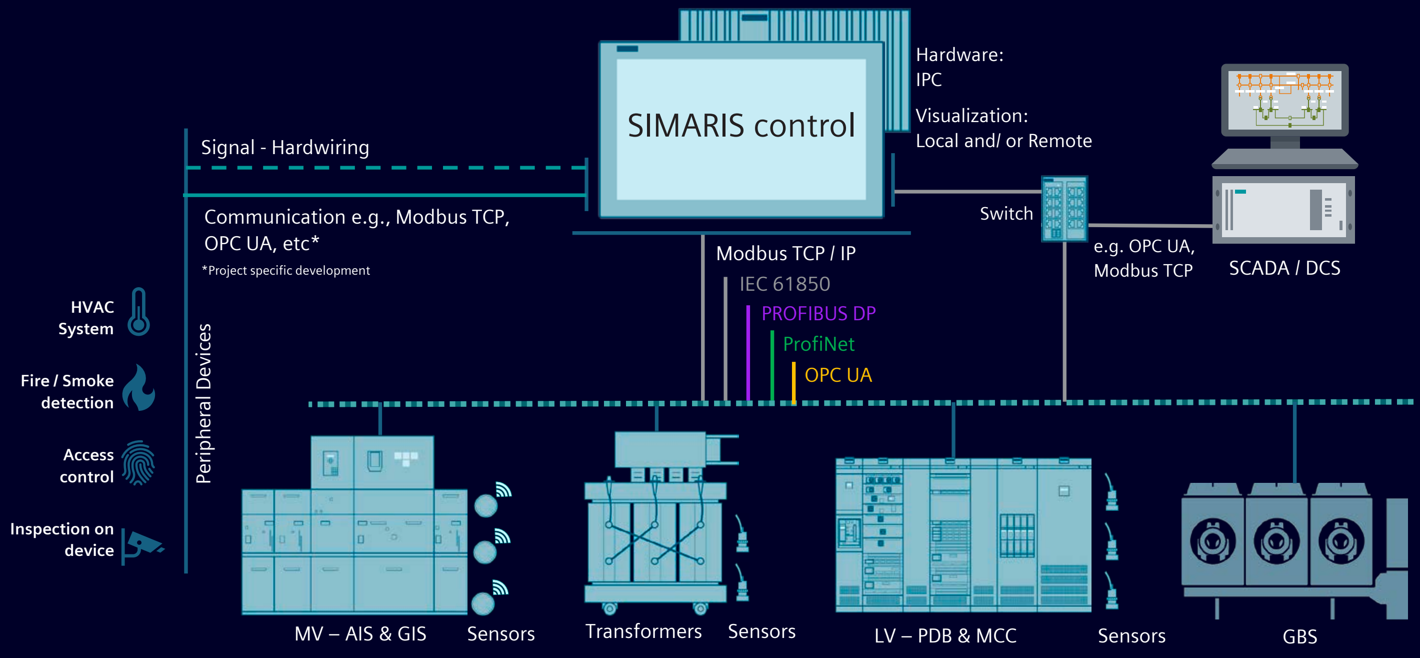
SENTRON powermanager

The energy monitoring software offers comprehensive transparency and monitoring for low-voltage energy distributions based on a flexible license system.

Freely configurable views can be created with the basic license. The optional graphics editor extension package offers additional programmable views such as system circuit diagrams. The software functions include the querying, visualization, archiving and evaluation of measured values, the generation of alarms and warnings and the storage of energy data in a flexibly expandable SQL database. It offers two user interfaces (function and role views) for easy handling and optimized standard views for supported Siemens devices.

The software supports the development of an internal energy management system in accordance with ISO 50001 and is TÜV-certified. Together with the operating system and environment, it ensures an overall system based on cybersecurity concepts and provides a cybersecurity guideline for optimal operation. The software supports Modbus TCP and enables subordinate Modbus RTU devices to be read out via gateways.

SIMARIS control
General architecture



SIMARIS control

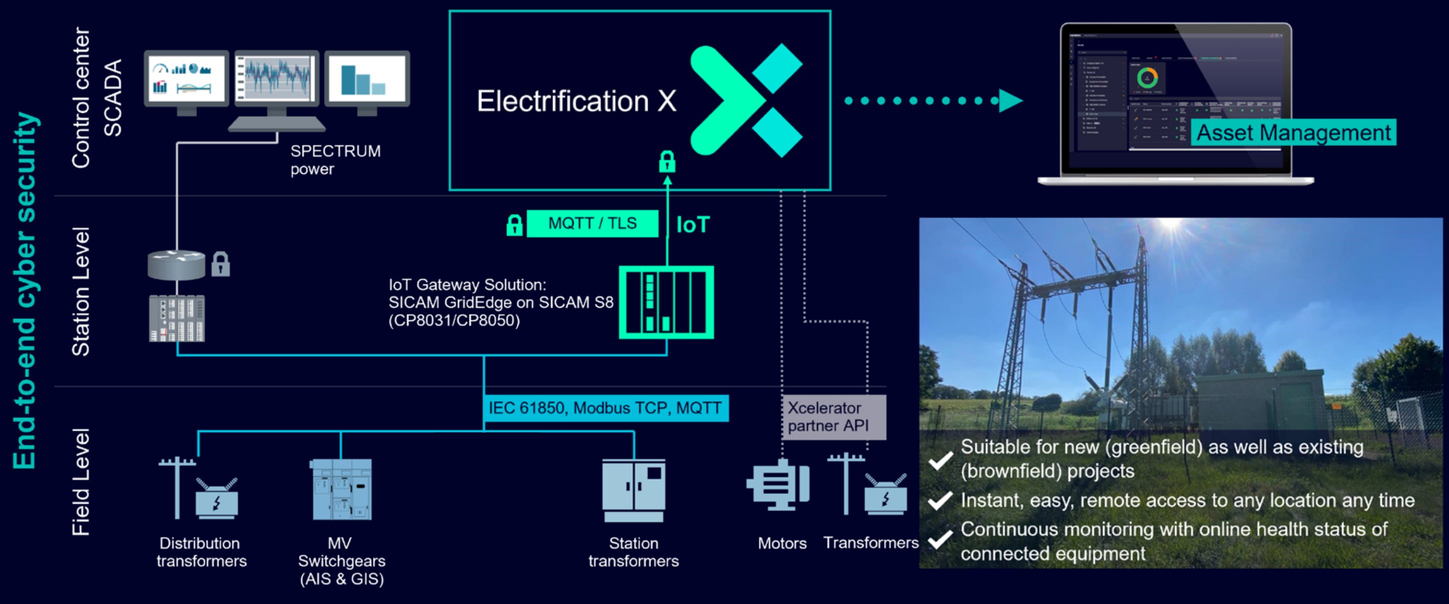
SIMARIS control is a powerful software application for monitoring, analyzing and controlling electrical power distribution systems in low- and medium-voltage, analysis and control of electrical power distribution systems in the low and medium-voltage range. The software enables comprehensive data acquisition from communication-capable devices. To ensure reliable data analysis, the collected data is stored on site.

It offers comprehensive options for condition monitoring in power distribution. This solution enables operators to continuously monitor the condition of their electrical systems and react to potential problems at an early stage.

A central function of SIMARIS control is status monitoring. Various parameters such as temperature, humidity and electrical values are continuously recorded and analyzed. This data provides valuable information about the current status of the switchgear. Continuous monitoring detects deviations from normal operating conditions at an early stage and thus enables preventive maintenance and avoid breakdowns. The diagnostic functions help to quickly identify and rectify the causes of faults, thereby reducing downtimes and increases system safety.

SIMARIS control increases the transparency of systems and contributes to energy efficiency. Operators can optimize the operation of their plants, reduce operating costs and increase the reliability of the systems. The software offers real-time monitoring, visual representation of the systems, alarm management and comprehensive reporting functions, enabling holistic energy management. Graphical representation and touch control make operation and maintenance intuitive and efficient, enabling predictive planning based on reliable status data.

Electrification X – Asset Management
Technical Setup



Electrification X – Asset Management

Siemens Electrification X Asset Management is a digital solution for managing energy distribution and automation systems as well as networks at medium-voltage level. The platform enables the visualization and continuous monitoring of electrical systems, whether in a single substation or across multiple locations. It provides operational data, information on the health status of the systems and visualizes all alarms including their status and details.

By integrating with the Siemens Xcelerator IoT Software-as-a-Service offering, Electrification X helps companies to efficiently manage their energy networks, increase uptime, improve asset reliability and utilization, and increase energy efficiency, sustainability and cybersecurity (**Chap. 2.5**).

> **siemens.com/Electrification X – Asset Management**

3.4 Energy Automation with SICAM Components

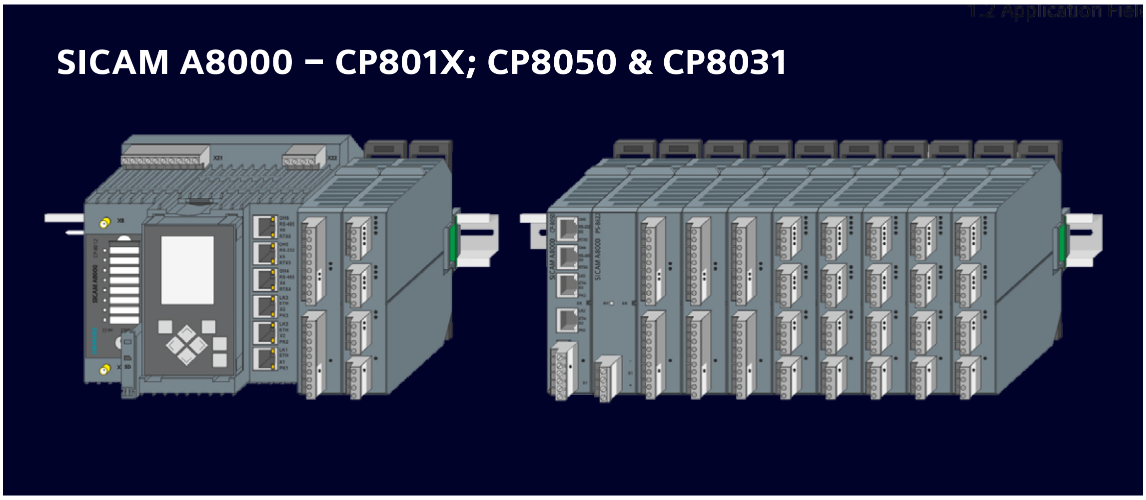
SICAM A8000

The SICAM A8000 devices are part of the SICAM 8 Power Automation Platform and suitable for power/gas distribution stations, hydropower plants, pipelines, as building protection or as an alarm device.

