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Application Models for the Power Distribution

High-rise Buildings

Answers for infrastructure.

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Introduction

High-rise Buildings – Definition

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Introduction

Because of the increasing urbanisation – it is estimated that 70 % of the world's population will be living in cities in 2050 compared with 50 % in 2010 – and the expansion of mega cities, the area available in the cities must be better utilized. As a result, the number of floors and the height of high-rise buildings will increase.

Definition of a High-rise Building

In Wikipedia, a tall, continuously habitable building of many storeys (at the end of the 19th century these were buildings with at least ten storeys) is called a high-rise building or skyscraper. Wikipedia Germany (www.wikipedia.de) defined (on 31.08.2012) a building, according to the state building codes, as a high-rise building "When the floor of at least one room is more than 22 metres above ground level. This is because fire brigade ladders can only rescue people from rooms that are 23 metres above ground level. For higher buildings, i.e. high-rise buildings, additional fire protection provisions have to be made, such as separate escape staircases. The requirements are specified in the High-Rise Directive."

Recently there has been real race to erect the highest building. According to Wikipedia, a classification according to height has been introduced for clearer structuring (see below).

Designation	Height in metres	Building time in years
Skyscraper	150-299.99	Approx. 2–4
Super tall skyscraper	300-499.99	3-5
Hyper tall skyscraper	> 500	>5

Classification of high-rise buildings according to height

Demands on Modern Planning

The demands placed on the power supply of a modern skyscraper are constantly increasing. A high level of safety, flexibility throughout the entire life cycle, a low level of environmental pollution, the integration of renewable energies and low costs are common demands nowadays that already have to be taken into consideration during the planning of a high-rise building. A special challenge is the coordination of the individual installations. The main installations are, for example, heating, ventilation, air conditioning and refrigeration, fire protection, protection against burglary, building control system and power distribution. In modern planning, the demands on a high-rise building are not simply split up among the individual installations, but have to be coordinated. An optimum solution is created from the networking of the individual requirements. This application manual provides an overview of the installations of a high-rise building that are important for the electrical power distribution and describes the basic and preliminary planning of the power distribution for an example. The planning requirements for an energy management system for the high-rise building are also integrated. Even if a building is used for 50 years or more, the significantly shorter cycles of changes in the usage, such as hotel refurbishment, new shop owners, new IT equipment in the computer centre and changes to the offices and in the life cycle of equipment and facilities require useful, long-term preliminary planning.

Chapter 1

Building Management Systems for Skyscrapers

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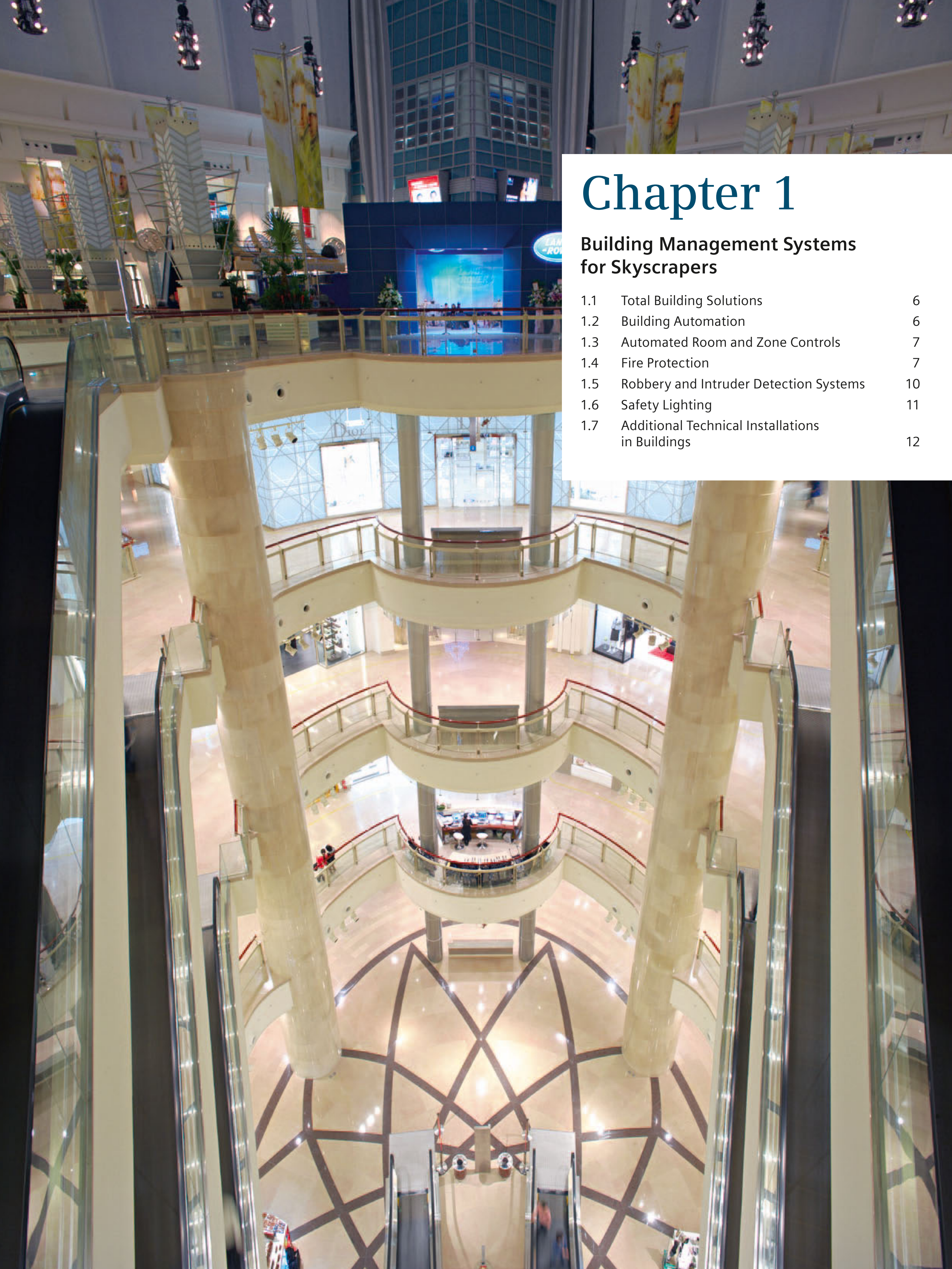


1 Building Management Systems for Skyscrapers

In the modern world of today and tomorrow, buildings shall provide maximum safety, consume few resources during construction and operation and be flexibly adaptable to future requirements. The intelligent integration of all building services installations offers an optimum to be attained for safety, energy efficiency environmental compatibility and flexibility in combination with maximum comfort. A tailored total solution for electric power distribution, building automation, fire protection and security systems create the added value the client expects.

1.1 Total Building Solutions

Total Building Solutions establish a balance between the requirements for safety and security of people and property and the desire for ease-of-use and problem-free operation. The result is a highly automated, intelligent building, designed for the entire life cycle of the property. In its requirements and structures, the Total Building Solution refers to the Technical Building Management (TBM) disciplines.

These customized solutions comprise:
- A central building control system
- Security and personnel control systems
- Control of heating, ventilation, air conditioning and refrigeration
- Automated room and zone controls
- Power distribution
- Fire protection
- Protection against burglary and intrusion
- Access control
- Surveillance systems (CCTV and video)
- Lighting systems
- Integration of third-party systems
- Display of messages and building data

1.2 Building Automation

Building automation means comprehensive solutions and services for controlling the heating, ventilation, air conditioning, lighting, shutters and sun shields as well as the integration of electric power distribution -ranging across individual rooms, entire floors and complete buildings and also managing distributed property areas.

Buildings are responsible for about 40 % of the total energy consumption within the European Union (EU). With Directive 2010/31/EU, the Energy Performance of Buildings Directive (EPBD), the European Union pursues the goal to improve the energy efficiency of properties by 20 % until 2020, compared to the reference year 1990. Amongst the most important measures specified are the creation of an energy certificate for buildings (or energy 'passport') and the determination of minimum requirements for buildings.

In the European standard EN 15232, "Energy Performance of Buildings – Effects of the Building Automation and the Building Management", the components of building automation systems are evaluated with regard to their effect on the energy consumption of buildings.

In accordance with the new standard, building automation systems (BAS) are divided into four different performance classes (Fig. 1/1):
- Class D corresponds to systems that are not energy-efficient; buildings with such systems have to be modernized, new buildings may not be equipped with these systems.

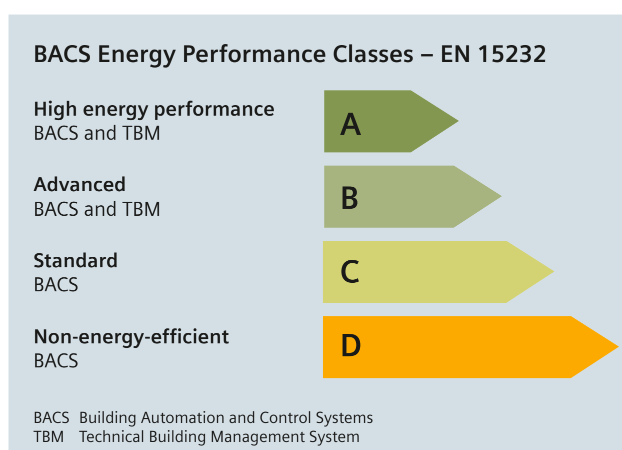


Fig. 1/1: **Performance classes of the building automation systems according to EN 15232**

- Class C corresponds to the average standard BAS system requirements currently in use.
- Class B designates further advanced systems and
- Class A corresponds to highly efficient systems.

This standard also contains procedures for the calculation of energy performance by means of user profiles for building types of varying complexity:
- Offices
- Hotels
- Classrooms, lecture theatres
- Restaurants
- Retail / wholesale centres
- Hospitals

Combinations of these standard elements provide clear specifications of how to achieve a certain performance class.

1.3 Automated Room and Zone Controls

Modern automated room control concepts provide integrated solutions for the air conditioning, lighting and sun shielding as an important precondition for the well-being and performance capability of those using the room. Switches and regulators for the operation of all room functions are available in various designs to satisfy individual requirements and architectural demands.

Communicative systems should be used to satisfy the requirements of EN 15232 for a Class A building. Open communication protocols such as LON or KNX/EIB in accordance with EN 50090 (VDE 0829) satisfy this requirement. A further advantage of such systems is the ease they can be extended with or flexibly adapted for various types of use.

1.4 Fire Protection

Fire requires an initial ignition and then oxygen to keep burning. Therefore, wherever people live and work, there is always a danger of fire. Constructional measures alone are not sufficient to prevent the initial ignition turning into a real fire. For this reason, effective fire protection is essential. Effective fire protection is in place, when the following two conditions are satisfied. Firstly, the fire must be detected quickly and clearly and signalled. And secondly, correct measures must be implemented as quickly as possible. This is the only way to avoid direct fire and consequential damage or at least to keep this to a minimum. Implementing the chain of action "Prevent – Detect – Fight – Learn" can be considered the control loop of integral fire protection (Fig. 1/2).

The Model High-Rise Directive (MHRD) in Germany demands for fire protection:
- Fire fighting lifts
  - with separate wells, into which fire and smoke cannot infiltrate
  - with stops on every building floor
  - at a distance of max. 50 m (running direction) to every place on that floor
- Positive pressure ventilation systems, so that the infiltration of smoke into interior safety stairwells and their lobbies as well as firefighters' lift shafts and their lobbies is prevented (provide for standby units)
- Automatic fire extinguishing systems with two rising mains cables in separate shafts
- Fire alarm systems, fire alarm control centre, fire emergency lift control; fire alarm systems must be equipped with automatic fire detectors, which ensure complete monitoring of all of the
  - rooms
  - installation ducts and conduits
  - hollow spaces of false floors
  - hollow spaces of suspended ceilings

  (mains-powered smoke detectors are sufficient for apartments).

1

1.4.1 Fire Protection Concept

Protective measures must be planned and carried out in such a way that
• smoke is detected as fast as possible,
• fire spreading is hindered,
• an alarm is triggered early and evacuation is carried out quickly
• the fire brigade can take appropriate action,
• the fire can be extinguished in the shortest possible time and without damage to people and property
• efficient smoke evacuation is ensured.

Optimally coordinated fire detection, alarm, evacuation and fire extinguishing systems are the basis of this fire protection concept and protect more effectively than separate solutions. The fire protection system can also be easily integrated with a management system in a larger security concept with intrusion protection, access control and video surveillance. This results in the creation of a comprehensive hazard management. Integration in the building control system and the associated intelligent interaction result in a more effective protection of people, property and the environment.

1

The fire detection system

An important element in fire prevention is the time between fire detection and intervention. The shorter this time that be kept, the less the immediate damage and the consequential damage. Intelligent, high-speed evaluation models of advanced fire detection systems such as the SINTESO detectors with ASA^{TM} (Advanced Signal Analysis) technology enable smoke and fire to be detected immediately and clearly, no matter how difficult the environmental conditions. These detectors can be programmed optimally for the conditions at the location of use (Fig. 1/3).

The alarm and evacuation system

The effectiveness of clear and unequivocal communication during a crisis situation is also of prime importance in the fire protection. An electro-acoustical or speech-controlled alarm and evacuation system has proven to be the best solution in all cases. Unique fire alarm signals, reassuring behaviour rules and clear instructions help to avoid panic breaking out.

In addition to the prompt detection of the fire, quick and orderly evacuation of the building is of prime importance to save lives. Especially with regard to court

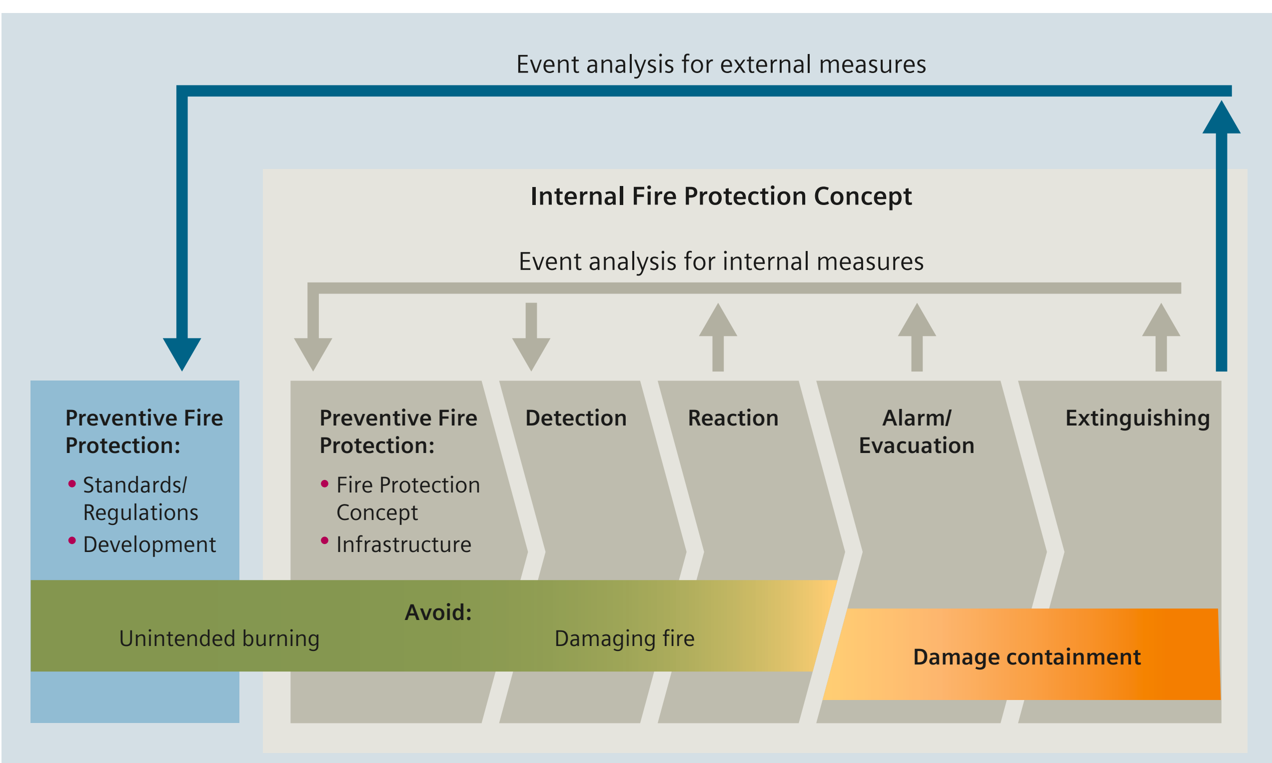


Fig. 1/2: **Control loop of integral fire protection** rulings on compensation claims, evacuation is playing an increasingly important role. But what is most important is that panic does not break out among the users or residents of the building in an emergency. This is best achieved with reassuring information and clear instructions.