Their core functionality qualifies the SICAM A8000 devices for versatile applications as:

- Classic telecontrol unit
- Telecontrol unit with versatile communication to the central station
- Automation and monitoring of transformer substations
- Control of transformers
- Energy transmissio and distribution
- Microgrids
- Traction power supply
- Connection of renewable energies (wind, sun, water)
- Communication-Gateway
- IoT-Gateway

All of these functions are available in the SICAM A8000 devices and individually configured and parameterized for the respective the respective purpose or application.

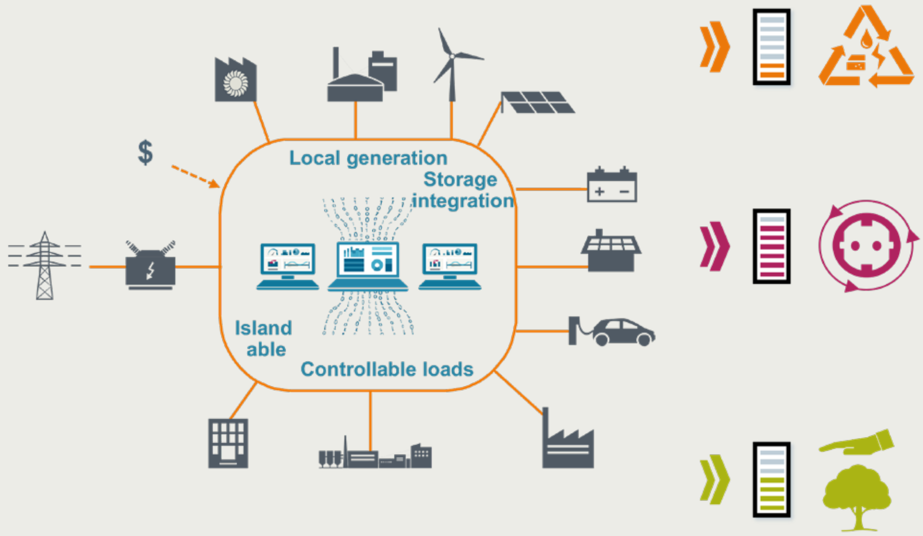


SICAM Microgrid Controller

Der SICAM Microgrid Controller is a state-of-the-art solution that revolutionizes energy management in various environments, such as industrial complexes, commercial buildings, campuses and remote communities.

It supports the integration of renewable energy sources and energy storage systems into conventional power grids. In the energy management system, the SICAM Microgrid Controller thus makes a valuable contribution to optimizing energy consumption, increasing resilience and making a sustainable contribution to reducing the CO_2 footprint.

SICAM Microgrid Controller – Function Overview

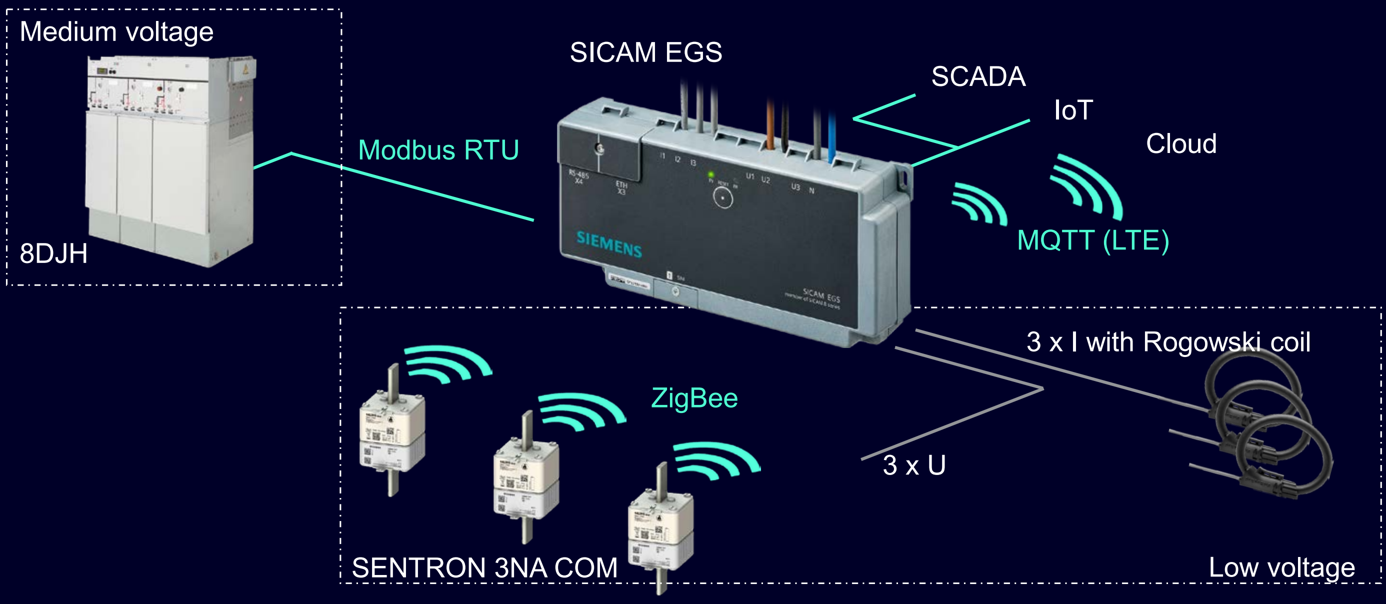


Economic & Energy efficiency
- Capex vs Opex
- Distributed generator control
- Load / storage control

Reliability, resilience
- Black start
- Network synchronization
- Online Control via HMI / Grid Monitoring and Control
- Enhanced SCADA functionality

Sustainability
- Generation / load forecast
- Dynamic grid constraint consideration using state estimator function

SICAM EGS (Enhanced Grid Sensor)
communication



SICAM EGS (Enhanced Grid Sensor)

SICAM EGS (Enhanced Grid Sensor) is used as a universal electronic measuring device, gateway and edge device for synchronous monitoring in the public low-voltage grid. Areas of application include substations, cable distribution cabinets and main distribution boards.

The measuring device offers RTU functions and measured value transmission to cloud or SCADA systems and is designed for use in harsh environments, high temperatures and EMC conditions, among other things.

Further information can be found at:

- **Electrification X**
- **SICAM 8 Power Automation Platform**
- **SICAM A8000**
- **SICAM Microgrid Controller**
- **SICAM EGS**

4 **Planning Principles** for an efficient Energymanagement System

4.1 Standards and Guidelines for Energy Efficiency

From planning to operation – the relevant energy efficiency standards at a glance.

IEC 60364-8-1

Low-Voltage Electrical Installations
Energy Efficiency

Levels

Power generation

Power distribution

Consumer

Efficiency-management

Consideration:

- Cost advantages
- Energy consumption
- Real-time adaption

Distribution

- Maximum safety
- Optimale usage
- Minimum losses

Measurements

- oriented at distribution-level
- Accuracy acc. requirements

Energy efficiency classes EE acc. IEC 60364-8-1

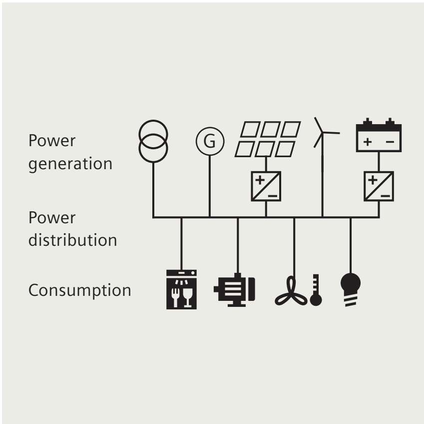
EE0 EE1 EE2 EE3 EE4 EE5

low efficiency high

IEC 60364-8-82

Low-Voltage Electrical Installations
Construction

Grid stability, Regulation of the electricity market



EN 50549-1/-2, IEC TS 62786
Connection to the distribution grid for the creation of plans (low/medium-voltage)

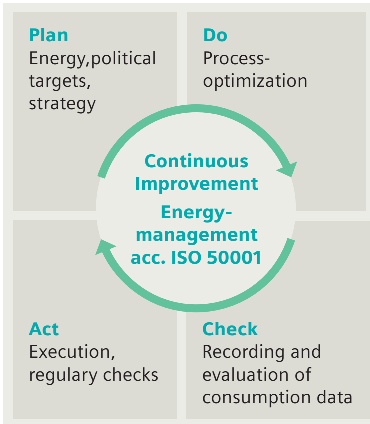
IEC 61000-2/-3/-4
Electromagnetic compatibility (EMV)

EN 50160
Voltage characteristics of electricity supplied by public distribution networks

ISO 50001

Energy Management-Process

Plan-Do-Check-Act- life cycle



ISO 50006
Energy management systems
Energy efficiency parameters (EnPI)

note:
In some countries different norms and standards might be basis for text reduction.

IEC 60364-8-81

The aim of the standard is to plan efficient electrical energy distribution and to create the basis, particularly in terms of measurement technology, for subsequent compliance with ISO 50001. The intension is to create the best possible combination of functional aspects and cost-effectiveness for the respective application. However, the measures described in the standard must not have a negative impact on availability or operating processes. The IEC describes 26 individual measures that must be considered when determining the energy efficiency class of the building to be planned. Depending on the type of building, there are different evaluations of the measures; this weighting is intended to reflect the effectiveness in the various applications.

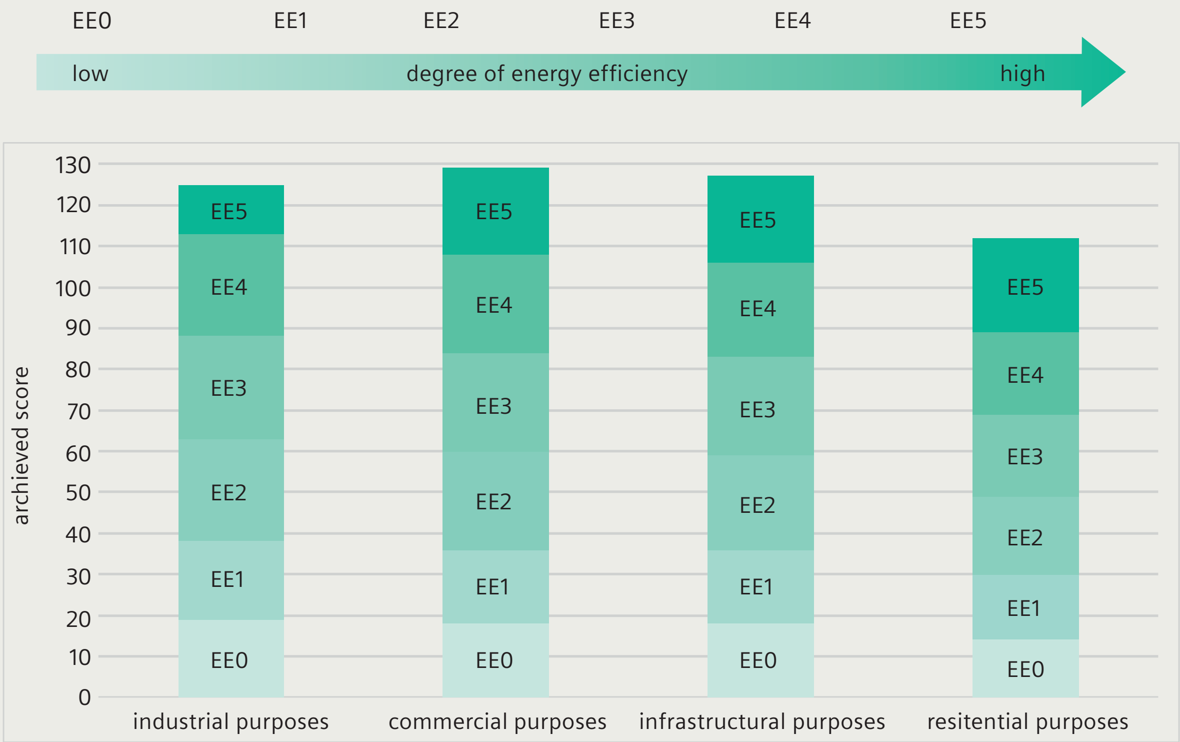


Fig. 4.1: Energy efficiency classes acc. IEC 60364-8-81 resp. DIN VDE 0100-801

IEC 60364-8-82

This standard defines the requirements for electrical installations that are to be designed as combined generation and consumption installations (PEI: Prosumers Electrical Installations). It applies both to systems with a connection to the public grid and to systems without such a connection. The aim is to set up a smart grid with dynamic load management in order to optimally coordinate the requirements of users and grid operators. An energy management system controls the system and must be able to work flexibly with different inputs, particularly with regard to the use of renewable energies, which often require storage solutions. The standard distinguishes between three types of PEI: individual, collective and shared PEI, and defines three main operating modes: grid reference, grid parallel operation with feedback and island operation.

EN 50160

The standard provides the essential framework for the quality of the mains voltage of the public supply network. Equivalently, there are requirements for system operators in the EN 61000 series.

VDI 2166 Sheet 1

VDI 2166 Sheet 1 is primarily aimed at system integrators, electrical planners and building operators. It only applies to the low-voltage range and customers with a consumption of over 100,000 kWh/a. The aim of the guideline is to establish correlations between building use and operation and the required electrical power demand. This is intended to serve as a basis for controlling and later to create a demand forecast based on the power flows. Transparency is created via the measured data.

ISO 50001

ISO 50001 defines the requirements for operating an energy management system.
With the specification of a continuous improvement process, a significant, sustainable contribution is to be made to climate and environmental protection. The aim is to increase energy efficiency and reduce costs and CO_2 emissions.
A permanent reduction in consumption can only be achieved through continuous monitoring and consistent energy management. Replacing outdated appliances is one possible aspect of this.
Companies wishing to be certified according to DIN EN ISO 50001 must develop an internal strategy for their energy management and set themselves corresponding optimization targets.
According to ISO 50001, a checklist must be worked through for this purpose and the continuous optimization process in the form of a Plan-Do-Check-Act (PDCA) list of measures must be set up.
The responsibility for successful energy management lies with the company management.
This should guarantee the necessary assertiveness for the implementation of the agreed measures and convey the importance of the topic. In addition, a team or an officer should be appointed for this topic.
It is crucial for the success of a continuous improvement process that the entire company is involved in this project so that every employee is aware of the necessity, meaningfulness and relevance of this initiative and that it is given appropriate priority at all levels.

- **Plan-Phase**
  First, the company's current situation is recorded and documented, to reveal potential for improvement and identify people or processes that influence consumption.
  On this basis, operational targets and a clear plan with a time frame are created and compliance with these is monitored.
- **Do-Phase**
  All defined measures are implemented in accordance with the schedule. The necessary resources must be available, and individual measures implemented must be documented and communicated.
- **Check-Phase**
  The measures implemented are evaluated and then serve as the basis for internal audits.
  Measurements can be used to document the savings achieved. All results are documented.
  In order to be able to guarantee systematic controlling internal audits should be carried out at regular intervals.
- **Act-Phase**
  The company management conducts a review. The results are evaluated, documented and used as the basis for deriving new targets.

4.2 Communication Structure of an Energymanagement System

The communication structure is based on the energy monitoring concept, which was planned for the respective industrial plant or infrastructure complex.

Advantages of an energy management system

By implementing smart metering systems, energy consumption can be monitored and controlled at key points (load management). This makes it possible to avoid overloading the grid (distribution grid or own grid) and energy costs through the (dynamic) power price (€/kW) can be avoided or reduced. Decentralized power generation, especially from renewable sources can be better controlled and monitored through networking and communication. The generation of surplus power can either be prevented in a targeted manner or be temporarily stored, converted or transferred to other locations in the grid during peak load times. Fault detection and rectification is simplified, as sensors and monitoring systems provide real-time information about events in the grid and can specifically identify the fault location. This significantly reduces the number of personnel required to detect, locate and rectify faults, minimizes downtimes and increases maintenance efficiency.

Challenges of setting up an energy management system

The digitalization of energy distribution leads to large flows of sensitive data from systems that are particularly worthy to be protected. Digitalization therefore requires sophisticated data protection and the development of holistic security concepts to protect the individual components or data interfaces from unauthorized access or manipulation. The availability of a digital energy distribution system highly depends on a large number of sensors, communication networks and software solutions, which means that malfunctions or failures of a single component could have a significant impact on the power supply in some cases. Redundancy and contingency plans are therefore important to limit the potential impact of technical faults from the outset.

The implementation of digital solutions for energy distribution requires complex infrastructures and systems, which potentially entail increased investment and operating costs. The installation and maintenance of smart metering systems and other digital technologies also requires specialized expertise. Thorough planning is therefore crucial to effectively meet these challenges.

The conceptual decisions that are affected by the energy monitoring concept influence the choice and structure of the communication structures in the further course of planning.

When setting up the measurement and communication network, the electrical planner must make the following considerations:

1. Which devices should be integrated where?

2. How often which data should be transmitted?

3. Which communication protocol should be used?

- Compatibility given / protocol converter required?
- What distances should be bridged?
- Wired or wireless data transmission?

4. Is a higher-level management system required?

- Monitoring/evaluation/control
- Is there a system already in place into which everything is to be integrated?

5. Advantages of integrated measurement

6. Cybersecurity

1. Placement of the Measuring Devices, Measurement Accuracy, Standardized Measurement Types

IEC 60364-8-1 and IEC 61557-12 divide measuring devices into three (PMD) types. These are intended to help select the right device for the respective measuring point. The distribution levels near the main power infeed and system-critical consumers should be equipped with higher-quality measurement technology with more functionalities.#
Table 4.2 can provide orientation here.

Functionalities symbol[1]	**PMD type**[2]		
	PMD-I Energy-Efficiency	**PMD-II Basic power monitoring**	**PMD-III Advanced power monitoring/network performance**
P		•	•
Q		•	•
S		•	•
E_a	•	•	•
E_r		•	•
E_{ap}			•
f		•	•
I		•	•
I_N			•
U and/or V		•	•
PF		•	•
THD_u and/or THD_v and/or $THD\text{-}R_u$ and/or $THD\text{-}R_v$			•
THD_i and/or $THD\text{-}R_i$			•

1 Only total quantities are mandatory
2 For PMD other than PMD-I, PMD-II or PMD-III, called PMD-x, other functions are allowed and shall be specified by the manufacturer.