In heavily frequented high-rise buildings, e.g. in shops, doctor's practices, hotel areas and parking areas, efficient evacuation of people is crucial. The rule of thumb is, the faster the evacuation, the greater the chance of survival. In this context it is important that panic does not break out, which is prevented by reassuring information and clear instructions. It is therefore best when a fire alarm occurs that spoken messages are used for the evacuation. Spoken instructions via loudspeakers are clear, they are understood and followed. This greatly increases the chances for people to save themselves. For this reason, speech-controlled alarm systems are an ideal complement to fire alarm systems in all buildings.

The fire extinguishing system

Each application requires a suitable extinguisher. Whether powder, wet, foam or a combination of these extinguishing systems: a fire extinguishing strategy that has been worked out individually and tailor-made not only protects your building, but also the environment when a fire breaks out.

A fire extinguishing system cannot prevent a fire starting. However, with prompt detection, it can extinguish a fire when it is still small. Especially in intensely used buildings such as high-rise buildings where there are special risks (many people, expensive property, high downtime costs, etc.), this is of invaluable, existential importance.

The basis for this is quick and clear detection so that fire sources are detected and located immediately. Depending on the situation, the correct intervention is started at the right time.

As an automatic fire extinguishing system represents the optimum initial intervention method in most cases, Siemens supplies a wide range of extinguishing systems. Adapted to the respective field of application (risk and target of protection), each of these systems provides optimum protection. The comprehensive range of extinguishing equipment also ensures that the quickest and best effect is achieved, suited to the situation in each special case.

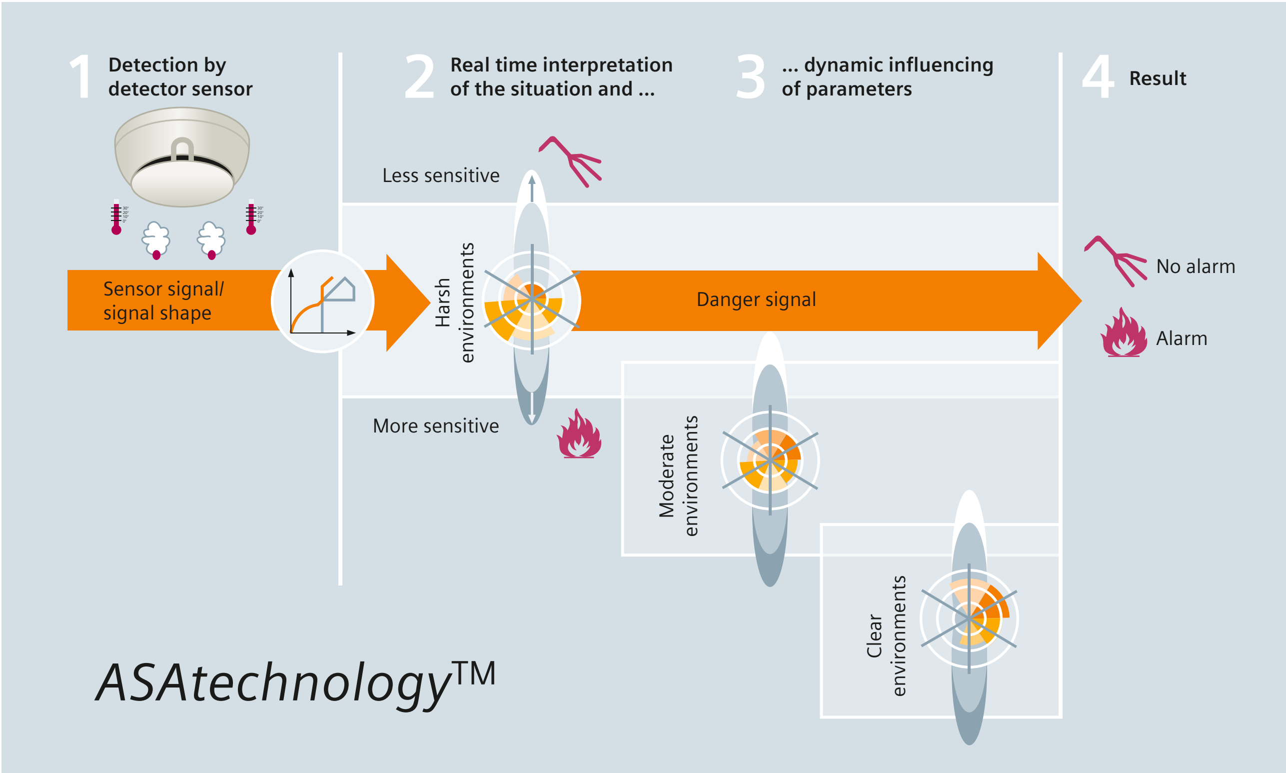


Fig. 1/3: **Functioning principle of ASAtechnology**

1.5 Robbery and Intruder Detection Systems

The necessity to protect people, property and other values against violence and theft was never as great as at present. The subject of security is becoming an increasingly important business factor. Therefore, reasonable provisions for the protection of people, the safeguarding of property or irreplaceable objects of value are especially important.

Naivety and carelessness help burglars just as much as inadequate security measures. Therefore, people and property must be protected passively as well as actively: passively by mechanical security devices, actively using an electronic alarm system. The additional observance of simple security rules and the necessary everyday prudence are another significant contribution to minimize the risk.

1

Four security aspects

Optimum protection of people and buildings is based on the following four pillars.
- Prudence as free-of-charge protection
- Mechanical protection equipment as the first line of defense
- Electronic robbery and burglar alarm systems for the reliable detection of dangers
- Forwarding of alarms for the immediate notification of personnel providing assistance.

1.5.1 Electronic Robbery and Intruder Detection Systems

As a rule, the following factors should be considered, when drawing up a security concept:
- Origin of the risks: are these only external risks, e.g. through intruders, or do they also occur within the high-rise building, e.g. through employees or visitors?
- Objects of value on the property: (cash, jewelry and works of art, high-quality producer goods and systems, sensitive data, etc.).
- The location of the object to be protected – busy or quiet area?
- Risk of vandalism: what does the social environment look like?
- Danger of extremism: is there a danger of specific acts of sabotage?

The consequences of burglaries, such as operational downtimes, the loss of customer data and the damage possibly resulting thereof, must also be taken into consideration.

All of the above aspects are relevant for our application example, so that a security concept aiming at a high degree of protection should be implemented. An electronic system has decisive advantages compared to purely mechanical protection measures: it already detects the first attempt at a break-in and immediately notifies the required security staff. This is not the case with purely mechanical building protection. If not detected, a burglar could make any number of attempts to overcome the mechanical protection measures. If you also consider that mechanical protection measures often cannot be used with modern building components, such as glass doors or special lightweight construction elements, then an active security system is frequently the only alternative. We recommend a sensible mixture of mechanical and electronic protection. The more time it takes to break in, the more time the notified security team has to intervene. The burglar also has much less time in the building, which can significantly reduce the possible damage.

1.5.2 Video Surveillance Systems

In sophisticated security concepts, the video system provides the visual basis for decisions and therefore plays a central role – in addition to the real-time monitoring of critical areas, the identification of persons with the aid of biometric processes, or the detection of dangers. Important elements are:
- Stationary digital zone surveillance
  In targeted zone surveillance, any changes are detected autonomously and different alarm zones are monitored. If an alarm is triggered, the video sequences are recorded digitally and forwarded to higher-level management systems. Existing IT infrastructure can also be utilized.
- Mobile video systems
  High-speed availability of data and images is extremely important for the monitoring of external installations, live coordination of service personnel or the management of mobile business activities. Numerous detectors and cameras are grouped around a mobile digital system that can store multimedia information and quickly pass this on via modern communication networks.
- Recording of alarm situations
  Recording an incident is not the only part a video surveillance system plays, it also documents the entire process: from recording of the video images, transmission and storage of this information, initiation of automated measures through to centralized data evaluation and archiving.
- The communication between the video system and the control centre is performed using TCP/IP via any Ethernet, ATM (asynchronous transfer mode) or other TN

(transport network) structure. In conjunction with a Video Web Client, operation, control and access is possible from anywhere in the world.

1.5.3 Time Management and Access Control Systems

Last not least, the proper technology for access control is a matter of security rules for individual parts of the high-rise building. The aim is to find rules (as to who shall be entitled to access equipment, facilities and data) which allow the authentication of persons to be flexibly adapted to individual or corporate requirements and access rights to be configured geographically and temporally at the same time. Therefore, open system solutions with flexible networks are required. Its special structures and the specific workflows also have an effect. Factors such as the size of the building, its layout, the number of people, doors, lift and access gate control as well as additional functions also have to be taken into account.

Future-oriented solutions include not only the linking of business management applications, but also the integration of other security systems. When linked to the building management systems, the information can also be optimally used under energy performance aspects.

1.6 Safety Lighting

The German MHRD demands a safety lighting system for high-rise buildings which is automatically switched on in case of a failure in the normal lighting. It must be available

- on emergency escape routes
- in the lobby areas of lifts
- for the safety signs of emergency escape routes

In addition to this, safety lighting fulfils more protection requirements, such as the illumination of fire fighting and alarm systems, thus facilitating rescue activities.

In contrast to IEC 60364-5-56 (VDE 0100-560), where the "Emergency Lighting Guide“ is purely for information, the German pre-standard DIN V VDE V 0108-100 stipulates the following for the safety lighting of high-rise buildings:

- Illuminance in compliance with DIN EN 1838
- A switch-over time between 1 and 15 seconds depending on the risk of panic breaking out and the danger evaluation
- A rated operating time of 3 hours for the safety power source (Note: 8 hours are required for residential-purpose high-rise buildings unless the safety lighting is continually operated together with the normal lighting. In that case, illuminated push-buttons acting as local switching devices must be fitted in such a way that it can be identified from any place even if the normal lighting fails. Safety lighting must automatically switch off after a settable time, when supplied from a power source for safety purposes.)
- Continually operated illuminated or back-lit safety sign
- A central power system (CPS) or a low power system, (LPS) or a single-battery system are permitted
- A maximum interruption time of 0 to 15 seconds is permitted for a power generating unit for safety lighting

1.7 Additional Technical Installations in Buildings

1.7.1 Lifts

The following applies in accordance with the Guideline for High-rise Buildings issued by the Bavarian State Ministry for the Interior: High-rise buildings must have at least two lifts with stops on every complete storey. Both lifts must be within easy reach from every part of the storey. Lift stops must only be accessible from corridors or lobbies. In storeys without windows (e.g.underground car parks, basements, technical equipment floors), lift access must be confined to lobbies only. At least one lift must be suitable for carrying wheelchairs, stretchers and loads (minimum depth of 2.1 metres) and must be directly accessible from the public traffic zone and all storeys providing recreation rooms, without that passengers would be required to overcome any stairs. A sign must be fixed at the access ways to the lifts indicating that their use is prohibited in case of fire. In the lobbies to the lifts, signs must indicate the storey level number and the nearest stairs. Additionally, it may be required that lifts be connected to a standby power supply so that they can at least be driven to the building entrance level one after the other in case of a general power failure. Requirements concerning firefighters' lifts are described in section 1.4.

1

Owing to the high number of passengers with different destinations and the need to transport loads, high-rise buildings that accommodate a hotel would require at least 20 or more lifts. Modern lifts for supertall and hypertall skyscrapers reach a travel speed of over 15 m/s and heights of 500 metres and more. It should be noted that an acceleration of more than 1.2 m/s^2 or respectively, an equivalent abrupt slowing down may have a disagreeable effect on sensitive passengers. In order to reach a speed of 15 m/s, the lift needs 12.5 seconds assuming this degree of acceleration. In order to limit the pressure exerted upon the passengers' ears, an atmospheric pressure control may be used and an aerodynamic passenger cabin may reduce the loss of performance as well as noise caused by the air resistance in the lift well.