Tab. 4.2: PMD types acc. IEC 61557-12 resp. VDE 0413-12

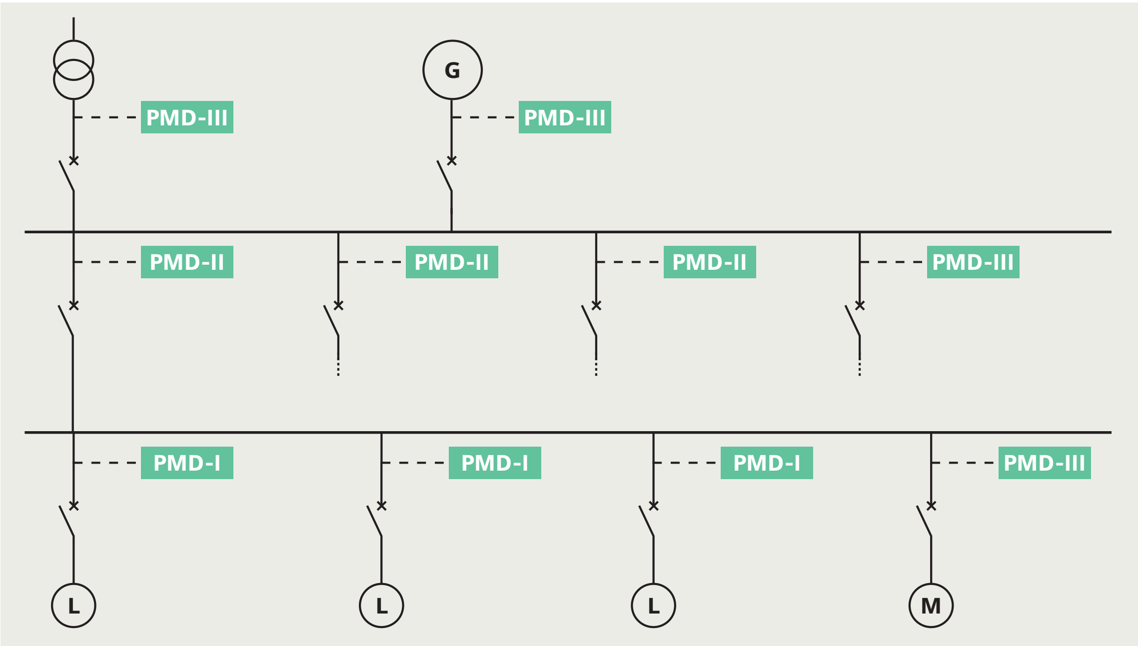


Fig. 4.3: Use of PMD types according to IEC 60364-8-1 in a power supply system

2. Required Measured Variables and Parameters, Transmission Rate

The frequency and type of data transmission as well as the (PMD) type of the measuring device depend on the type of consumer or outgoing circuit. The more important the consumer is for the operation of the overall system, the more comprehensive its monitoring should be. However, the load on the communication paths, the available storage capacity and the further processing of the data must not be disregarded. Modern measurement technology already offers a selection of measurement intervals that have proven themselves in practice. This can also be a combination of two intervals, such as 15-minute average values in combination with 10-second maximum and minimum values. This combination offers several advantages. Firstly, a 15-minute average value is standard in the energy industry and is a good compromise between frequency and informative value. Secondly, the maximum and minimum values within these 15 minutes offer a bandwidth that is lost in the 15-minute average value. This means a transmission interval of 3 measured values within 15 minutes does not overload either the communication channels or the storage capacities. Exceptions to this are, for example, statements on energy quality, where a 10-minute moving average is prescribed by standards. Such special requirements should be taken into account before selecting the measuring devices. In principle, the functions of the measuring device should be fully utilized in the form of the available measured values. Otherwise, the use of another, more suitable measuring device should be considered.

3. Communication Structure/-Protocol, Data Transmission

The choice of the communication protocol depends, among other things, on the selected measuring devices and existing infrastructures into which the new system is to be integrated. The amount of data to be transmitted and the transmission interval also play an important role in this decision.

In addition, there may be possible restrictions on the number of devices to be connected or the distance to be bridged. If possible, standardized protocols and interfaces should therefore be used when selecting the communication protocol. Protocol converters can be used to successfully integrate third-party components whose communication options are limited. In addition to the classic expansion variant with a fixed communication cable connection, more and more radio-based systems are now entering the market. These offer faster installation and retrofitting due to the fact that no cable installation is required and can sometimes also bridge very large distances. The higher susceptibility of radio signals to interference, caused by other existing radio signals or possible shielding, e.g. by the building structure (steel reinforcement installed in concrete walls and ceilings), can be a disadvantage. In some places, it may be necessary to use a data concentrator in addition to the measuring device in order to collect the collected data and information in a targeted manner and pass it on centrally. Wireless systems are particularly advantageous if there is insufficient space available at the installation site or access to the required connection points is difficult.

A typical communication structure is illustrated in the following diagram.

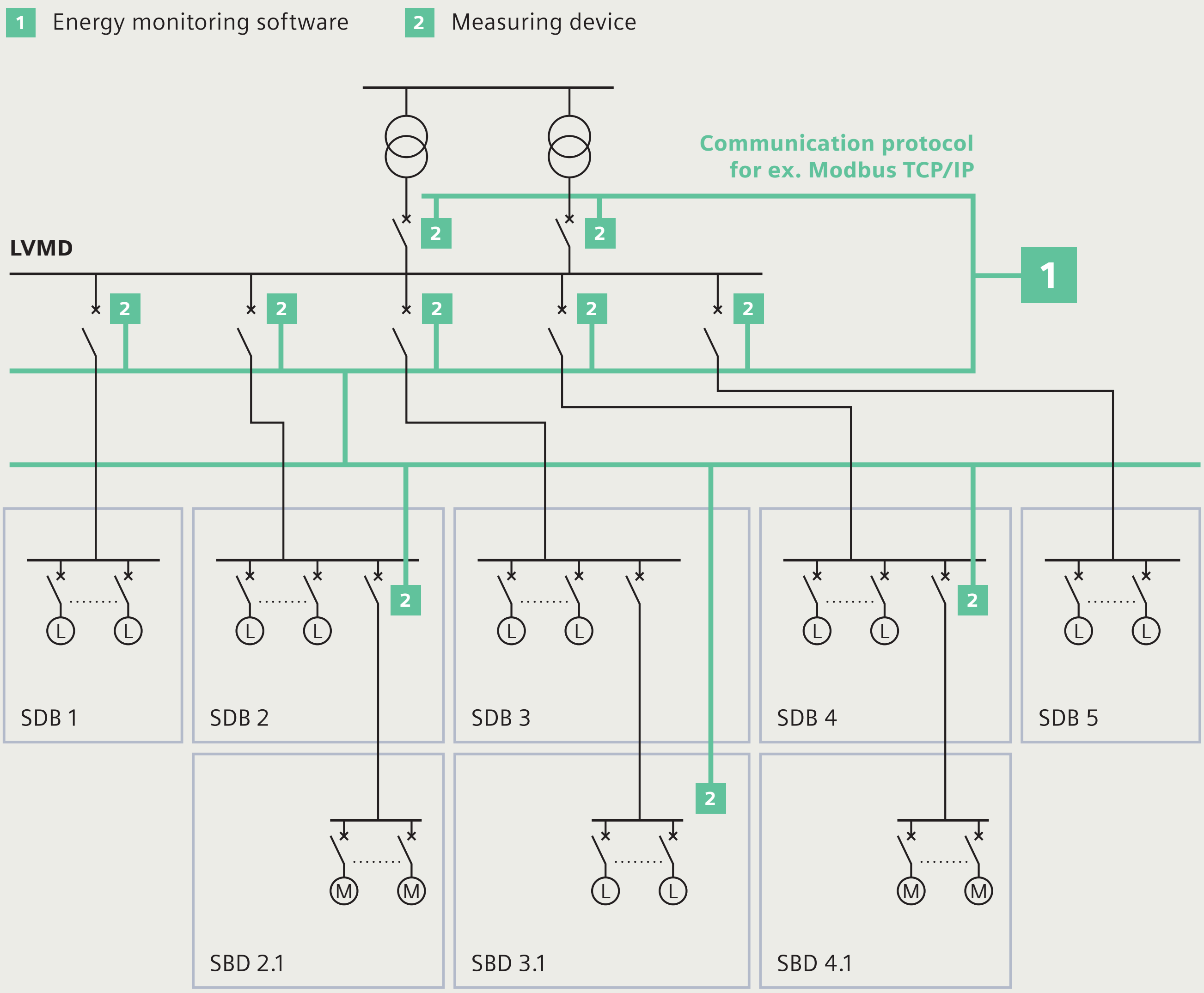


Fig. 4.4: Principle diagramm of the communication strucure for an energy management system

4. Integration into a (existing) central Energy Automation System

The benefits of the measurement technology used are fully utilized when the data can be processed directly and conclusions can be drawn automatically. For this reason, every measurement system should include higher-level software that can combine and graphically process measurement data. The need for additional functions is usually system-specific. These can be automatic reports on energy quality, consumption and the resulting recommendations for action or load management functions. Specific system knowledge may be required to use these functions. When using load management functions, for example, the specifics of the respective machine (motor, pump, etc.) and its integration into the production or operating sequence of the system must be known before specific times for a load shutdown are defined.

It is particularly relevant for the integration of measuring devices to determine whether the energy automation system should be set up as a purely local system or (cloud-based) with the option of remote access. For example, a data concentrator with a web server connection or a PC with corresponding energy monitoring software, which in turn enables remote access, can be used for the intended remote access. License-based or subscription-based models (software as a service) exist for the energy monitoring software. Subscription-based models generate ongoing costs, but their use is generally associated with lower initial investment costs, although individual adaptations to the respective system are still possible.

If a central building management system is already in place, it makes sense to integrate the energy monitoring system into it. In this case, the existing visualization functions should be retrofitted with additional control options to enable load management, for example.

5. Use of Switching/Protective Devices with integrated Measurement/Communication Function

As shown in Chap. 3, it is conceptually possible to provide additional separate measuring devices at required measuring points(**Chap. 3.1**) or alternatively switching/protection devices with integrated measuring and communication function (**Chap. 3.2**).

Starting points for planning and advantages/disadvantages of each solution are compared in the following table.

Ext. Measuring Devices with Accessories	Protection Devices with integrated Measuring
Investment costs	
Lower than for integrated solutions. Total investment is highly dependant on the application and number of measuring point required.	Typically more expensive than conventional protection devices; included recording of measurands and device status data; no accessories required for single measuring points.
Device Selection	
Selection of suitable components into a complete system, often complex; risk of incompatibility; reordering of forgotten accessories.	Easy selection of devices based on required protection functions; available measuring function acc. PMD-types.
Effort for Installation/Commissioning	
Complex device installation due to large no. of components; high error-rate during commissioning/parameterization; mistakes are found later during operation.	Small installation effort due to constant no. of devices; comissioning with less error-rate.
Measurands	
Recording of multiple energy and power data incl. measurands for power quality monitoring (for ex. harmonics, asymmetricals, voltage dips).	Available basic data for energymonitoring; recording and communication of device status data; possible evaluation of power system life-status.
System Integration	
Device replacement independant of system operation; subsequent integration of additional modules; particularly well-suited for existing „Brownfield“-installations.	Device replacement causes system downtime; Measuring range of protection device only partially adjustable; particularly well-suited for „Greenfield“-installations.
Space Requirement	
Additional space requirent in distribution board for measuring devices and components, especially with multiple measuring points.	Integrated solution for protection and measuring functions in one protection device.
Legal Metrology-Compliant Measurement	
Existing MID-certificate for legal metrology-compliante measurement and third-party electricity consumption delineation; depending on device-configuration suitable for embedded power generation plants (CLP).	no legal metrology-compliant measurement possible.
Cybersecurity	
Well-suited for safety-critical applications like data centers due to geeignet durch existing physical separation between protection and measuring function.	Security features tp prevent unauthorized access depend on manufacturer and product family.