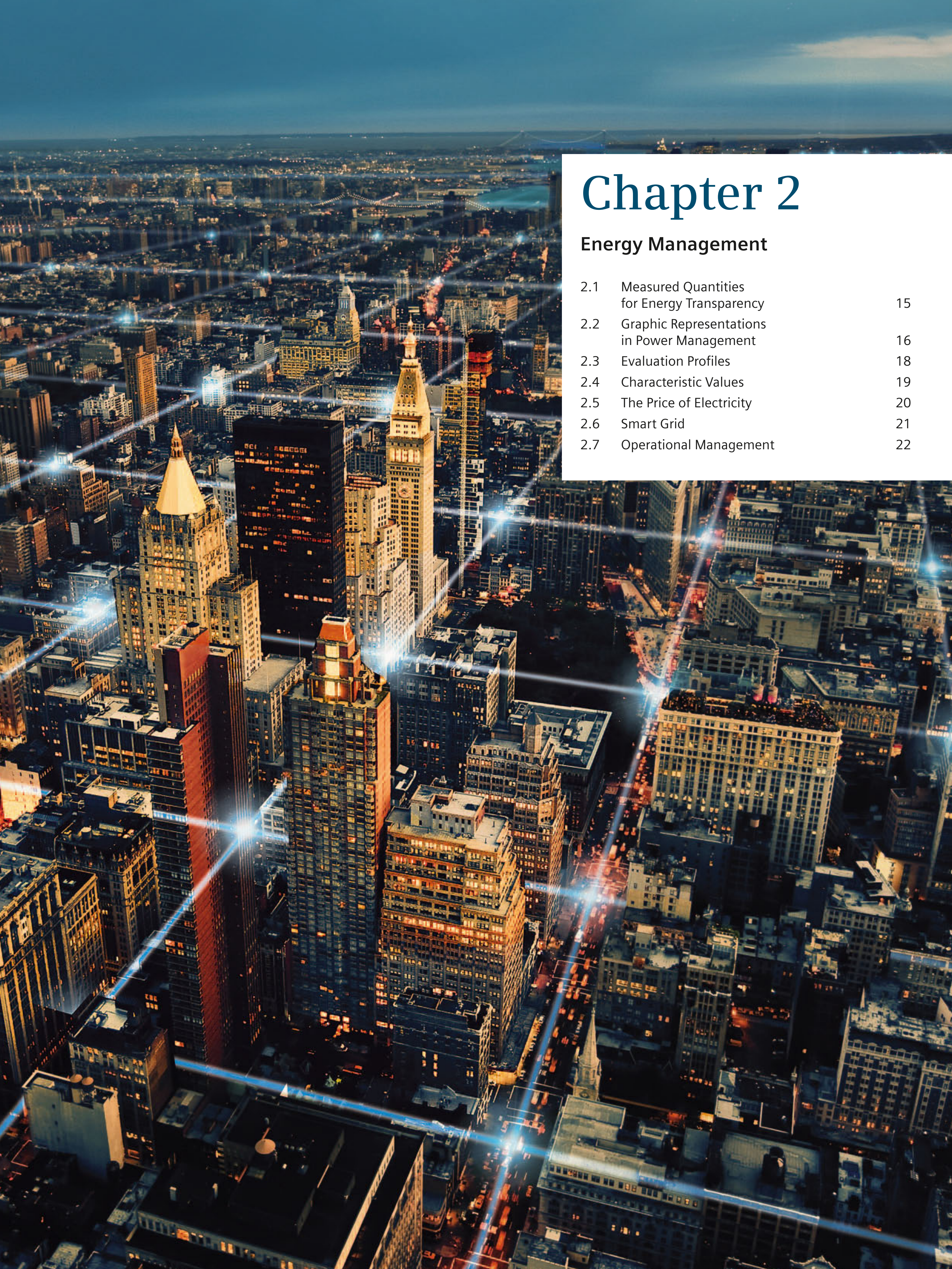
Therefore it is reasonable to use express lifts to overcome large heights. At least two groups of express lifts seem suitable for tall skyscrapers. They take their passengers to different heights and force them to change at the respective top end. Besides firefighters' lifts and express lifts, goods lifts and escalators for the shopping centre must also be factored in.

1.7.2 Standby Power Supply System

All of the electrically operated life safety equipment, such as emergency lighting, lifts for firefighters and for the evacuation of people, indoor radio communication for security staff, water pressure risers, fire alarm and fire fighting systems, safety-relevant ventilation and gas alarm systems, as well as access control and access prevention systems must be connected to the standby power supply. Specifications concerning safety-purpose power sources can be found in IEC 60364-7-718 (DIN VDE 0100-718). Please note that an interruption of power supply of up to 15 seconds is permissible. Standby power supply equipment must be fire-resistant and self-contained – for low-voltage main distribution also spatially separate from the normal power supply. However, critical consumers which must not be exposed to power interruptions (e.g. smoke vent flaps, which work according to the static current principle) must be backed by an uninterruptible power supply system (UPS).

1.7.3 Water Pressure Boosters

According to the Guideline for High-rise Buildings issued by the Bavarian State Ministry for the Interior, wet rising main piping must be operated through water pressure booster installations if the pressure at the most unfavourable tap is less than 3 bar assuming a water flow rate of 100 l/min (connection of a C-nozzle). In dry rising main piping, water pressure booster installations must be built in if the measure between the feeding point for water supply and the topmost tap is more than 80 metres. Water pressure booster installations must ensure a pressure of min. 3 bar and max. 8 bar assuming a flow rate of 100 l/min at all tap points.



Chapter 2

Energy Management

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2 Energy Management

High supply and operational reliability and flexible use are the key factors of every modern power distribution system. With the energy costs making up a greater share of the total operating costs of a building, optimization of the operating costs is an absolutely essential goal, even at the planning stage. Essential elements are an ecologically and economically focused optimization of energy consumption and energy costs.

Even in the design stage of a high-rise building, energy analyses are called for. When basic data is established and pre-planning work is carried out, which corresponds to Phase 1 and 2 according to the Regulation of Architects' and Engineers' Fees (HOAI) in Germany, targets must be agreed upon as to the kind of energy to be utilized and the measuring systems to be employed and an energy concept must be developed.

2

Based on the energy flows in the building, energy transparency, energy management and energy efficiency all interact. Data collection and data processing ensure energy transparency on which a functioning energy management is based. A building's energetic efficiency is directly influenced by the integration of automation systems and the definition of energy efficiency levels for the equipment as based on client specifications:

Energy efficiency

Energy efficiency describes the relation between energy outlay and resulting benefit. To determine the efficiency h (e.g. of lift motors), the ratio of power input in relation to the effective power output is evaluated over a defined period of time. Efficiency targets are fundamental elements of planning.

Energy transparency

Energy transparency creates the data basis for actions, reactions and improvements. Basically, energy transparency is part of operational management, since energy flows can only be analysed with precision in practice. Even so, the measuring, evaluation and data management systems shouldn't be forgotten in the pre-planning stage.

Energy Management

The VDI 4602 Sheet 1 guideline defines energy management as follows: "Energy management is the clear-sighted, organisational, and systematized coordination of procurement, conversion, distribution and usage of energy to meet requirements taking ecological and economical objectives into accounts." All resources enabling this coordination are defined as energy management systems in this standard: "Energy management systems comprise the organisational and information structures required to put energy management into practice. This includes the technical resources involved, such as software and hardware."

If energy management requirements are to be considered in addition to personal and system protection, measuring instruments as part of electrical power distribution must also be factored in. This is necessary in order to be able to verify the implementation and operation of a energy management system as required in EN 50001. For the planning work, this means identifying measuring points at an early stage, defining the scope of measurements and specifying measuring instruments. Without metrology there is no energy transparency and thus no energy management.

There is a growing tendency to expect an analysis of the plant life cycle costs to come from the planning engineer. Limit values obtained in the plant dimensioning process are unsuitable for determining the cost for losses. The power losses of transformers, busbar trunking systems and cabling figure prominently in life cycle cost calculations. Current is factored in with its square value.

For an ohmic load, power loss P_V is calculated as follows:

$P_V = I^2 \cdot R$ (current I, specific resistance R).

The costs for losses are the product of the electricity price and power losses. But without a realistic load curve for the period under review, it is not possible to obtain an estimation of power consumption that reflects operating conditions. However, this is a prerequisite for the determination of power losses and hence the life cycle costs.

On average, 5 % of the energy procured are dissipated as heat (power losses) within an electrical power distribution system. Owing to consumption-optimized dimensioning of individual distribution system components, such as transformers, busbar trunking systems and cables, according to the load curve, there is an absolute energy saving potential of up to 1 % (in relation to the 5 % power loss in the whole power distribution system, this means a relative saving of 20 %), really a non-negligible dimension over a period of 20 years. Under the aspect of life cycle costs, the optimization of transformers, busbar trunking systems and cabling should be part of the standard scope of services in present-day engineering and electrical design and thus should be asked for and offered accordingly.

2.1 Measured Quantities for Energy Transparency

Feed-in, transformers and generators are dimensioned on the basis of their apparent power S in kVA. Currents I measured in A are crucial for the busbars, cabling, protection and switching devices integrated in the electrical power distribution system. Loads are always factored in with their active power P in kW and the associated cos φ.

If these electrical quantities, which served as the planning basis, are to be substantiated during operation, appropriate measuring devices need to be provided. When allocating the energy consumed to different cost centres, the quantity of work or energy W (in kWh) within the feed-in system and for every power consumer to be allocated must also be measured (Fig. 2/1).

To ensure transparency of plant operation, it is useful to measure voltage (U in V), current (I in A), power factor and the proportion of total harmonic distortion (THD) (total

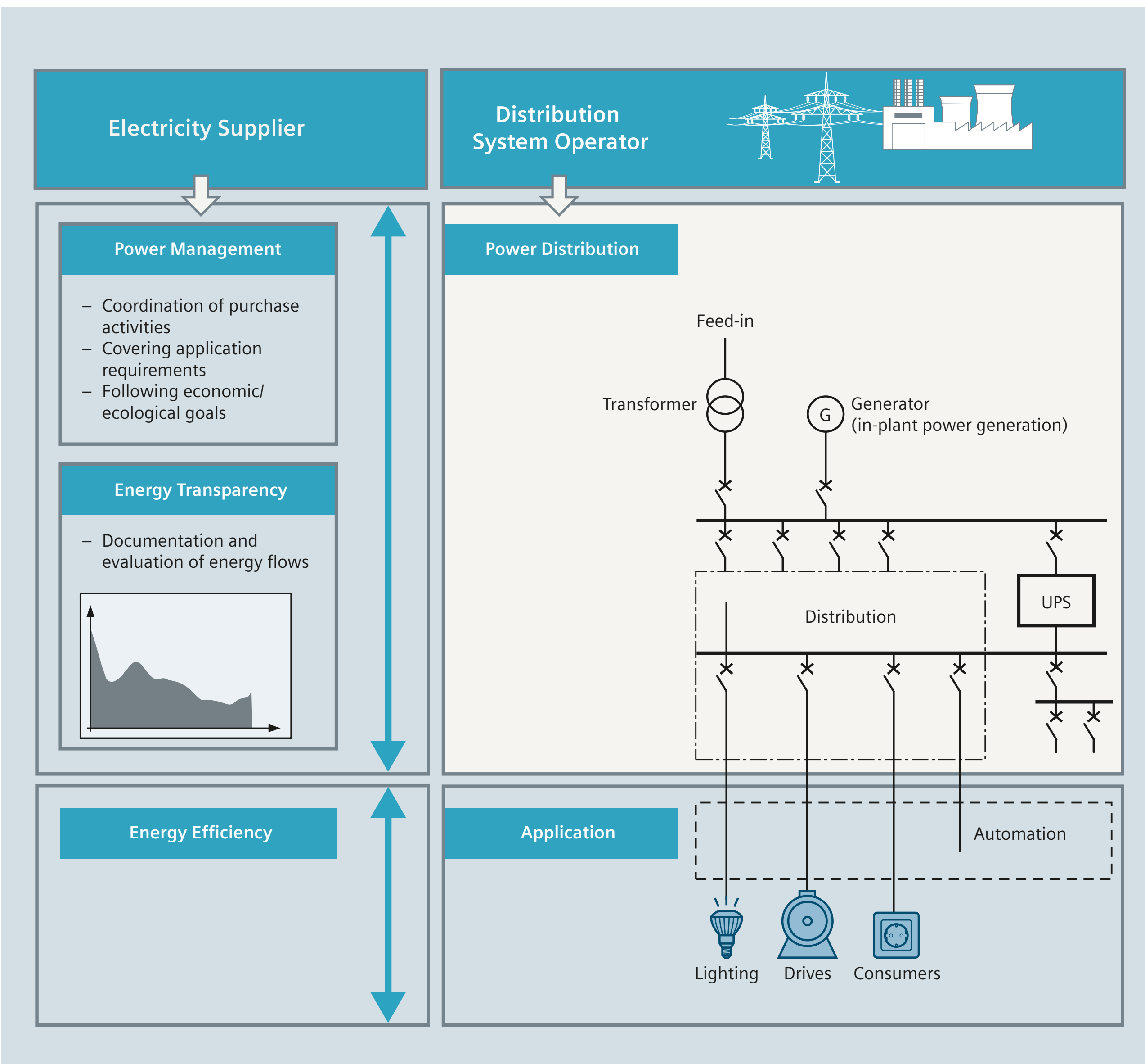


Fig. 2/1: **From energy management to energy efficiency with the help of energy transparency**

2

harmonic content both for voltage and current) at the transformer in addition to the above mentioned apparent power. In the distribution network, it is sufficient to perform a single voltage measurement directly downstream of the transformer. For the distribution networks downstream of the transformer, it is sufficient to be aware of the voltage drop. Based on a certain maximum prospective current, voltage drop dimensioning verifies that every final consumers keeps within the permitted voltage limits (max. +10 % / -14 %). IEC 60038 (VDE 0175-1) specifies a permissible deviation of +/- 10 % for alternating current networks of a nominal voltage between 100 V and 1,000 V and refers to the additionally permitted 4 % voltage drop within a consumer installation, as described in IEC 60364-5-52 (DIN VDE 0100-520) (Fig. 2/2).

A generator is treated like a transformer, but in addition, the produced work W must be measured in kWh.

Leased or tenant areas are billed on the basis of electricity consumption W in kWh. An electricity meter records the consumption. Here it must already be clarified in the planning stage, whether this meter must be a calibrated meter for billing purposes. Calibrated meters for billing purposes must be used if the metered values are to be used as the basis for invoicing.

2.2 Graphic Representations in Power Management

The measured values as rows of figures constitute the basis for various graphics in an energy management system. Normally, users can only understand the response of individual system components and the interconnection between energy usage and the corresponding energy demand by analysing the graphs of the measured values.

Note: Owing to their time relation, mean values of power output and power consumption determined at 15-minute intervals can be derived from one another.

- Measurement: Mean active power P (kWh) at a 15-minute interval
  Mean power consumption E = P · 0.25 h [kWh]
- Measurement: Mean power consumption h(kWh) at a 15-minute interval
  Mean active power P = E / 0.25 h [kW]

2.2.1 Load curves

Load curves are graphs of measured values in their chronological order. Time is entered on the X-axis, measured values on the Y-axis.