6. Cybersecurity

Cybersecurity is the guarantee of the availability, integrity and confidentiality of products, systems and solutions for and at the user, both in the OT and IT environment. Cybersecurity includes all mechanisms for protecting systems such as power distribution, devices such as circuit breakers or software applications (such as a monitoring system) against unauthorized access and deliberate or unintentional manipulation. It also prevents unauthorized access to confidential information (measurement and status data). Cybersecurity is always viewed holistically as an interaction between people (organization), processes and products. Conceptually, a multi-layered approach is pursued (e.g. Defense in Depth).

During implementation, various industrial, national and international standards are usually taken into account, which specify different levels of protection depending on system use and acceptable risk level. Tested and certified system descriptions (blueprints) from manufacturers can be used as the basis for a cyber-secure system.

> **siemens.com/cybersecurity**

5 Application Examples – planned integratively

5.1 Application Example – Tram Depot

The tram depot is used for the maintenance, servicing and storage of trams. The structure of such a depot is designed to ensure the smooth operation and efficiency of the public transport system. It therefore requires a well thought-out concept for monitoring and controlling the electrical systems. The depot consists of several building sections, each of which places different demands on the electrical supply.

The depot has extensive track systems on which the trams can be parked, shunted and positioned for maintenance work. These tracks lead to the workshop halls and washing facilities. Repairs, maintenance work and inspections are carried out on the tram wagons in the workshop hall. The hall has lifting platforms, cranes and diagnostic equipment. The depot has a storage area where spare parts, consumables and tools are kept. There are changing rooms, sanitary facilities, break rooms and administrative offices for the staff. There is also a small computer center for administration and management.

Due to the manageable complexity and size of the system, a local software solution based on SENTRON Powercenter 3000 is suitable (Fig. 5.1).

In accordance with the recommendations of IEC 60364-8-1 and IEC 61557-12, the distribution levels close to the main power supply and system-critical loads are monitored with higher-quality measurement technology.

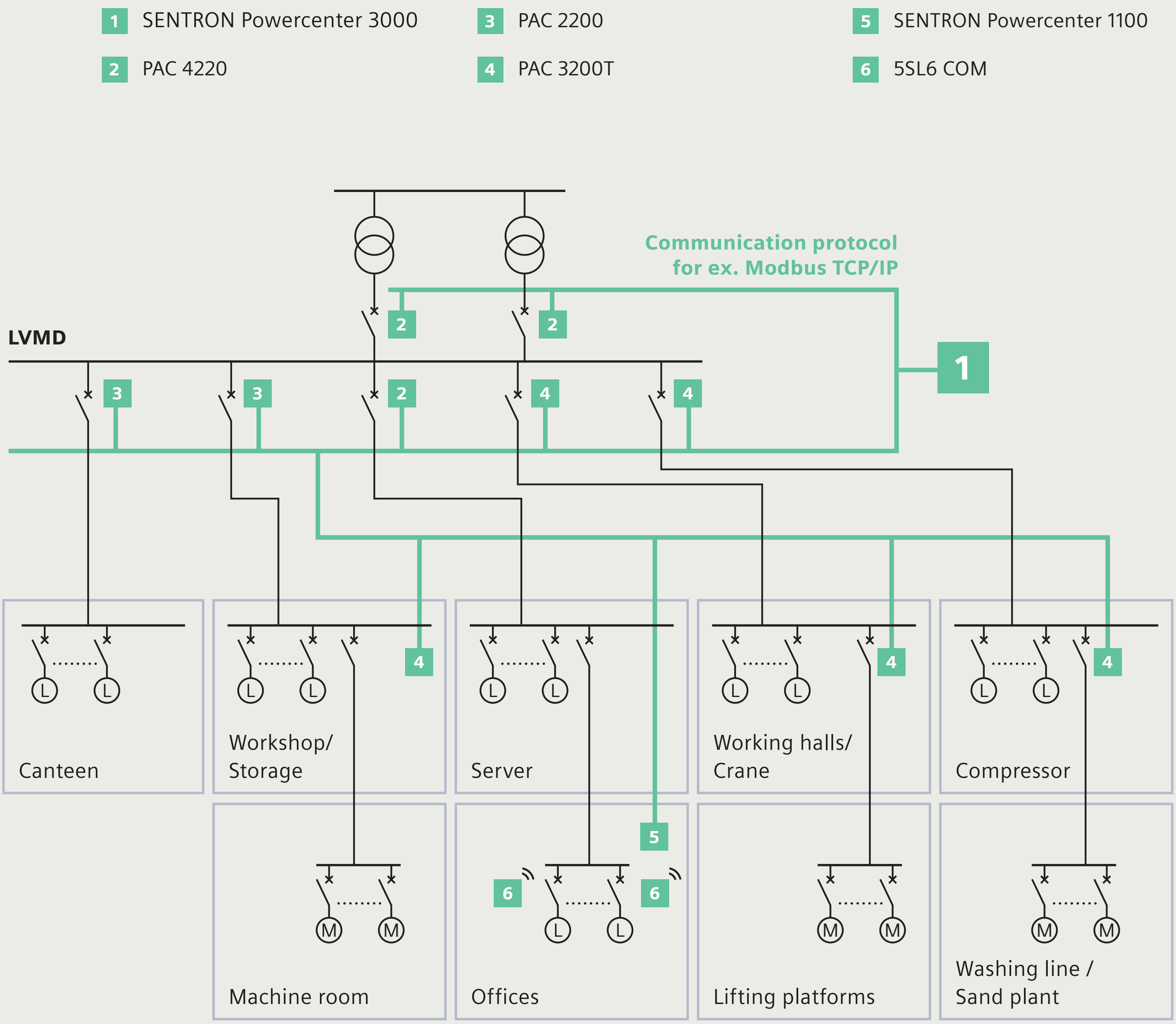


Fig. 5.1: Application example tram depot – Communication structure of the energy management system

The SENTRON Powercenter 3000 (short: POC) can be used as a stand-alone solution for energy and status monitoring directly via the integrated web interface. It bundles all the data from the connected (measuring) devices and can make it available to cloud-based applications if required. This leaves the way open for a later system expansion from a local solution to a cloud-based solution over the entire service life.

The metering concept offers simple transparency and focuses on the power infeed and significant energy consumers. This means that sub-distributors mainly are recorded in total at the power infeed and only individual loads are measured directly.
In the main power infeed and for the server room, measuring devices with extended functions for grid quality are used to obtain an overview of the own grid and the servers as critical loads.
To better differentiate between the consumption of the servers and the office applications, the loads in the office are recorded with circuit breakers that offer integrated measuring functions.
This means that no additional space is required in the sub-distribution board apart from the one subdivision unit for the Powercenter 1100. With the exception of the canteen and the workshop, the PAC 3200T is used, a DIN-rail device that does not require a display and therefore does not need any cut-outs in the switchgear door. The PAC 2200, a device with
MID function (Measurement Instruments Directive), is used for the canteen and for the workshop, which enables sub-charging for external providers.

For device communication within the system, the widespread Modbus TCP/IP communication standard is used for device communication within the system. This is an industrial communication standard that transfers the familiar Modbus protocol for serial communication to a TCP/IP-based network. It enables data to be exchanged between different devices in a network, such as controllers, sensors and actuators. Modbus TCP/IP offers high interoperability with other devices and systems as well as easy integration into existing networks. It also supports a wide range of applications in automation, such as monitoring machines or controlling production processes.

When selecting the measuring devices, attention is paid to compatibility in order to avoid converters to other protocols and thus additional effort.
All devices used here natively support Modbus TCP/IP.

Software/ Data Concentrator	Characteristics	Access
SENTRON POC 3000	• Web-based energy monitoring • Optional Cloud connection • Condition monitoring • Up to 32 devices • Basis for ISO 50001 • Support for third-party devices	Local/expandable to cloud connection
SENTRON POC 1100	• Radio-based • Data transceiver for up to 24 devices • 1 modular width	Local

Measuring device	Characteristics	PMD type
PAC 4220	• Network analysis meter • Harmonic detection • Gateway function	III
PAC 3200T	• DIN rail technology w/o display	III
PAC 2200	• MID-Certification available • Direct measuring up to 65 A	II
5SL6 Com	• Integrated measuring function • 1 modular width	II

5.2 Application Example – University Campus

The university campus extends over an extensive area and offers a diverse infrastructure.

This results in increased requirements for the energy management system. Due to the number of buildings and the possibility that a campus may be expanded or changes of use may occur in the buildings themselves, the energy management system should be designed to be centralized and scalable. Another reason for this is the number and spatial distribution of the required measuring devices, as otherwise a large number of decentralized systems would have to be managed. The campus has an energy center that coordinates the campus's power supply. This also offers the opportunity to locate the central IT infrastructure for an energy management system.

The other buildings are typical campus facilities, such as lecture halls, institute buildings, offices, a parking garage and a small data center for the digital infrastructure. All of the university's IT services are managed centrally here, including databases, servers and internal networks. The security and availability of these digital resources is a high priority in the electrical planning. For this reason, there is also the option of supplying them with a backup power system in the event of a fault (**Fig. 5.2**).

In order to minimize the ecological footprint, sustainable energy sources support the company's own generation to cover its electricity needs.

Another special feature is the electric charging stations in the parking garage; these can pose additional challenges in terms of grid quality and billing and are provided with corresponding devices in the metering concept.