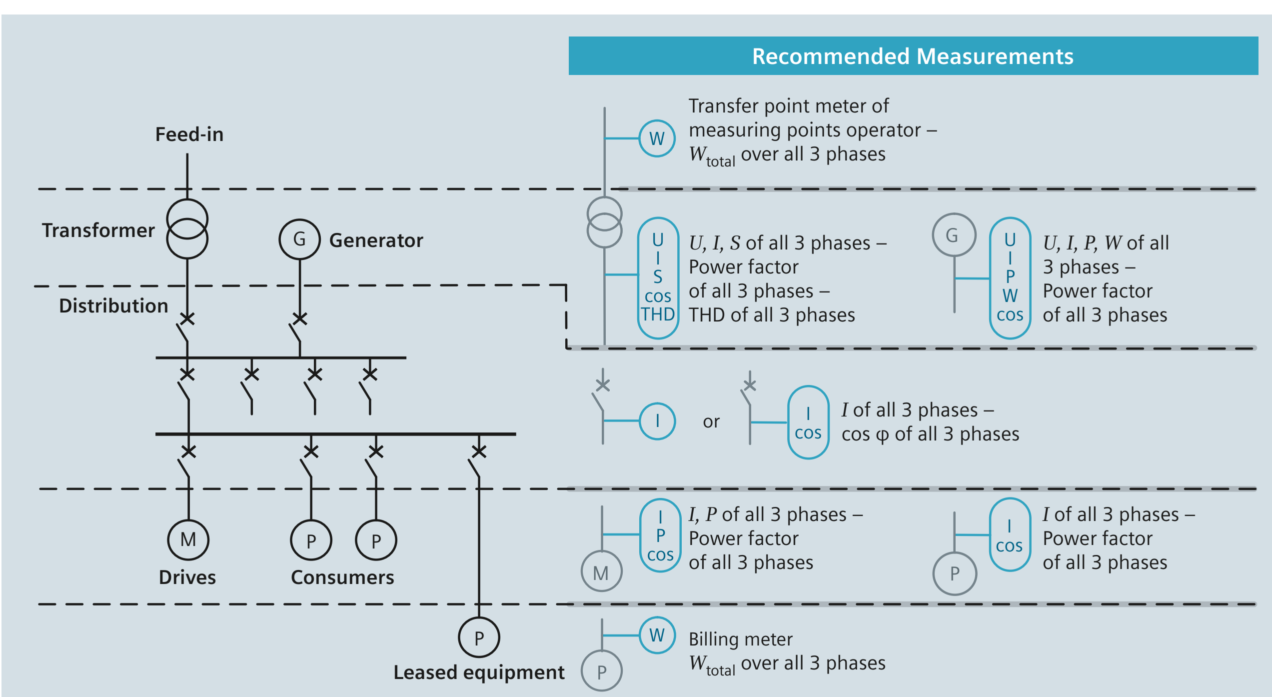


Fig. 2/2: **Recommended measurements for managing a high-rise building**

A one-year load curve (Fig. 2/3) starts with the measured value of the first day of the year on 00:15 a.m. and ends with the value of the last day of the year under consideration on 24:00 p.m. The mean values are entered at 15-minute intervals, beginning with the full hour. For performance curves, the average power output of a 15-minute interval is entered over the corresponding period. A graphical representation as load curve allows for the following typical analyses:

- When was it necessary to purchase considerable quantities of power?
- Is there a typical consumption behaviour (e.g. a typical time/power pattern)?
- Are there correlations over time with pronounced changes in the measured power values?
- How high is the base load?

Please note that with a mixed utilization of a high-rise building, an analysis needs to be undertaken of the specific load curves of the different applications. Such analyses can be offered as services to tenants and building users.

Depending on the resolution of the time axis, even more specific interpretations, such as consumption behaviour in special situations or trends, become feasible.

The evaluation of yearly load curves is suitable for providing an overview regarding

- Load pattern
- Continuity over months
- Electricity peaks at certain points in time over the year
- Seasonal variations
- Operating holidays and other special operating situations
- Minimum performance requirements as load base

The graph of a monthly load curve (Fig. 2/4) may be utilized to demonstrate a possibly typical behaviour:

- Similarities of power purchase
- Continuity at the weekends
- Purchased power over night (i.e. power consumption)
- Base load
- Bank holidays /bridging days/ weekends and other 'operations closed' days (Fig. 2/5)

In this way, day-specific differences become obvious, such as

- Daily demand
- Daily variations
- Typical work-shift patterns
- Demand peaks

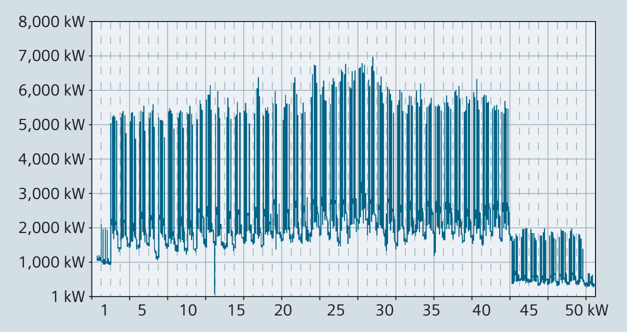


Fig. 2/3: **Yearly load curve for a measuring point**

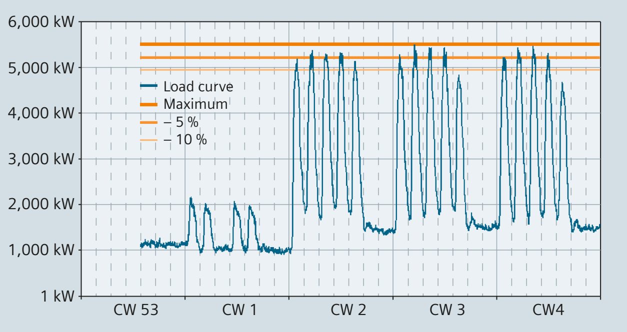


Fig. 2/4: **Monthly load curve for a measuring point**

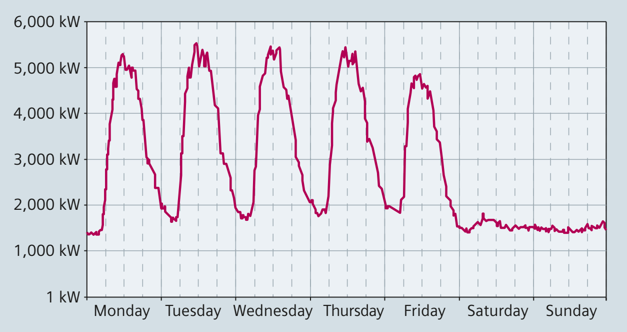


Fig. 2/5: **Weekly load curves for a measuring point**

2

The individual 15-minute intervals are entered into the daily load curve (Fig. 2/6), so that the following points in time can be recognized:
• Precise representation of the daily demand and moments of change
• Breaks
• Work-shift changes

2.3 Evaluation Profiles

To emphasize correlations, characteristic performance values and typical conditions by graphics, the measured values are processed in different evaluation profiles, for example
• Load Profile
• Frequency distribution
• Evaluation of Maxima

2

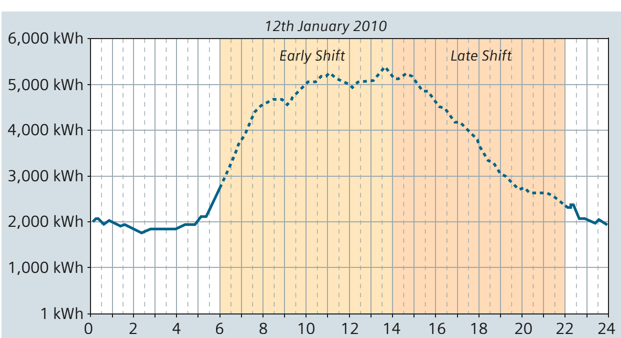


Fig. 2/6: **Daily load curve for a measuring point**

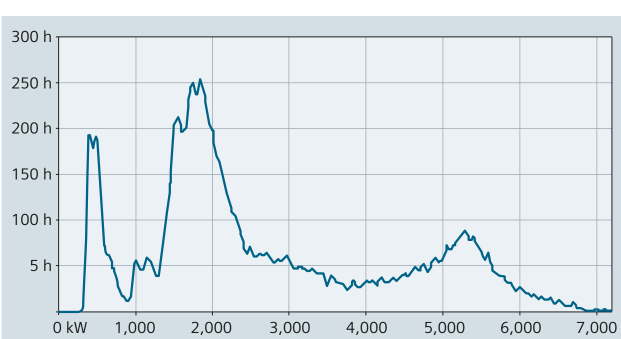


Fig. 2/7: **Load profile of a measuring point over one year**

2.3.1 Load Profile

In terms of the load profile, the load values are shown on the X-axis and the number of hours in which the respective value was measured are shown on the Y-axis shows The performance profile, which is based on the power values measured every 15 minutes, starts with the base load and ends with the maximum purchased power. The load profile allows you to identify power core areas, i.e. the most frequently required power values of a plant or system (Fig. 2/7).

The load distribution profile is important for efficiency analyses and allows conclusions to be reached as to energy efficiency:
• Equipment ratings (e.g. transformers)
• Loss analyses (life cycle costs)

2.3.2 Frequency Distribution

The frequency distribution is a statistical complement of the load profile showing cumulated values. For the frequency distribution, the number of hours are entered on the X-axis and the power needed for the respective number of hours is entered on the Y-axis (Fig. 2/8). Since the number of hours is entered with a rising edge, the frequency distribution curve starts with the maximum purchased power and ends with the base load. The frequency distribution allows conclusions to be drawn as to the continuity of power purchase. In particular, deviations from the mean curve progression allow such conclusions to be drawn.

Typical evaluations gained from frequency distributions are:
• Load peak characteristics
• Electricity purchase continuity
• Shift models
• Base load

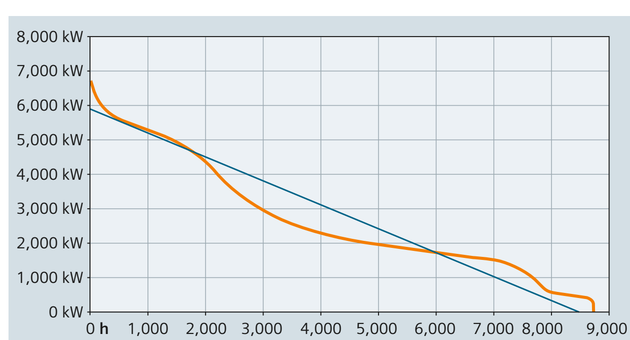


Fig. 2/8: **Frequency distribution over one year and mean curve progression**

2.3.3 Evaluation of Maxima

For a graphical representation of maxima (Fig. 2/9), the highest measured values including the time stamp are entered in a descending order. Two reference lines are frequently drawn to mark a peak load reduction by 5 % or 10 % respectively. A Maxima view clearly shows in how many 15-minute intervals a load management system should have intervened and which power reductions would have had to be applied in order not exceed a defined peak value.

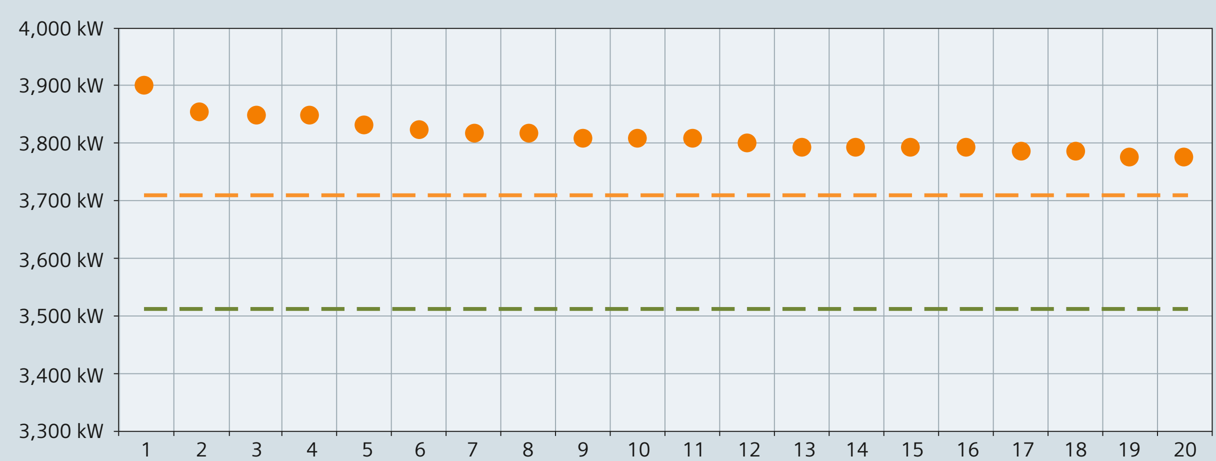
Variants of the Maxima view map a daytime-specific distribution of load peaks, or show monthly maxima to enable the identification of leverages for load management improvements or an altered plant management.

2.4 Characteristic Values

The point of characteristic values is to provide an overview and enable comparisons to be made. Typical characteristics are analysed as month-/year-related summation, maximum, mean, and/or minimum values. They can act as a leverage for energy management, since they illustrate the spread of time-dependent power demands. Characteristic measured quantities are:

- Work (important for the kilowatt-hour rate)
- Power peak value (important for the demand charge)
- Usage period (important for prices)
- Full load hours
- Simultaneity factor
- Unit-specific power values, e.g. work-shift values, item-based values, time-specific work values
- Maximum, mean and minimum values of current, voltage, power factor, power, and work etc.

Note: Characteristic values directly indicated can constitute the basis for further analyses which may be utilized to characterise buildings (energy per usable area, power demand related to the cooling demand, ambience-specific dependency on extreme values, etc.) For more detailed information about characteristic values, data analyses and interpretations, please refer to M. Weiß, Datenauswertung und Energiemanagement, 2010 (ISBN 978-3-89578-347-0).



15-min. value	Date/Time	15-min. value	Date/Time	15-min. value	Date/Time
3,904 kW	12.1.10 9:00	3,816 kW	12.1.10 8:45	3,792 kW	11.1.10 10:45
3,856 kW	12.1.10 10:30	3,816 kW	12.1.10 8:45	3,792 kW	11.1.10 10:45
3,848 kW	13.1.10 8:30	3,808 kW	12.1.10 9:00	3,784 kW	11.1.10 8:15
3,848 kW	13.1.10 8:30	3,800 kW	12.1.10 11:45	3,784 kW	11.1.10 8:15
3,832 kW	12.1.10 11:00	3,792 kW	11.1.10 10:45	3,776 kW	13.1.10 8:15
3,824 kW	12.1.10 9:15	3,792 kW	11.1.10 10:45	3,776 kW	13.1.10 8:15

Peak cutting
- **by 5 % 3,709 kW**
- **by 10 % 3,514 kW**

Difference between highest and 20th value 3 %

Fig. 2/9: **Maxima view as a ranking of peak load values**

2.5 The Price of Electricity

The price of electricity is composed of the kilowatt-hour share, the demand charge, taxes and duties:

The kilowatt-hour share is owed to the power supplier for the amount of electrical energy supplied. The kilowatt-hour share of the electricity price is the product of work consumed [kWh] and the kilowatt-hour rate [Cent/kWh].

The demand charge is owed to the distribution system operator for providing the infrastructure. It is the product of the highest 15-minute-interval purchased power [kW], or the average of n · 15-minute-interval purchased power values [kW] (n is an agreed number of maximum values) and the demand charge [€/kW].

Taxes and duties are to be paid to the national government or local authorities. These taxes include the value-added tax, the eco tax, a duty on renewable energies and, if applicable, one for combined heat and power generation.

The concession fee is raised for the usage of public land and paid to the local authorities. Taxes and duties are calculated as a percentage of the kilowatt-hour rate and the demand charge.