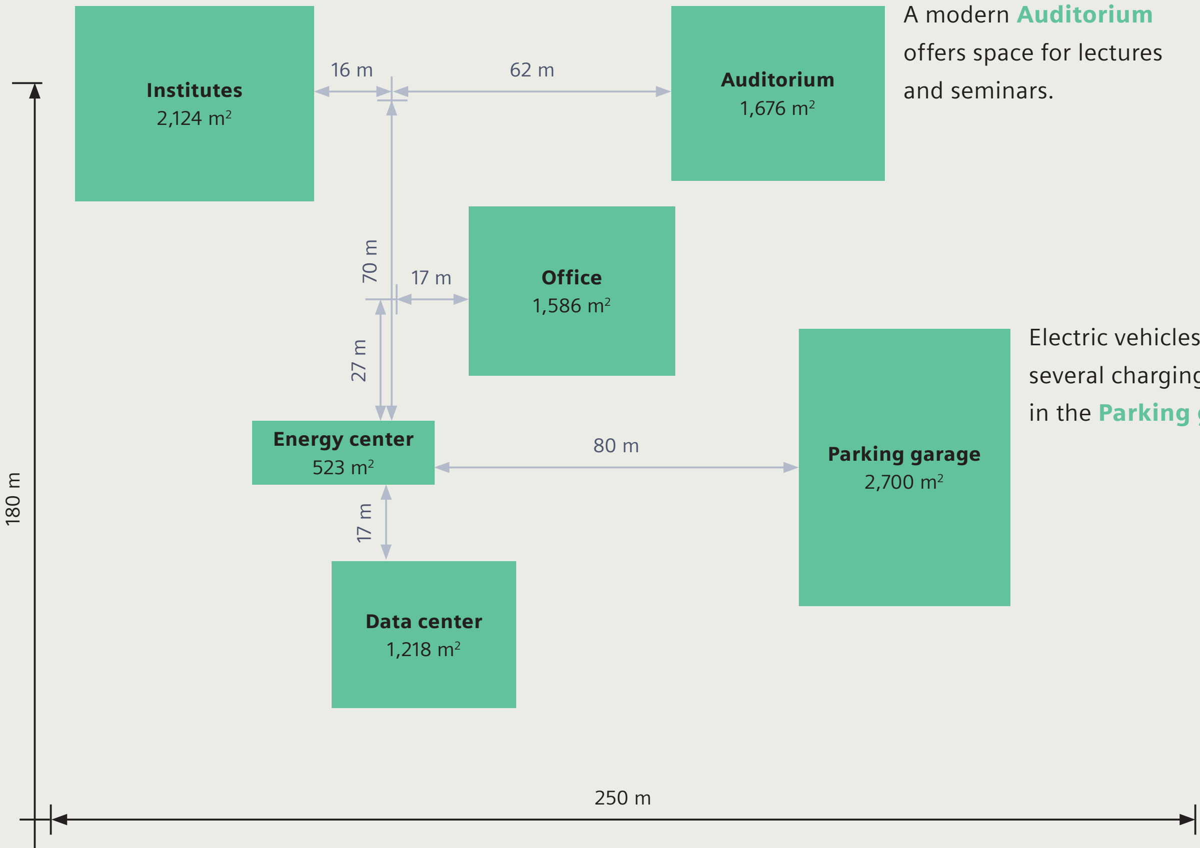
Specific Applications with different challenges characterize the power supply of the extensive campus area:

Multiple **institutes** with specific premises for research and teaching.

The **Energy center** supplies the entire infrastructure exactly as needed and reduces the CO_2 footprint with renewable energy sources.

A modern **Auditorium** offers space for lectures and seminars.

Electric vehicles can use several charging stations in the **Parking garage**.



The **Data center** manages all IT-services incl. databases, servers and networks whose safety and availability is essential.

The **Office** maintains the administration, deans' and lecturers' offices.

Fig. 5.2: Application example university campus – site plan and building complexes

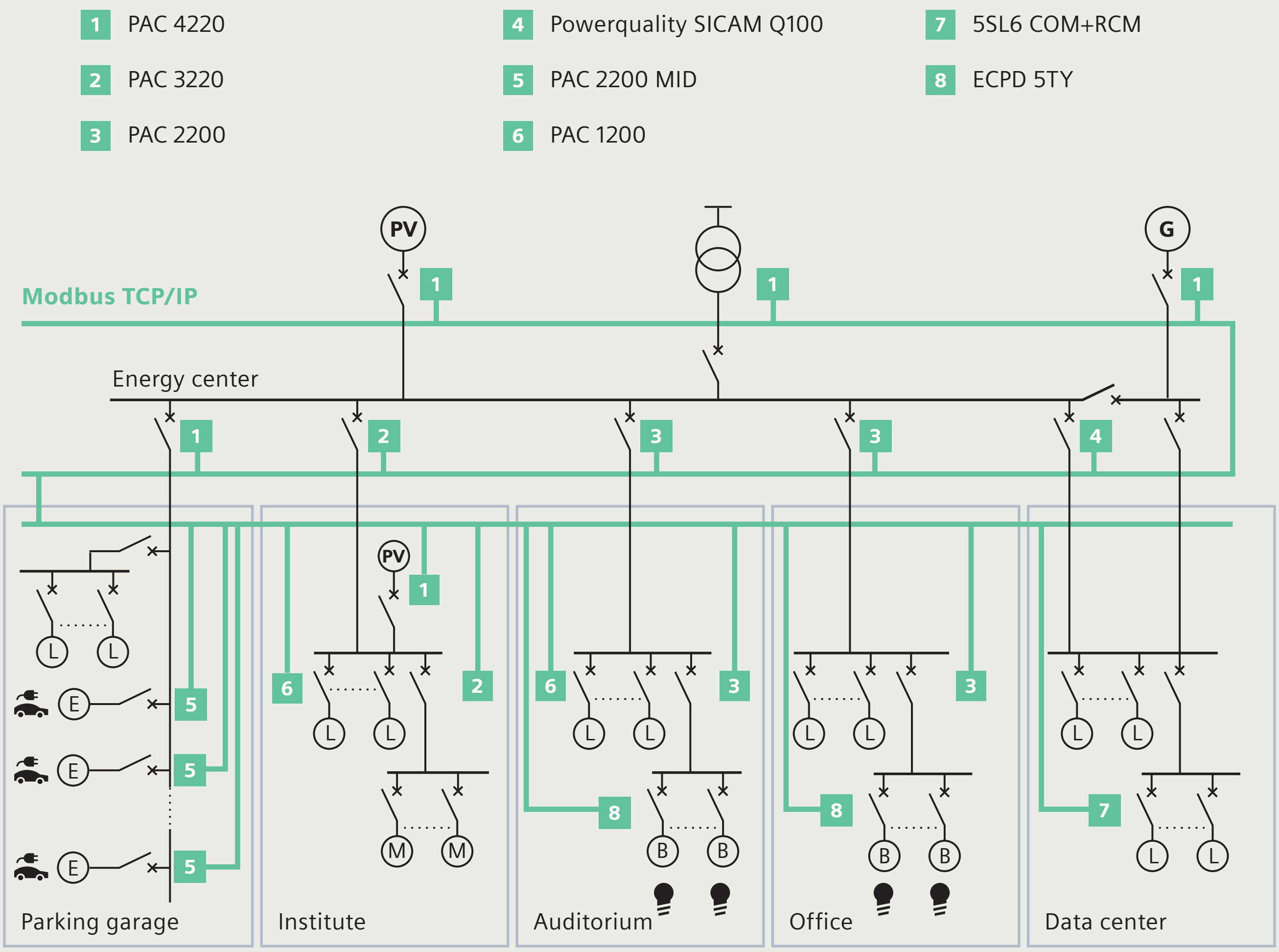


Fig. 5.3: Application example university campus – Energy monitoring concept configured as local software solution

Energy center

The Energy center for the power supply of the campus is realized at low-voltage level (Fig. 5.3).

The energy measuring system is therefore based on SENTRON PAC measuring devices. These offer the right solutions for the various requirements of the campus.

The design is based on the recommendation of IEC 60364-8-1, which is why high-quality measuring devices (here: PAC 4220) with extensive functions in the power infeed are used. The devices comply with type PMD-III and record harmonics as well as energy, power, voltage and current, for example. This enables a detailed view of the power quality in order to detect potential faults at an early stage.

Desigo CC with the Powermanager plugin will be used to record and evaluate all data centrally.
Desigo CC is also part of the Xcelerator portfolio and, as a central platform, offers the possibility of bundling all building automation functions. In addition to electricity, other energy sources can be measured and integrated. The Powermanager plugin offers additional evaluations and reports that are specially tailored to the requirements of electrical consumers and ISO 50001. This covers all building and energy management requirements for such a property.

Parking garage

Due to the expected harmonics from the existing charging stations, the feed for the parking garage will also be equipped with a PAC 4220. The individual charging points will be equipped with PAC 2200 with MID. This offers the option of charging electricity quantities for vehicle charging at the charging points.

The use of PAC 2200 energy meters is sufficient for the remaining building feed-ins and consumer loads with a corresponding distance to the energy center. For these power supply paths, the measurements concentrate on recording the active energy.

Institute

The institute has a PV system on the roof and therefore has the special feature of two feeds. Two different measuring devices are used for this. The PV system is measured with the PAC 4220 in order to record any harmonics that may occur in the inverter. The building feed-in is recorded with the PAC 3220; the focus here is on basic energy monitoring and recording. The PAC 1200 multi-channel measuring devices are used for the sub-distribution boards. These offer a simple way of recording several final circuits and ensuring basic transparency without generating an unnecessary amount of data. In combination with the infeed measurements, this results in a well-rounded concept for the building.

Auditorium / Office

In the respective building feeds, the use of PAC 2200 energy meters is sufficient, as no interference due to excessive harmonic loads is to be expected. The measurements therefore concentrate on recording the active energy. As in the institute building, PAC 1200 multi-channel meters are used for the final circuits. However, there is an essential difference in the lighting circuits of large halls.

State-of-the-art semiconductor protection devices (ECPD: Electronic Circuit Protection Device) are used for the lighting circuits in both buildings. With their technologically advanced inrush handling, ECPD devices are particularly suitable for this application. Inrush currents occur when one or more light sources are switched at the same time. These inrush currents can be up to 100 times greater than the rated current of the respective light source and only last a few microseconds. This behavior limits the number of lights that can be connected per circuit or per switching device. Inrush handling based on semiconductor technology allows the ECPD a significantly higher number of luminaires per circuit compared to conventional switching/ protection technology.

The number of circuits (and switching devices) required to switch the room lighting can be reduced by a factor of 3 to 4 in this way, which means significant savings for the required cable and electrical installation.

Indirectly, this also reduces the fire load in the entire building, makes it possible to construct smaller, more compact distribution boards, cable routes can be made smaller and working hours for cable laying can be reduced.