Internally, the price of electricity is normally calculated from the kWh-rate and the demand charge only. Taxes and duties are not considered.. The price of electricity (in € per kWh) is usually updated on a monthly basis. The average electricity price (AEP) is calculated from the sum of kWh-share and demand share divided by the quantity of electricity supplied:

$$\text{AEP [Cent/kWh]} = \frac{\text{(kWh-share [€] + demand share [€])}}{\text{quantity of electricity [kWh]}}$$

Development of the electricity price as a function of the usage period can be graphically represented. The different

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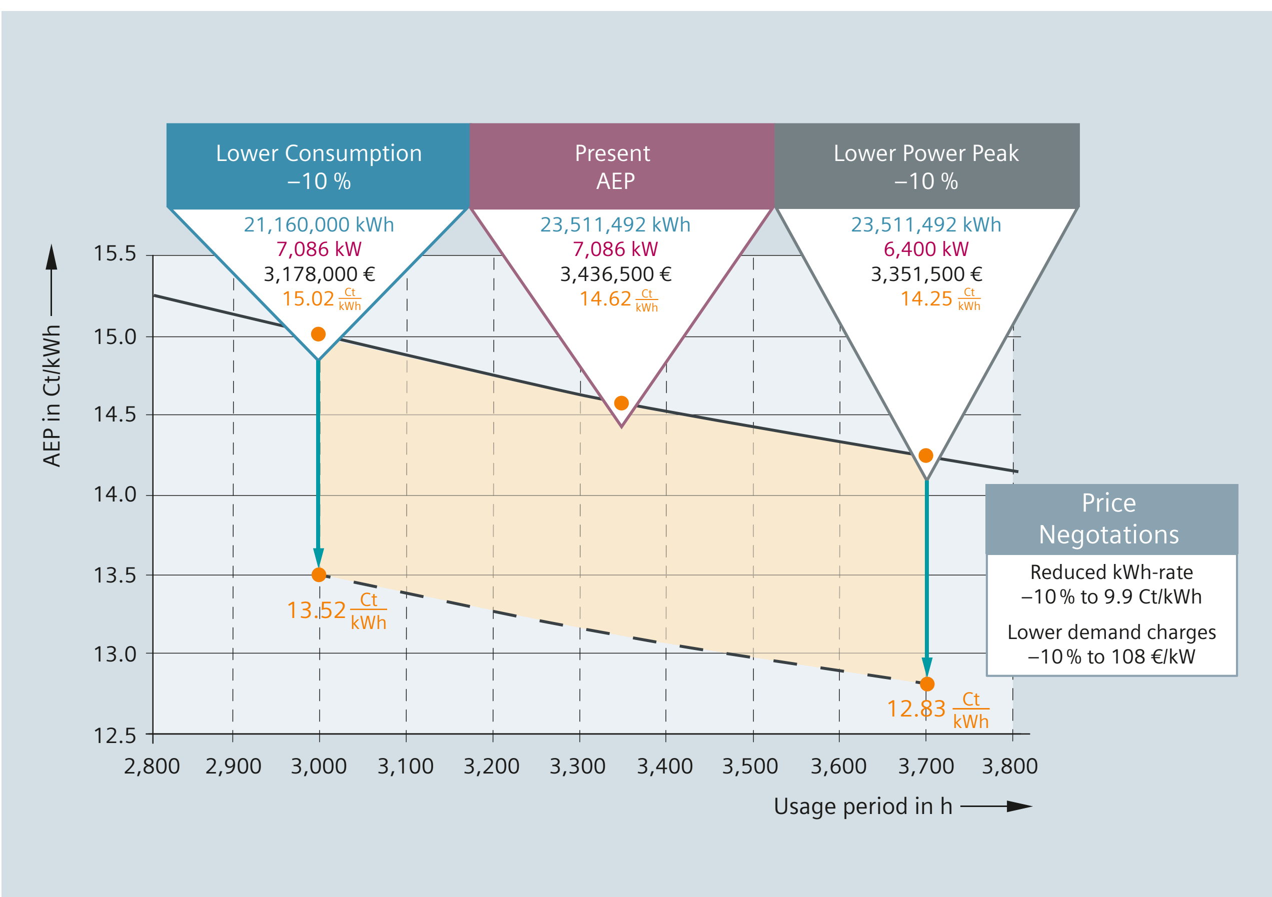

Fig. 2/10: **Example of an "optimization window" for the average price of electricity** options for optimization as a result of kWh-rate and demand charge variations as well as specific time limits can thus be illustrated. In the graphics this will finally generate an "optimization window" (Fig. 2/10), which is defined by the following key points:

- Current AEP
- Possible energy savings while maintaining the maximum power purchase
- Possible saving of purchased power while keeping to the same amount of energy consumption
- Possible revised kilowatt-hour rate
- Possible revised demand charge

In the graphics, the assumption is a price reduction of kWh-rate and demand charge of 10% each. In the three tabs above the "optimization window" of Fig. 2/10 kWh-rate and demand charge are fixed prices. Please not that it is not the absolute cost of electricity that can be read from the "optimization window" but a mean electricity price per kilowatt-hour consumed. Depending on the supply situation at the power supplier's and grid operator's, the variation of consumption and power peak can result in different starting positions for price negotiations. Of course, other characteristic parameters, distributions and evaluations may also have an influence here.

2.6 Smart Grid

The term "Smart Grid" describes the intelligent interplay of power generation, storage, distribution and consumption as an energy- and cost-efficient overall system (Fig. 2/11):

- The consumer is part of the smart grid and operates an interface to it.

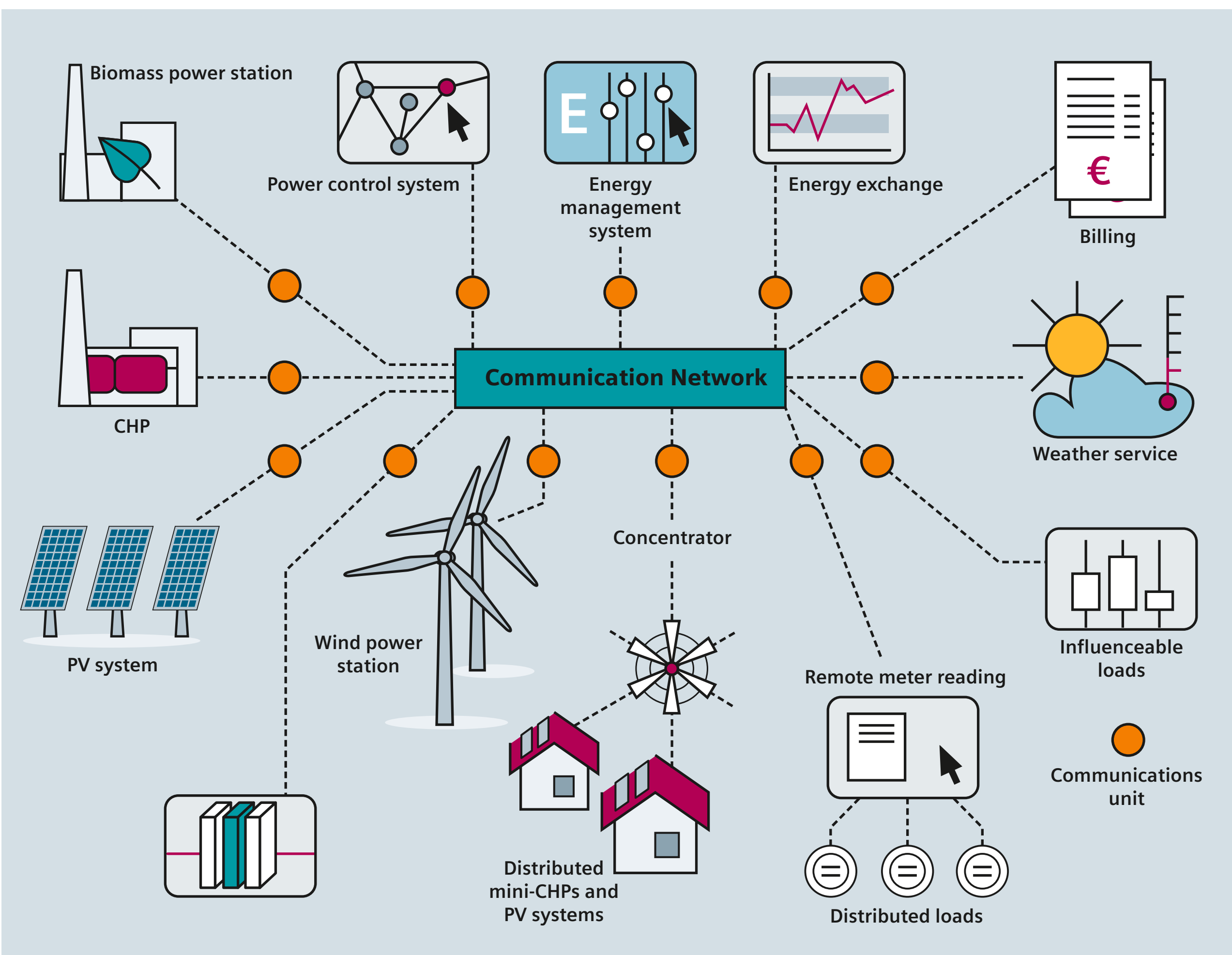

Fig. 2/11: **Energy management and communication between all parties involved and across all energy networks are the essential prerequisite for a Smart Grid**

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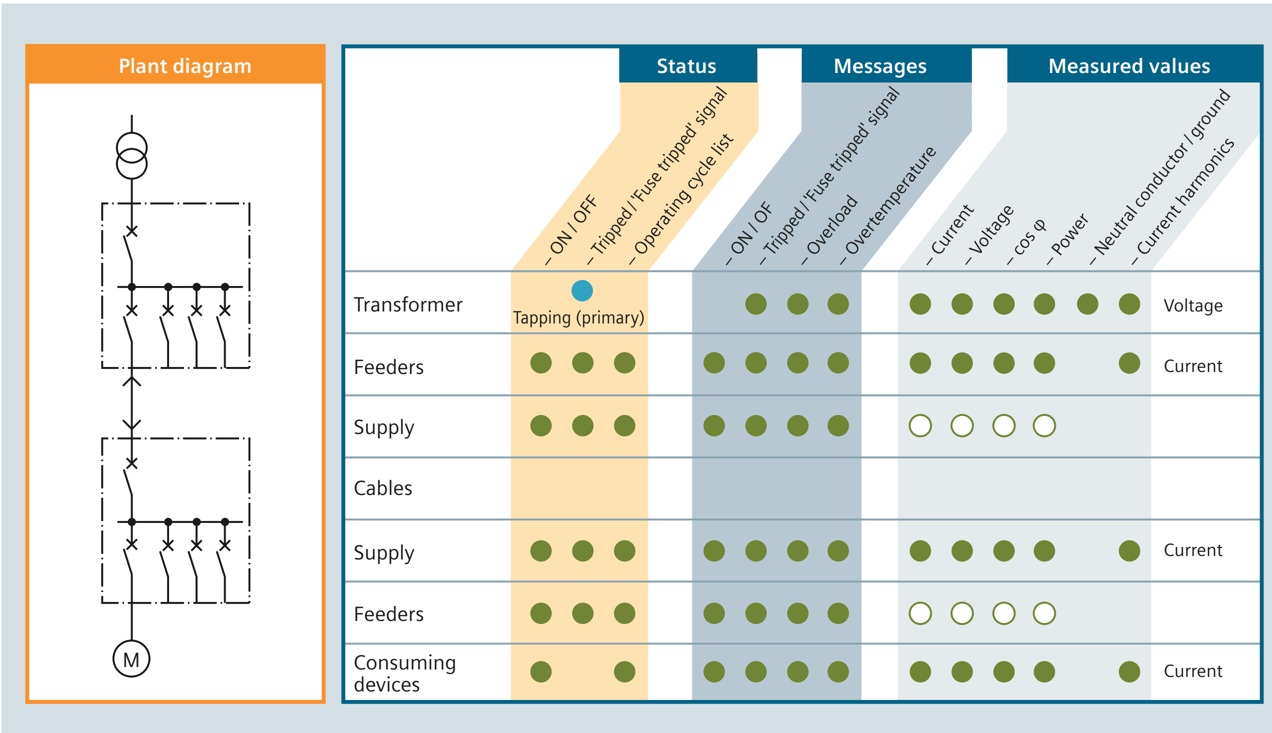


Fig. 2/12: **Operational view on electric power distribution (white dots may optionally be used)**

- Though the power supplier does supply the electricity, he nevertheless expects a demand forecast one week in advance at 15-minute intervals. Cost allocation is performed on the basis of the energy schedule ordered by the consumer, multiplied by the negotiated kilowatt-hour rate.
- The distribution system operator provides the connection to the supply grid and expects a statement about the power output ordered, which he must "keep in stock" accordingly. Cost allocation is performed on the basis of the negotiated demand charge multiplied by the highest 15-minute power value within the period under consideration (month or year).
- The metering operator measures the energy quantity delivered and makes the data available to the consumer. He is paid for his services with a flat rate.

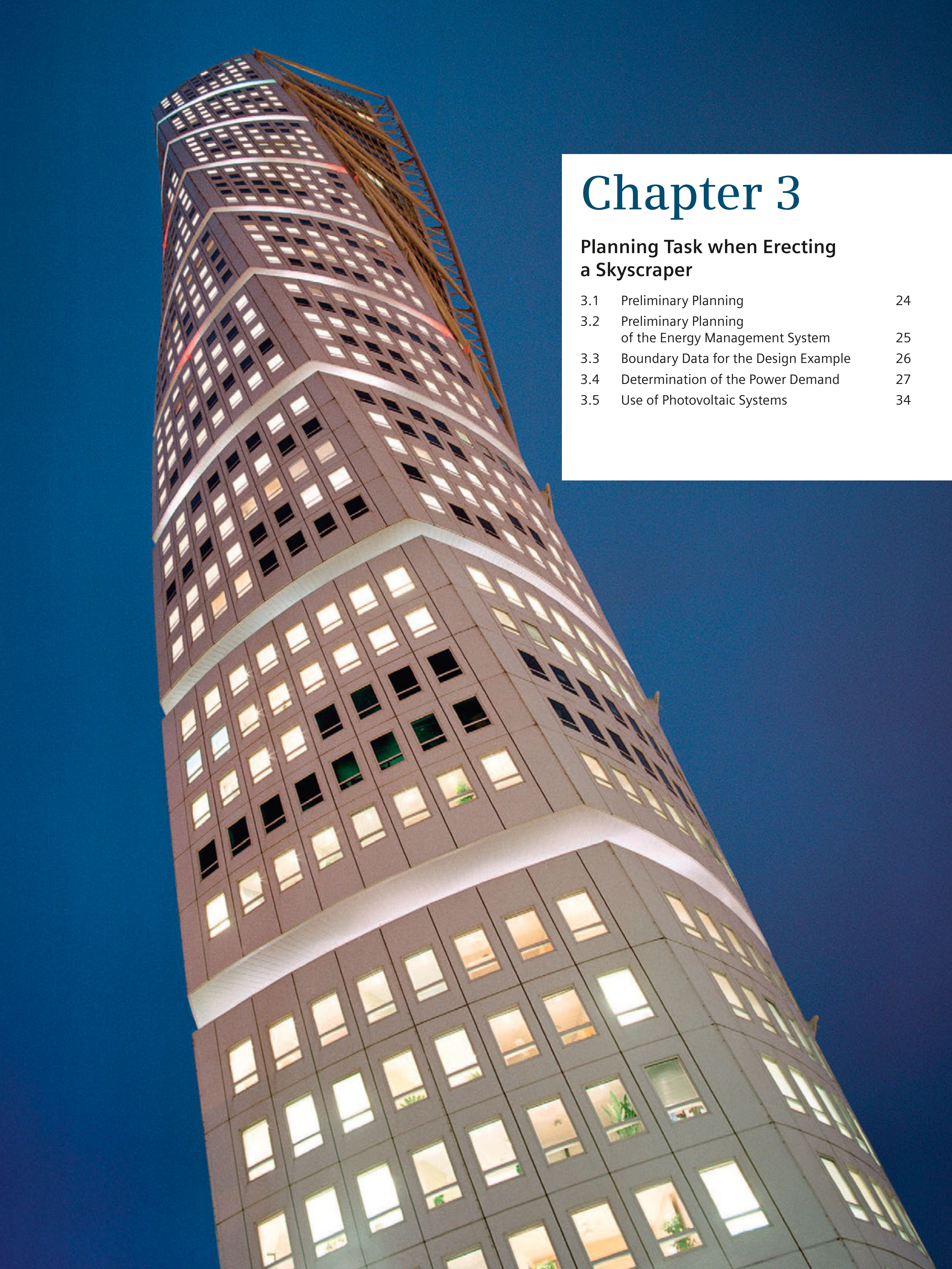
2.7 Operational Management

Technical operation management for a building uses the energy management system as a basis for its own planning. With the focus on power supply, efficient monitoring of operations and energy consumption using status displays and signalling equipment must be planned in line with the envisaged building usage. Even at the building concept stage, the associated measuring and control systems for building automation are to be provided and should comprise the following functional layers:

- Acquisition of status and measurements; processing level for data acquisition
- Operator control and monitoring with visualization, archiving, reports, control of switchgear, status monitoring / measuring points

The following reasons are strong arguments in favour of a technical operation management system:

- Quick and simple online overview of the states of the power flow/consumption in the building (Fig. 2/12)
- Validity check of the recorded values, avoidance of reading errors
- Optimization of the purchasing contracts adjusted to the individual consumption shares
- More precise specification and more economical power consumption from exact knowledge of the demand profile
- Transparency of costs in the energy sector
- Benchmarking



Chapter 3

Planning Task when Erecting a Skyscraper

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3.2	Preliminary Planning of the Energy Management System	25
3.3	Boundary Data for the Design Example	26
3.4	Determination of the Power Demand	27
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3 Planning Task when Erecting a Skyscraper

The greatest potential for the optimization of the power supply of a building is already clear during the planning phase. At this stage, the course is set for additional costs and cost increases which may incur during the erection and subsequent use of the building. Compared to conventional planning, integrated planning continually improves the cost-benefit ratio. When tackling complex tasks, integrated planning takes the synergies of coordinated, intelligent, integrated systems and products from a single supplier into account and implements them in cost-effective solutions. Interfacing and elaborate harmonization of different systems and products of different manufacturers becomes obsolete.

3.1 Preliminary Planning

Because of the numerous options for utilizing, arranging and styling the rooms and floors of a high-rise building, there are always specific requirements for the planning of the electric power distribution. When compiling the boundary conditions, the following must be taken into account during the preliminary planning of the high-rise building:
- Type, utilization and shape of the parts of the building (differentiation of the supply areas)
- Regulations and requirements of the building authorities (e.g. in Germany the Model High-Rise Directive – MHRD)
- The technical building equipment required for operation
- Requirements of the distribution system operator, such as the technical supply conditions
- Power demand application, tariffs, connection costs
- Possibilities of distributed power generation, own utilization, energy storage and system feed-in
- Determination of the building-related connection values depending on the supply area loads that correspond to the building's type of use
- Determination of the load centres in order to specify the transformer arrangement and the associated low-voltage main distribution system

When planning a high-rise building the optimal solution is always sought , which should be checked with regard to usefulness and cost-effectiveness taking the following conditions into account:
- Compliance with the regulations for erecting electrical systems (IEC 60364 and IEC 61936 resp. VDE 0100 and VDE 0101), stipulated guidelines and regulations (e.g. safety of persons in the accident prevention rule BGV A3), as well as project-related regulations for special systems.
- Clarity of the network topology
- Cost-effectiveness through the medium.voltage distribution through to the load centres and optimized rating of the planned equipment according to operating current and fault current carrying capacity
- Supply and operational safety through redundancy, selectivity, short-circuit strength, overvoltage protection, fault current carrying capacity and a high degree of availability of the equipment
- Supply quality, system perturbations and electromagnetic computability
- Minimization of the adverse environmental effects during creation and operation
- Flexibility to power changes through simple adaptation options
- Ease of maintenance through the use of uniform components
- Optimization with regard to voltage drop and transmission capability
- Ambient conditions such as installation altitude, humidity, ambient temperature, required fire protection and spatial boundary conditions

In accordance with these points, the following dimensioning criteria must be taken into account when planning the power supply:
- Determination of the network load (connection value)
- Simultaneity factors
- Utilization factors
- Specific area load for estimated power factor
- Power system configuration taking into account
  - Structure of the supply area and purpose
  - Number, size and position of the load centres
  - Transformer arrangement options and the associated low-voltage main distribution system (transmission losses, voltage drop)
  - Routing
  - Low-voltage (mostly distributed) or medium-voltage (mostly central) emergency power supply
- Rating and selection of
  - Electrical equipment
  - Switchgear
  - Distribution transformers
  - Conductor cross sections (for cable and busbar trunking systems)
  - System protection

3.2 Preliminary Planning of the Energy Management System

An energy management system (EnMS) is used for the systematic acquisition of the energy flows and facilitates investment decisions to improve the use of energy. Appropriate planning of the measuring and evaluation equipment creates the prerequisites for this. Proof of the continual improvement of the output-related energy utilization can also be provided and the legal requirements taken into account. Important goals of the improvement measures can be:

- Cost reduction
- Sustainable management
- Environmental protection
- Time and resource optimization
- Improvement of image and social acceptance
- Legislative and tax relief

To achieve these goals, the holistic approach of the EnMS from the planning, through the construction, use and renovation to the dismantling must be taken into account. In accordance with the schematic diagram in Chapter 2, Fig. 2/2, appropriate measurements should be incorporated in the preliminary planning. According to M. Weiß – "Datenauswertung von Energiemanagementsystemen" (ISBN 978-3-89578-347-0) (Data Evaluation of Energy Management Systems), the measurements and displays described in form the basis for an energy management system.

Load management and energy schedule

The power and energy demand is greatly influenced by the varied applications in the high-rise building and the numerous variables. The prerequisites for a load management and the creation of energy schedules based on this should be established during the planning. The load management can be used to limit the maximum power consumption to a settable value, in order to maintain the agreements made with a distribution system operator.

Measurements			Displays	Information
Voltages	Phase – phase	$U_{L1\text{-}L2}$, $U_{L1\text{-}L3}$, $U_{L2\text{-}L3}$	Characteristic values	Identification of unbalanced loads
	Phase – neutral	$U_{L1\text{-}N}$, $U_{L2\text{-}N}$, $U_{L3\text{-}N}$		Detection of earth faults
Currents	Phases	I_{L1}, I_{L2}, I_{L3}	Characteristic values	Identification of unbalanced loads
	Neutral	I_N		Neutral conductor currents indicate unbalanced load and/or harmonics
			Load curves	Resource-consumption behaviour as with the power display
Power factor	Total-cos φ	$\cos \varphi_{\Sigma}$	Characteristic values	Display for compensation demand
	cos φ of the phases	$\cos \varphi_{L1}$, $\cos \varphi_{L2}$, $\cos \varphi_{L3}$	Load curves	Identification of problems with the compensation
Power	Active power	P_{Σ}	Characteristic values	Value comparisons
	Reactive power	Q_{Σ}	Load curves	Time dependency of the load profile
	Apparent power	S_{Σ}	Frequency distributions	Description of the usage behaviour
Energy	Consumed energy	$W_{\Sigma,\text{Demand}}$	Characteristic values	Consumption values over 15 min
	Generated energy	$W_{\Sigma,\text{Supply}}$		Generation values over 15 min
			Load curves	Energy value overview
				Quantity check
			Total values	Cost centre allocations
Power quality	Total harmonic distortion, voltage	THD_U	Characteristic value	Necessity of harmonic filters
			Load curve	Problem identification, as, for example, critical load

Tab. 3/1: **Preliminary planning of measurements and displays**

3

Consumers that can be specifically switched on and off should already be identified during the initial planning phases. In addition, the networking of the energy distribution, automation and IT should be planned for the load management so that the operational processes in the various parts of the high-rise building can be clearly displayed. Otherwise, the planned maximum power demand must be selected much too high, especially with mixed usage.

As the electricity price is made up of a kilowatt-hour rate and a demand charge, load and forecast management should be taken into account when planning the associate measuring and evaluation equipment so that a demand-optimized energy schedule can always be created. In the future, supply contracts and mandatory compliance with schedules will play an increasingly important role in the cost optimization. When completing such contracts, the customers will have to specify their electricity demands in quarter of an hour intervals for one week in advance. Based on these values, the electricity trader purchases the electricity and demands an agreed price. If the actual demand is less than the forecast demand, this will not be credited. The agreed price will therefore be paid for a greater amount of electricity than that actually used. If more electricity is required than forecast, this results in additional costs which are based on the price for ancillary services at the time of demand.

If the supply contract contains a schedule clause, a forecast management should monitor the schedule. If the demand is greater than forecast, consumers are switched off and with demand lower than forecast, consumers are switched on. Consumers must be defined that can be specifically switched on and off for this purpose.

3.3 Boundary Data for the Design Example

It is not possible to define a standard high-rise building. Ambient/environmental conditions, official regulations, building use, operator wishes and specifications for equipment, schedule and costs require building-specific planning. For this reason, the following specifications have been selected as an example for a super tall skyscraper.

The super tall skyscraper is to be planned for mixed use and with a total of 80 floors. It is to have 75 floors above ground level and five below. With a floor height of four or five metres, this will result in an overall height of over 300 metres above ground level. The building narrows towards the top for architectural reasons, user-friendly

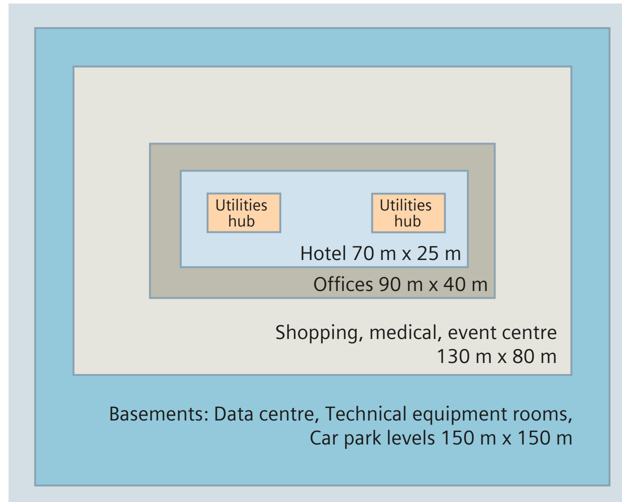

Fig. 3/1: **Plan view for the spatial arrangement of the various usage levels**

room and window areas as well as to reduce the wind load and turbulence at great heights (Fig. 3/1).

The vertical distribution of the building use with the associated areas is specified in Tab. 3/2. This distribution is shown schematically in Fig. 3/2, whereby the various types of lifts required for a high-rise building are displayed in colour. Instead of considering each single floor, which would be necessary to assign the technical equipment and lifts or escalators in detail, the technical equipment areas and the walls refer to the floor area. 10% are subtracted from the floor area for staircases, walls and corridors and 10% for technical equipment areas and lifts for the effective area on each floor.

Floor	Function	Area per floor in m²	Total area in m²
F 72 to 74	Technical equipment rooms	70 × 25	5,250
F 57 to 71	Hotel	70 × 25	26,250
F 6 to 56	Offices	90 × 40	183,600
F 5	Event centre / medical centre	130 × 80	6,000/4,400
GF to F 4	Foyer, shops	130 × 80	52,000
BM -1	Technical equipment rooms, warehouse / computer centre	150 × 150	16,500/6,000
BM -5 to -2	Parking decks	150 × 150	90,000

Tab. 3/2: **Vertical allocation of the high-rise building model**

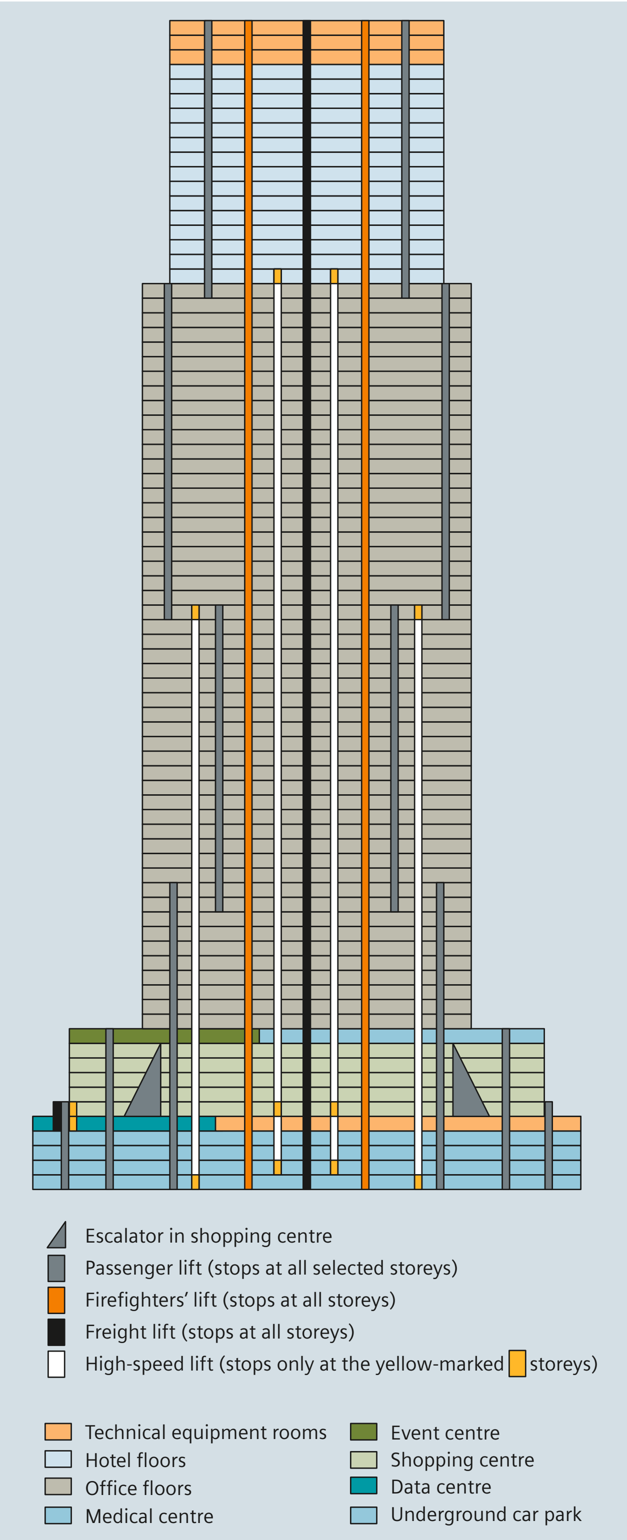

Fig. 3/2: **Schematic side view of the super skyscraper; the various usage areas and types of lift in the building are shown in colour (see legend)**

3.4 Determination of the Power Demand

The planner is already expected to provide advice on the total power demand during the Phase 1 for planning the power supply of a building, where basic data is established. An estimate based on the effective area under consideration of the workmanship is sufficient. The planner's design experience and information on the customer's ideas with regard to the workmanship are required to obtain realistic data. These can then be used immediately as boundary conditions for an initial cost estimate.

In the Phase 2 of the preliminary planning, a planning concept should be created with rough dimensioning of the important systems. Different variants should be considered with regard to cost-effectiveness, environmental compatibility and sustainability.

3.4.1 Estimate of Power Demand

Characterisation according to room structure, comfort and air conditioning can be used for a rough estimate of the power demand. At the same time, further factors play an important role in the estimate such as the expense of the technical installations and the integration in a building management system. Whereby, it is not always the case that a sophisticated technical solution is combined with a high-quality building management system.

The experience that we have gathered in numerous projects forms the basis for the initial, simplified calculation. A value of approx. 60 to 150 W/m² in relation to the effective area of the building is used to estimate the power demand (power to be supplied) of a high-rise building. Because of the wide range, it must be estimated for the planning of the building whether the figure will be closer to 60 W/m² or 150 W/m². For this purpose, we provide an estimation procedure with various calibration factors in the following as a simple help. A similar procedure is also used in EN 15232. Efficiency factors are used in this procedure that quantify the classification of the technical building characteristics and the use of systems for the building automation (BA) and the technical building management (TBM).

3

These factors (Tab. 3/3) are calibrated later for our estimation procedure on a value range between 0 and 1 and for a characterisation of BA/TBM and the technical building characteristics. Numerous addition factors influence the power demand and we want to use some for our simple calculation model. We will restrict ourselves to six characterisation features that are applied equally:

- Building placement
- Room structure
- Level of comfort
- Air conditioning option
- Technical characteristics
- BA/TBM

Of course you can also use your own factors as additional boundary conditions. The planner and the client should always agree on these factors to ensure the traceability of the calculation. Six calibration factors corresponding to the six characterisation features identify the power demand of the building in the model.

- Calibration factor k_{plc} for the building placement
- Calibration factor k_{struct} for the room structure
- Calibration factor k_{comf} for the level of comfort
- Calibration factor k_{clim} for the air conditioning options
- Calibration factor k_{tech} for the technical characteristics
- Calibration factor $k_{BA/TBM}$ for the BA/TBM

As we do not want to apply any further weighting to the factors, the mean value of the calibration factors can be defined as the total value:

$$k_{tot} = \frac{(k_{plc} + k_{struct} + k_{comf} + k_{clim} + k_{tech} + k_{BA/TBM})}{6}$$

To determine the specific power demand, we will start with the lowest expected value (here: 60 W/m²) and determine a factor k_{tot} from our estimations of the six subfactors. This factor is used to weight the difference (90 W/m²) to the upper expected factor 150 W/m² and added to the basic value of 60 W/m². First of all a characterisation of the individual calibration factors and the specification of the values are required for the estimation (Fig. 3/3).

Placement of the building – calibration factor k_{plc}

The location of the building has a fundamental influence on the planning of the power supply. The following questions can also be used to obtain an estimation:

- Do special conditions with regard to adjacent buildings have to be considered?
- Which traffic routes and connections can be used?
- What type of power supply is possible? And to what degree?
- Are there legal boundary conditions that have to be taken into consideration?

Class	D (C)	C (B)	B (A)	A (A+)
Offices	1.10	1	0.93	0.87
Auditoriums	1.06	1	0.94	0.89
Educational facilities (schools)	1.07	1	0.93	0.86
Hospitals	1.05	1	0.98	0.96
Hotels	1.07	1	0.95	0.90
Restaurants	1.04	1	0.96	0.92
Buildings for wholesale and retail	1.08	1	0.95	0.91
A distinction is not made for other types (such as sport facilities, warehouses, industrial facilities, etc.) so that factor = 1 (scaled = 0.5) is selected for all classes.				

Tab. 3/3: **Efficiency factors (electric) for the building automation according to EN 15232 for different non-residential buildings**

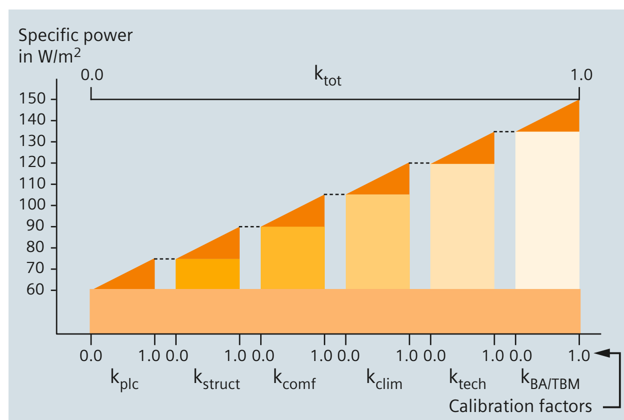

Fig. 3/3: **Influence of the calibration factors on the specific power**

As the super tall skyscraper in the example is to be considered with special local conditions, the placement factor k_{plc} = 0.5 is set.

Room structure – calibration factor k_{struct}

Smaller rooms are easier to ventilate and the lighting is distributed better in the room through reflection on the walls and ceiling. This calibration factor can also take the intended room height into account. Our estimations that are displayed in Fig. 3/4 as a curve also take into account that small rooms and areas frequently have direct ventilation and not air conditioning. Larger rooms and halls generally have a larger calibration factor k_{struct}. At this point, we would again like to emphasise that the experience and project knowledge of the planner and the agreement with the client are decisive when determining the factors. You can also talk about your specific projects with the Siemens promoters for TIP.

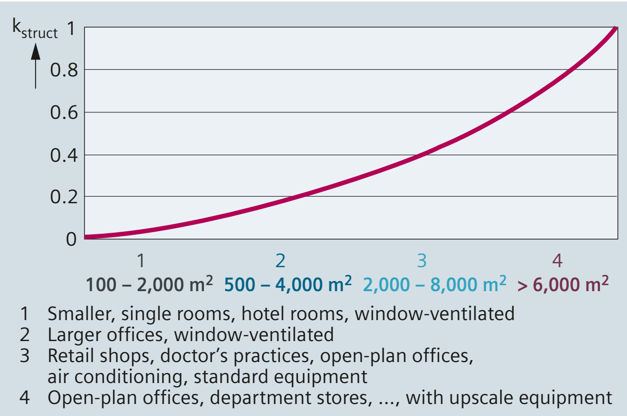

Fig. 3/4: **Schematic dependency of the estimation of the power demand of the building structure using the simple factor k_{struct} – the bars with the effective floor areas serve as reference values for the high-rise building**

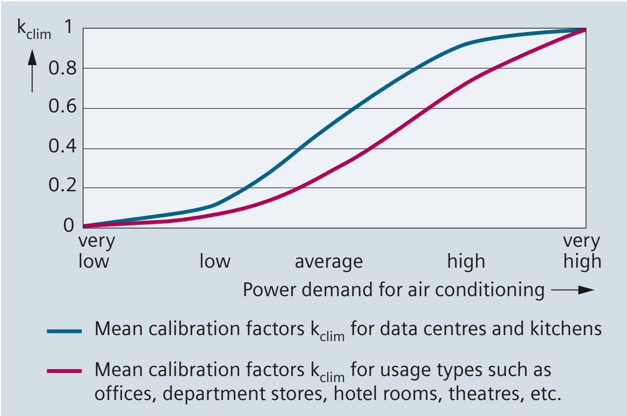

Fig. 3/5: **Schematic dependency of the estimation of the power demand of the building air conditioning using the simple factor k_{clim}**

The use of a large number of floors for small hotel rooms and offices results in a favourable factor k_{struct} of 0.3 in relation to the floor area for the model of the super tall skyscraper.

Comfort and safety equipment – calibration factor k_{comf}

It is difficult to make general statements about comfort as it is largely dependent on how the building is used. Whereas good lighting, an audio system and a monitoring system are considered as standard in a shopping centre, these characteristics may be considered as comfort features in office areas. On the other hand, blinds play no role in shop windows, but are important in hotels and offices. High-speed lifts for large loads require more power, as well as special stagecraft technology and technically sophisticated, medical diagnostic equipment. Control and monitoring systems make buildings safe and user-friendly. We will therefore select a factor $k_{comf} = 0.5$ for our model.

Air conditioning – calibration factor k_{clim}

With regard to the air conditioning of a building, natural ventilation, the efficiency of the cooling equipment and the possibilities of reducing the solar radiation without impairing the light conditions in the rooms must be taken into account. In Germany, the Association of German Engineers (VDI) have considered the building-specific power demands of the air ventilation and cooling in guideline VDI 3807-4.

We have displayed the calibration factors in a curve for the data described therein for the specific power installed in offices, hotel rooms, kitchens, computer centres, theatres, department stores, multi-storey car parks, etc. for the various demand classes from "very high" to "very low". Computer rooms that are better planned without windows, generally require more expensive air conditioning – constant temperature and humidity – although there is little effect from solar radiation. It should also be noted that the air conditioning depends on the room structure and the comfort requirements. For the example of a super tall skyscraper with mixed use, we assume a factor of $k_{clim} = 0.4$ because this takes into account the good use of natural cooling options and also the increased expense for the air conditioning of the computer centre (Fig. 3/5). The superimposition of lots of individual curves has shown that only types of use with a high demand for cooling, such as computer centres and kitchens, display a slightly different curve shape.

Technical characteristics – calibration factor k_{tech}

Even when the functionality of the technical building equipment has been defined, the difference in the technical versions is significant. High-speed lifts required higher starting currents than slower lifts, fans with EC motors (electronically controlled) save power and modern light fittings reduce the power demand, and the efficiency of many electrical consumers differ greatly from version to version. A general classification for the energy efficiency according to standard EN 15232 is listed in Tab. 3/4.

The efficiency factors of EN 15232 from Tab. 3/3 are transformed in Tab. 3/5 to the desired calibration area between 0 and 1.

A distinction is not made for other types (such as sport facilities, warehouses, industrial facilities, etc.) so that factor of 0.5 is selected for all classes.

For the high-rise building model, we assume large technical expenses averaged over the areas of the building, corresponding to class B and therefore high efficiency, so that we select $k_{tech} = 0.3$.

Class	Energy efficiency
A	Highly energy-efficient devices and systems (low-friction AC drives, EC fans, LEDs, transistor converters, etc.)
	Regular maintenance, possibly with remote monitoring
	Extensive communication and control options
B	Improved efficiency devices and systems
	Extensive communication and control options
C	Standard devices and systems that represent the current state of technology during operation
	No communication options, only mechanical adjustment possible
D	Simple devices and systems that only satisfy the required functionality
	Only On/Off switch

Tab. 3/4: **Classification of the technical characteristics of a building with regard to energy efficiency according to EN 15232**

Efficiency class	D	C	B	A
Offices	1.0	0.57	0.26	0
Auditoriums	1.0	0.65	0.29	0
Educational facilities (schools)	1.0	0.67	0.33	0
Hospitals	1.0	0.44	0.22	0
Hotels	1.0	0.59	0.29	0
Restaurants	1.0	0.67	0.33	0
Buildings for wholesale and retail	1.0	0.53	0.24	0

Tab. 3/5: **Calibration factors for the technical equipment of buildings and BA/TBM corresponding to the efficiency factors (electric) according to EN 15232 for different non-residential building types**

Building management – calibration factor $k_{BA/TBM}$

In the same way as for the technical characteristics, standard EN 15232 (Tab. 3/6) can be used for the building management.

However, note that energy efficiency class D from EN 15232 plays no role for the planning of BA/TBM systems of new buildings. The advantage of our procedure with scaled calibration factors is displayed here. Characterisation features can be adapted to the latest technology through the scaling and the classification always defined through the own current experience.

We will therefore omit class D and select a new class A+, which in addition to the properties of class A, is characterised by remote monitoring, remote diagnostics and remote control as well as analysis tools for BA/TBM, as part of Smart Grid. For the four new classes C, B, A and A+, we will then take over the appropriate calibration factors according to Tab. 3/5. Averaged across the various types of use in the building, we will select a high efficiency together with large expense for control, management and automation through a further-developed BA system. The factor $k_{BA/TBM} = 0.3$ will the be assumed for our high-rise building model.

This results in

$$k_{tot} = \frac{(k_{plc} + k_{struct} + k_{comf} + k_{clim} + k_{tech} + k_{BA/TBM})}{6} = 0{,}383$$

and therefore a specific power demand of

$P_{spec} = 60\ \mathrm{W/m^2} + (90\ \mathrm{W/m^2} \cdot 0.383) = 94.5\ \mathrm{W/m^2}$.

A total area of 390,000 m² is calculated from Tab. 3/2. The total area of the building is multiplied by a factor of 0.8 for an approximation of the effective area.

Effective area = 390,000 m² · 0.8 = 312,000 m²

The product from effective area and specific power demand results in an estimated power demand of 29.5 MW for the entire building.

3.4.2 Estimated Determination of the Power Demand

Through the precise consideration of the type of building use, the building equipment and the associated network topology, the power demand can be estimated as described in the Siemens TIP planning manuals.

With the distribution of the use and areas from Tab. 3/2 and Tab. 3/7 this results in the following for the individual floor areas:

– Basements –5 to –2:
Effective area = 0.8 · floor area = 18,000 m²

Average power demand (multi-storey car park) = 8 W/m²

Power demand for each floor = 144 kW

– Basement 1:
Area distribution: 6,000 m² computer centre / 16,500 m² technical equipment area
Effective computer centre area = 0.8 · 6,000 m² = 4,800 m²
Effective technical equipment area = 0.9 · 16,500 m² = 14,850 m²

Average power demand (computer centre) = 1,500 W/m²

Power demand share for computer centre = 7,200 kW

Class	Energy efficiency and building management
A	Corresponds to highly energy-efficient BA systems and TGM. • Networked room control with automatic demand acquisition • Regular maintenance • Energy monitoring • Sustainable energy optimization
B	Corresponds to further developed BA systems and some special TBM functions. • Networked room control without automatic demand acquisition • Energy monitoring
C	Corresponds to standard BA systems • Networked building automation of the primary systems • No electronic room control, thermostatic valves on radiators • No energy monitoring
D	Corresponds to BA systems that are not energy efficient. Buildings with such systems have to be modernized. New buildings must not be built with such systems • No networked building automation functions • No electronic room control • No energy monitoring

Tab. 3/6: **Efficiency classification for executing the function of building automation and technical building management systems according to EN 15232**

– Ground floor
Effective area = 0.8 · floor area = 8,320 m²

Average power demand (shopping centre / bank) = 50 W/m²

(additional larger room height)
Power demand for ground floor = 416 kW

– Upper floor 1, 2, 3, 4:
Effective area = 0.8 · floor area = 8,320 m²

Average power demand
(shopping centre) = 40 W/m²

Power demand for each floor = approx. 333 kW

– Upper floor 5:
Area distribution: 6,000 m² event centre / 4,400 m² medical centre

Effective event centre area = 0.8 · 6,000 m² = 4,800 m²
Effective medical centre area = 0.8 · 4,400 m² = 3,520 m²

Average power demand
(event centre) = 40 W/m²
Average power demand
(medical centre) = 100 W/m²

Power demand share for event centre = 192 kW

Power demand share for medical centre = 352 kW

– Upper floors 6 to 56:
Effective area = 0.8 · floor area = 2,880 m²

Average power demand (offices) = 50 W/m²

Power demand for each floor = 144 kW

– Upper floors 57 to 71:
Effective area = 0.8 · floor area = 1,440 m²

Average power demand (hotel) = 50 W/m²

Power demand for each floor = 70 kW

Building use	Average power demand [1)] in W/m²	Simultaneity-factor g [2)]	Average building cost per walled-in area in €/m³	Average cost for power current in a walled-in area [2)] in €/m³
Bank	40 – 70	0.6	300 – 500	25 – 50
Event centre	40 – 120	0.8	300 – 600	20 – 50
Office	30 – 50	0.6	250 – 400	17 – 40
Shopping centre	30 – 60	0.6	150 – 300	12 – 35
Hotel	30 – 60	0.6	200 – 450	10 – 35
Department store	30 – 60	0.8	200 – 350	20 – 45
Medical centre	80 – 120	0.6	300 – 600	18 – 50
Multi-storey car park	3 – 10	0.6	100 – 200	7 – 15
Data centre	500 – 2,000	1	300 – 500	40 – 80

[1)] The values specified here are guidelines for demand estimation and cannot substitute precise power demand analysis.
[2)] The simultaneity factor g is a guideline for preliminary planning and must be adapted for individual projects.