Data center

System-relevant consumers, such as the IT infrastructure, should be monitored more closely due to their importance for the operation of the university campus. The power supply for the data center should therefore also be equipped with a PAC 4220. Alternatively, the use of a SICAM Q100 power quality recorder can be considered for a particularly detailed insight into the energy consumption behavior. The measurement of individual final circuits can be realized either with PAC 1200 multi-channel measuring devices or 5SL6 COM miniature circuit breakers with communication capability.
Optionally, an additional residual current measurement can be carried out with RCM.

Software application	Characteristics	Access
Desigo CC	• Automation and Management system • Cross-trade • Optional cloud connection • Powermanager modul • Support of third-party devices	Local/expandable to cloud connection
SENTRON Powermanager	• Energymonitoring software • ISO 50001 • TÜV certified	Local

Measuring device	Characteristics	PMD type
PAC 4220	• Network analysis meter • Harmonic detection • Gateway function	III
SICAM Q100	• Network quality recorder • reports acc. EN 50160 • Harmonics up to 63rd • PQ-Events incl. direction detection	III
PAC 3220	• Additional module for conductor & Residual current measurement	III
PAC 2200	• Available as calibrated energy meter • Direct measuring up to 65 A	II
5SL6 Com/RCM	• Integrated measuring function • 1 modular width • with residual current measurement RCM	II
ECPD 5TY1	• Semiconductor protective device • Integrated measuring functions • Inrush handling	II

5.3 Application Example – Industry Campus

The industrial campus consists of a total of five larger facilities and extends over a large area (**Fig. 5.4**).

Due to the spatial expansion, the electrical supply is realized by means of a 10 kV ring network. This offers clear advantages over stub connections. Faults can be separated from the ring and the fault-free areas can continue to be supplied. This increases the system's reliability and minimizes operational interruptions.

One of these facilities is the tram depot from **Chap. 5.1**, which is fed via the industrial campus's electrical grid. The **Chap. 5.1** energy monitoring system already present in the tram depot is integrated into the higher-level energy monitoring system of the industrial campus.

Two production facilities (Production 1 and Production 2) as well as an administration building and a research building represent typical facilities of an industrial campus in this application example.

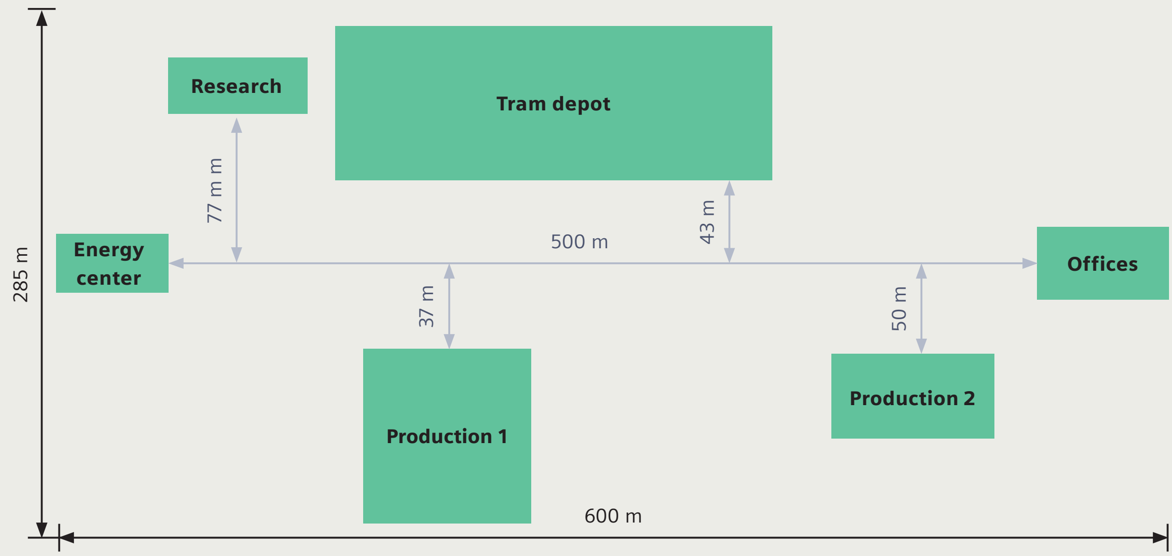


Fig. 5.4: Application example Industry campus - site plan and building complexes

The following single-line diagram provides an insight into the power supply network of the industrial campus using the example of the "Production 1" facility (**Fig. 5.5**).
The associated network calculations and component dimensionings were carried out using the tool SIMARIS design.

Industry campus – Production 1

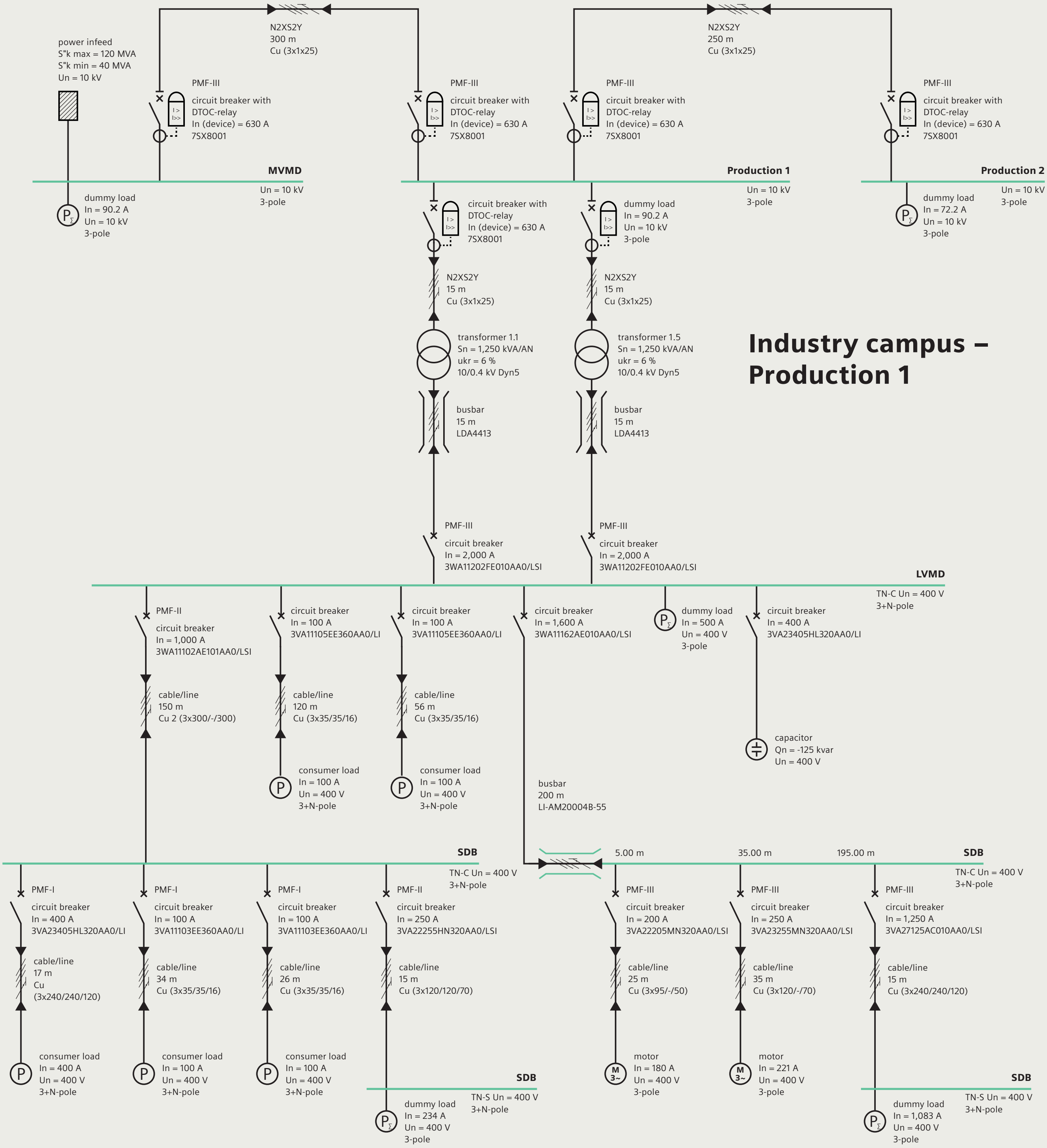


Fig. 5.5: Application example Industry campus – Single line power supply network built up with SIMARIS design for building „Production 1"

The energy management and monitoring system based on this is realized with proven SIPROTEC 5 protection devices for medium-voltage. These offer a sufficient range of measuring functions to create basic transparency at the medium-voltage level.

In the main power infeed (**Fig. 5.5: MSHV**) a SICAM Q100 power quality recorder is also used to provide detailed information on harmonics and power quality. These devices also offer the option of generating fault reports.

If other facilities, e.g. production 1/2 or research facilities, are increasingly using similar equipment whose operation has a disproportionate impact on the grid/voltage quality (e.g. converters, motors), additional SICAM Q100 power quality recorders should also be provided at these points within the energy monitoring concept. At medium-voltage level the IEC 61850 standard protocol is used for communication. It offers reliable and interoperable communication and enables the integration of a wide range of devices, which simplifies subsequent expansions.

There are various approaches to software applications, which are presented below. In practice, system and user-specific requirements determine the type and scope of the required software solution.

Energy monitoring with SIMARIS control 10/0.4kV

SIMARIS control offers a comprehensive but engineering-intensive solution (**Fig. 5.7**)

With this solution, communication-capable measuring and protection devices at medium and low-voltage level (in this application example: 10/0.4 kV) can be integrated into an overall system. This purely local solution (without cloud connection) could be installed in the low-voltage main distribution board (LVMD).

SIMARIS control supports both the communication protocols used as standard in low-voltage and the IEC 61850 protocol, which is mainly used in medium-voltage applications.

Energy monitoring with SIMARIS control for medium- and low-voltage

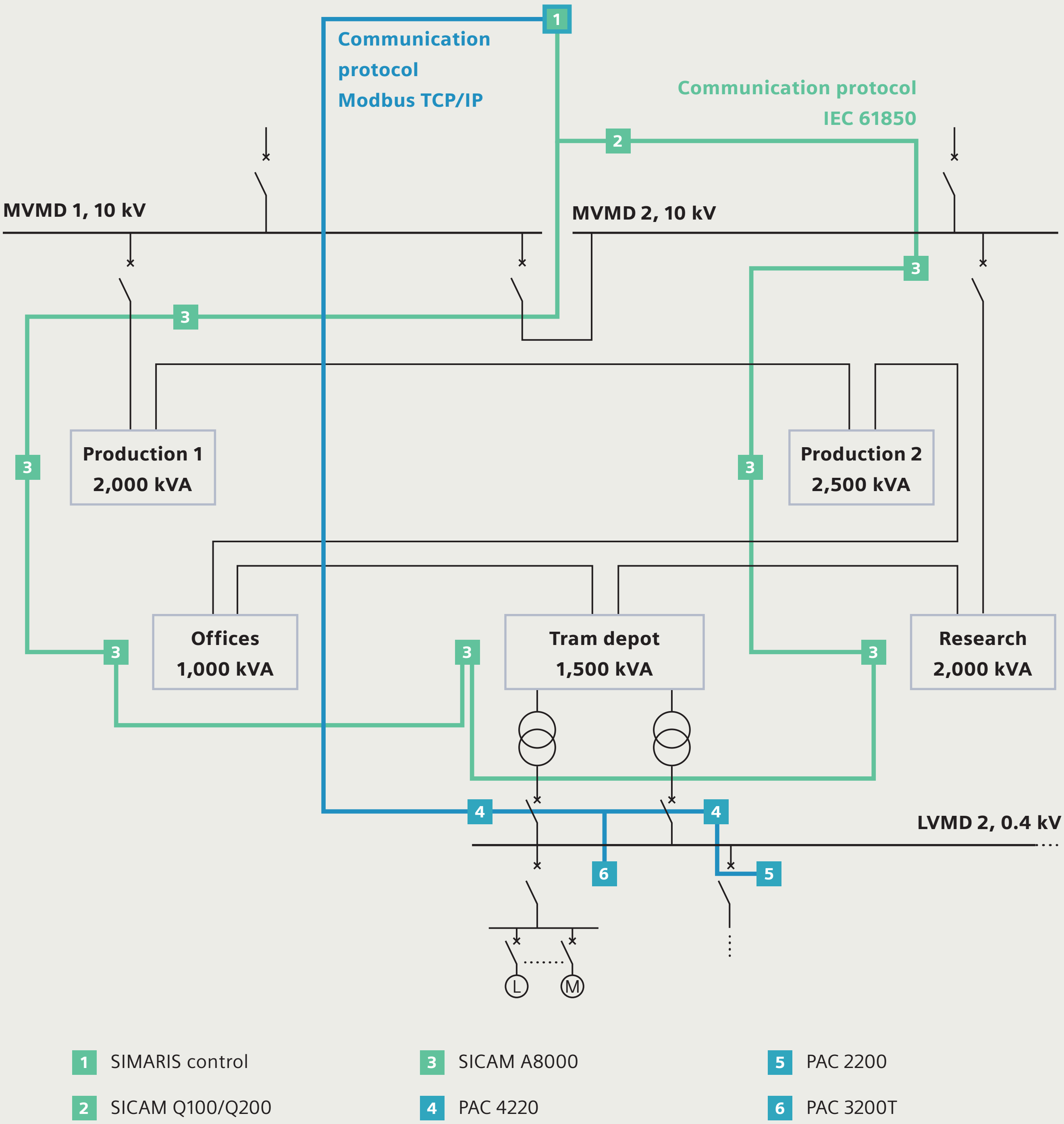


Fig. 5.6: Application example Industry campus – Energy monitoring concept with SIMARIS control for medium- and low-voltage

Energy monitoring with Electrification X

Alternatively, the communication network at the medium-voltage level (in this application example: 10kV) can be connected with the asset management solution from Electrification X (Fig. 5.7).

This solution offers the possibility of bundling several locally distributed properties in one overview in order to be informed about the operating status of all systems at any time at a central location by means of corresponding messages.

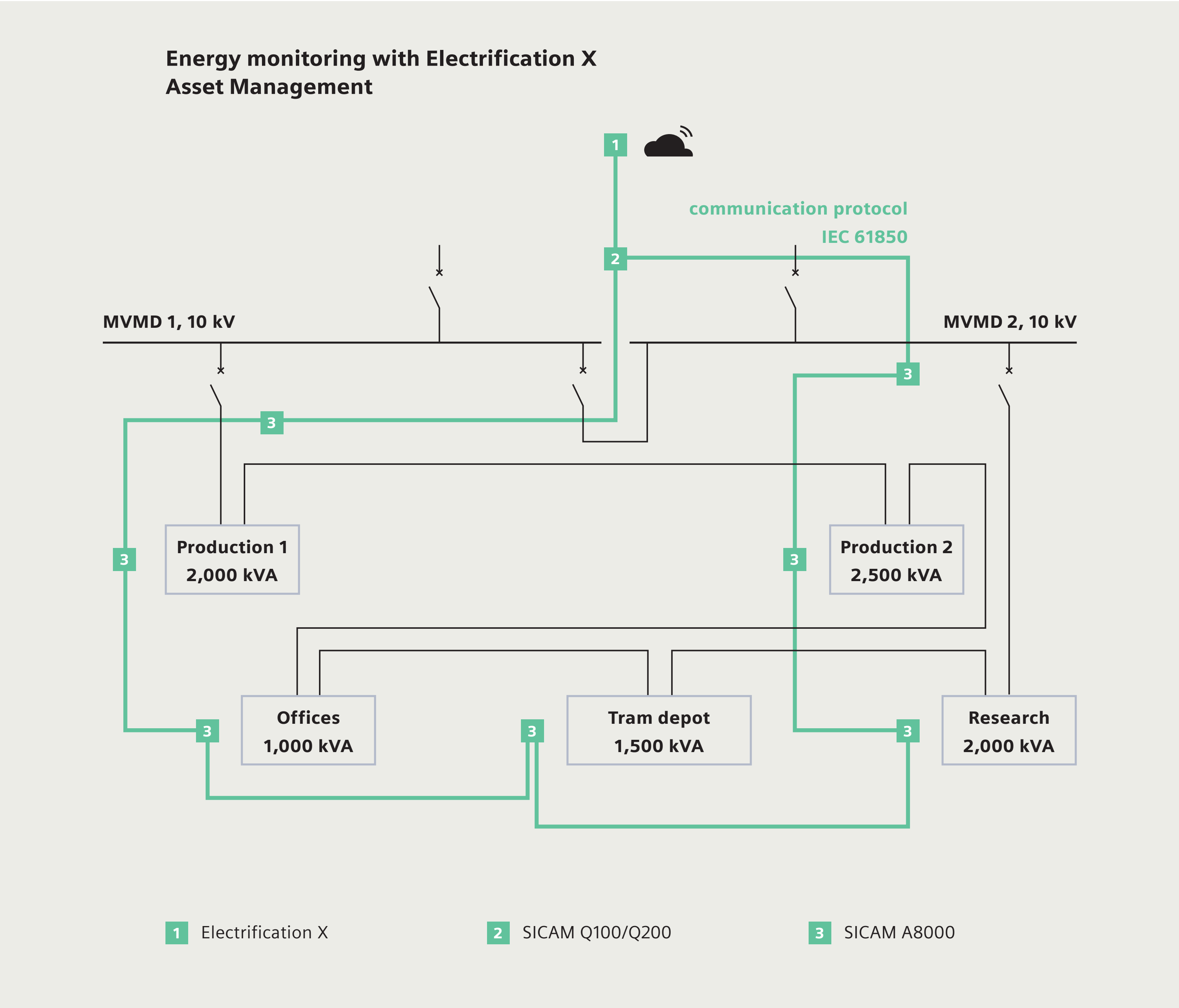


Fig. 5.7: Application example Industry campus – Energy monitoring concept with Electrification X Asset Management mit cloud-connection for medium-voltage

Energy monitoring concept – hybrid solutions

Alternatively, hybrid solutions from the previous examples are also conceivable.
This can be particularly interesting, if low-voltage is only required locally for on-site analysis, but the medium-voltage should also be available in the cloud for comparative analyses.

Software application	Characteristics	Access
Electrification X – Asset Management with cloud-connection	• Overview of several properties worldwide • Integration of SIPROTEC measurement values • Temperature and humidity	Cloudapplication
SIMARIS control (local)	• Energy monitoring software	Local application

Measuring device	Characteristics	PMD type
SICAM Q100	• Power quality recorder • Reports acc. EN 50160 • Harmonics up to 63rd • PQ-events incl. direction detection	PMD-III with significantly extended functionality than required by standards
SIPROTEC 5	• Medium-voltage relays • Integrated measuring functions • Condition monitoring	–

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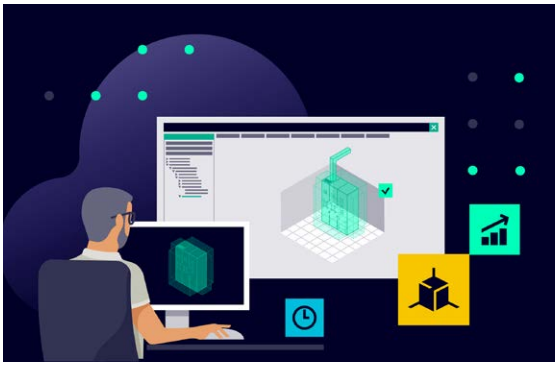

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BIM (Building Information Modeling) for easy exchange of all relevant building data ensures the quality, and saves both time and money. Totally Integrated Power provides BIM-capable objects, data and tools for power distribution, such as Revit files for low-voltage switchboards and medium-voltage switchgear, busbar trunking systems, and transformers.

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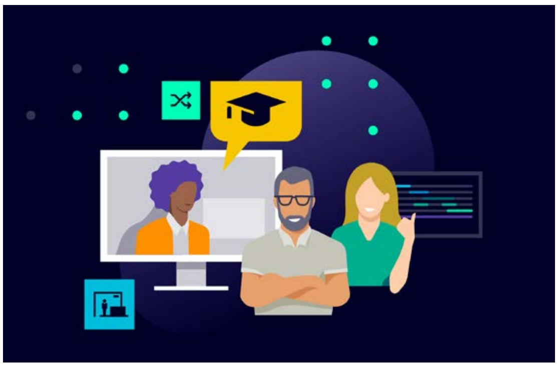

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