Tab. 3/7: **Average power demand of buildings according to their type of use**

3

Refrigeration/ventilation

An average power demand of 50 W/m² can be assumed for cooling and ventilation of the effective area above ground. The air conditioning requirement for the computer centre has already been included in the average power demand, as this is a major criterion for the energy efficiency of a computer centre.

For the effective area above ground of 217,800 m², the power demand for ventilation and refrigeration is 10.89 MW.

Distribution of the power demand of the computer centre

For a computer centre with an efficient infrastructure, 75 % of the required electricity is used for the supply of the ICT equipment (ICT = information and communication technology; i.e. servers, routers, switches, data storage, etc.) and 25 % for the supply of the infrastructure (air conditioning units, ventilation, uninterruptible power supply, lighting, monitoring, etc.). The PUE factor (PUE = Power Usage Efficiency) known in the IT sector mirrors the relationship between the total power demand and the power demand for the ICT equipment (here 5,400 kW). With the assumptions made earlier, this results in a PUE value of 1.33. This results in a power demand of 1,800 kW for the cooling and ventilation of the server rooms in the computer centre.

Technical equipment areas

An average power demand of 10 W/m² is assumed uniformly for the technical equipment rooms on the individual floors, which is multiplied by the total technical equipment area and used to determine the power demand. A lower ventilation and air conditioning power demand is taken into account for these areas.

The technical equipment areas for each floor from Tab. 3/8 add up to 56,400 m² for the whole building resulting in:

Power demand for the technical equipment areas of the building = 56,400 m² · 10 W/m² = approx. 560 kW

From the sum of the total power demand for the effective areas from Tab. 3/8 for the technical equipment areas and for the air conditioning of the building areas above ground, this results in a total power demand of approx. 29.9 MW.

Floor	Use	Total area per floor in m^2	Effective area per floor in m^2	Technical area per floor in m^2	$P_{Ø}$ in W/m^2	P_{Use} in kW
BM -5 to -2	Parking decks	22,500	18,000	2,250	8	576
BM -1a	Technical equipment rooms	16,500		14,850	10	
BM -1b	Data centre	6,000	4,800	600	1500	7,200
GF	Bank/shops	10,400	8,320	1,040	50	416
GF, F 1 – 4	Shopping	10,400	8,320	1,040	40	1331
F 5a	Event centre	6,000	4,800	600	40	192
F 5b	Medical centre	4,400	3,520	440	100	352
F 6 – 56	Offices	3,600	2,880	360	50	7,344
F 57 -71	Hotel	1,750	1,400	175	50	1,050
F 72 – 74	Technical equipment rooms	1,750		1,575	10	

Tab. 3/8: **Areas and power demands in relation to the type of use**

3.4.3 Distribution According to Supply Types

The required transformer output and the shares of the safety power supply and the UPS are now determined for the values for the total power demand found in section 3.4.1 and 3.4.2.

The application-specific outputs are multiplied by the simultaneity factors from the data from Tab. 3/7 and added up for the total required power.

Total power demand =

= (4 · 144 kW) · 0.6	(multi-storey car park)
+ 416 kW · 0.6	(bank / shopping centre)
+ 4 · 333 kW · 0.8	(department store)
+ 192 kW · 0.8	(event centre)
+ 352 kW · 0.6	(medical centre)
+ 7,200 kW · 1.0	(computer centre)
+ 51 · 144 kW · 0.6	(offices)
+ 15 · 70 kW · 0.6	(hotel)
+ 560 kW · 0.3	(technical equipment)
+ 10.89 MW · 0.7 =	(refrigeration, ventilation)

= 22.05 MW

If cos φ is specified as 0.9 and the transformer degree of utilization as 80%, a total transformer output = 22.05 MW / (0.9 · 0.8) = 30.6 MVA is required.

The dimensioning of the safety power supply (SPS) depends mainly on the building utilization and on average is approx. 20 to 30 % of the power required for the normal power supply (NPS). However, this value must be determined project specifically and is only an estimation of the connected applications here: In this example, the computer centre in the high-rise building requires a large share of the SPS for the UPS systems. The following must be taken into account for the SPS:

- Emergency lighting (approx. 3 to 10 % of the illuminance of the normal lighting, depending on the safety classification of the valid safety regulations; the following is required in the workplace regulation in Germany: $E = 0.1 \cdot E_n$ [E_n = rated illuminance]; however at least 15 lux)
- Supply of the fire control centre / smoke vents / sprinkler system / smoke extraction system
- Evacuation lifts, lifts for the fire brigade
- Maintenance or controlled shutdown of processes (this is usually an extra requirement from the user in order to reduce downtimes; there are no general statutory regulations for interruptions in the work process)
- Control and protection systems that must be maintained in an emergency
- Supply of life-supporting systems (e.g. in a clinic: generally an additional power supply, APS, is required here that can ensure an uninterruptible power supply in accordance with IEC 60364-7-710 (VDE 0100-710) through battery backup)

UPS systems are generally used to maintain operation in a computer centre and the ICT equipment of various applications. They take over the power supply of critical consumers with switching interruptions and start-up mode. Air conditioning and ventilation equipment may belong to the critical consumers in the computer centre if heat problems occur in the server racks when these components fail for just a few seconds.

Taking into account power redundancy, cos φ = 0.9 and a reserve power of 20 %, various UPS systems with different outputs and different UPS types can be considered for the ICT equipment in the computer centre:

- Static UPS comprising: Rectifier/inverter unit and battery or flywheel energy storage to bridge a power failure – for long-term supply when the NPS fails, the UPS systems are supplied via generators of the SPS.
- Rotating UPS comprising: Motor/generator set and flywheel energy storage or rectifier/inverter unit with battery to bridge a power failure

Without taking a redundancy concept into account, UPS systems with a total rated output of 7,500 kVA must be installed for the computer centre, and an additional UPS output of approx. 250 kVA for the control centre, safety systems and lighting.

Suitable rooms should also be provided for further UPS systems in all other areas of the high-rise building. Depending on the application sizes and the technical characteristics, the percentage of the UPS in relation to the NPS can differ greatly. The specifications can only serve as a guide:

- For the payment, access, guidance and safety systems in the car park (5 to 10 % UPS)
- For the payment, communication and safety systems in the shops (2 to 5 %)
- For the counter, communication and safety systems in the bank (3 to 10 %)
- For the ticket, media, guidance and safety systems in the event centre (2 to 10 %)
- For the office, communication, safety, diagnostic and treatment systems in the medical centre (2 to 20 %)
- For the data processing, communication and safety systems in the offices (2 to 10 %)
- For the hotel administration, communication, access and safety systems in the hotel (2 to 5 %)
- From the previously determined values for the power demand, this results in a UPS demand of approx. 250 kVA, which can be covered by smaller, distributed UPS systems, that can be supplied via the NPS and SPS of the floor distribution systems. The power distribution for our example is shown in Tab. 3/9.

Supply	Power demand in MVA	Percentage of power in %
NPS	18.5	Approx. 60.5
SPS	4.35	Approx. 14.2
UPS	7.75	Approx. 25.3

Tab. 3/9: **Power distribution in the high-rise building**

3.5 Use of Photovoltaic Systems

Particularly on the upper floors, the façade of a high-rise building provides a suitable surface for the energy use of photovoltaic (PV) systems. The photovoltaic modules can also be used to protect the façade, for soundproofing, thermal insulation and can be incorporated in the façade design. The additional benefits can be evaluated in monetary terms and set against the costs of the photovoltaic system.

In addition to the geographic location of the building, the alignment of the façade and the angle of inclination to the horizontal influence the amount of energy produced by the photovoltaic system. Compared to an optimal angle of inclination for Central Europe of 35° to the horizontal, a vertical arrangement of the photovoltaic modules reduces the annual amount of energy produced with a southerly alignment by approx. 25 to 35 %. However, a vertical arrangement has advantages with regard to the soiling of the module surfaces.

The photovoltaic system has no effect when determining the power as a maximum power demand without photovoltaic supply must be assumed. In standard IEC 60364-7-712 (VDE 0100-712) for setting up low-voltage systems, "Part 7-712: Requirements for special installations or locations – Solar photovoltaic (PV) power supply systems", it is explicitly stated that when selecting and setting up facilities for disconnection and switching, the public power supply must be considered as power source and the PV system as load.

In such on-grid systems that supply electrical energy in parallel to public electricity supply systems, the DC voltage produced by the PV modules is converted to AC voltage by an inverter. Since the start of 2012, new requirements for Germany are described in the VDE code of practice VDE-AR-N 4105 for a PV system greater than 13.8 kVA that can be summarised as follows:

- Frequency-dependent active power reduction between 50.2 and 51.5 Hz from 100 % to 48 % (this function is already integrated in the solar inverter SINVERT PVM[1])
- Reactive power control to a cos φ value between cos φ_{ind} = 0.9 and cos φ_{cap} = 0.9 – the characteristic curve has already been implemented for devices of the SINVERT PVM type
- Power supply and system protection to monitor the supply voltage and frequency as well as a bus coupler circuit breaker – PV systems up to 30 kVA can be isolated by the bus coupler circuit breaker integrated in SINVERT PVM; up to 100 kVA, SIRIUS 3RT contactors in type-tested combination with fuses of the 3NA and 5 SE

1 Further information at www.siemens.com/sinvert

product families can be used for a central, redundantly set up bus coupler circuit breaker; above 100 kVA, the 3VL moulded-case circuit breakers and moulded-case line disconnector switches with motor drive and the appropriate auxiliary release can be used as bus coupler circuit breaker

Conceptionally, a distinction can be made between a central and a distributed PV system:

- Central PV system – on the DC side the electrical energy of the PV modules is brought together in so-called string boxes and led to a central inverter via the generator connection box (Fig. 3/6). A DC voltage of up to 1,000 V on the DC side places special demands on the protective components (see chapter 5 for suitable products).
  Advantage: Only one installation site or utilities room with good accessibility required; easy to maintain
  Disadvantage: DC system required

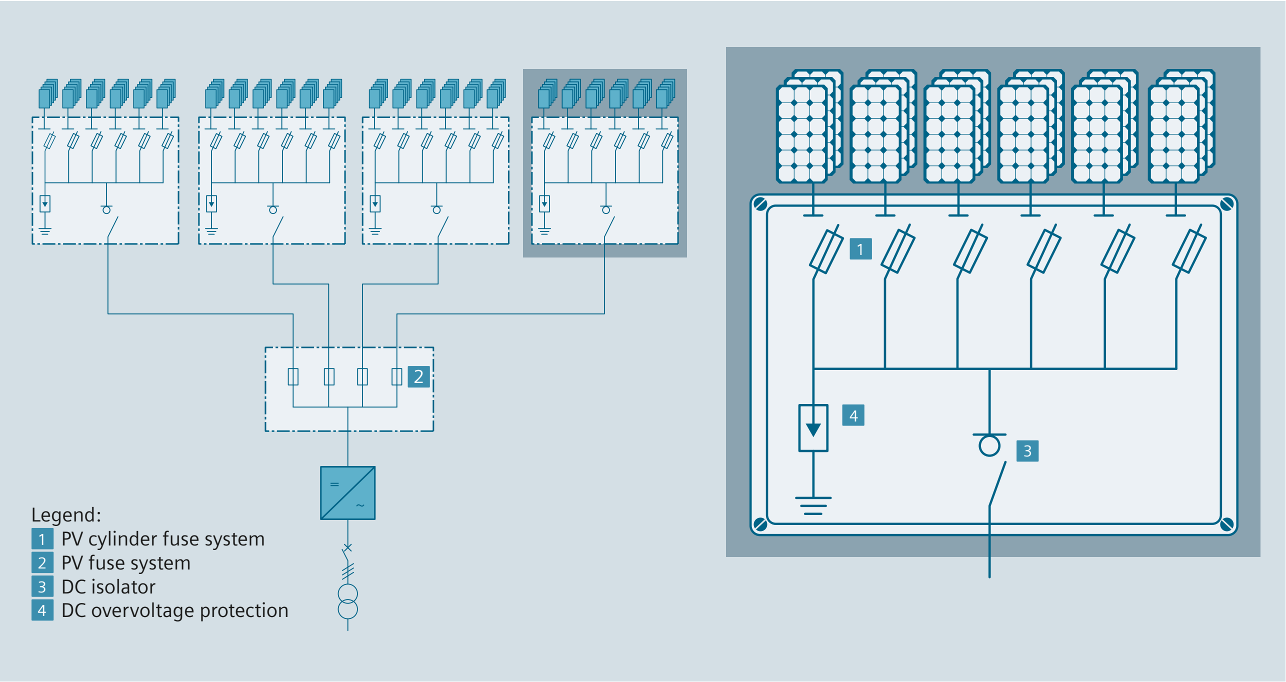

Fig. 3/6: **Single-line diagram for a central PV concept**

3

- Distributed PV system – the modular structure with inverters that are assigned to the respective PV modules can be used flexibly. Several strings of a module are led directly to an inverter and the AC side of several inverters is collected in the so-called AC collection boxes (see Fig. 3/7) and fed into the low-voltage system. A protection concept must be provided here for the AC side (see suitable products in chapter 5).

  Advantage: Can be easily integrated in the AC system
  Disadvantage: Maintenance expense for distributed facilities

Through the arrangement of the PV modules in several tiers, a distributed concept can offer advantages for a high-rise building if there is very little DC cabling and suitable rooms can be easily set up for the inverters.

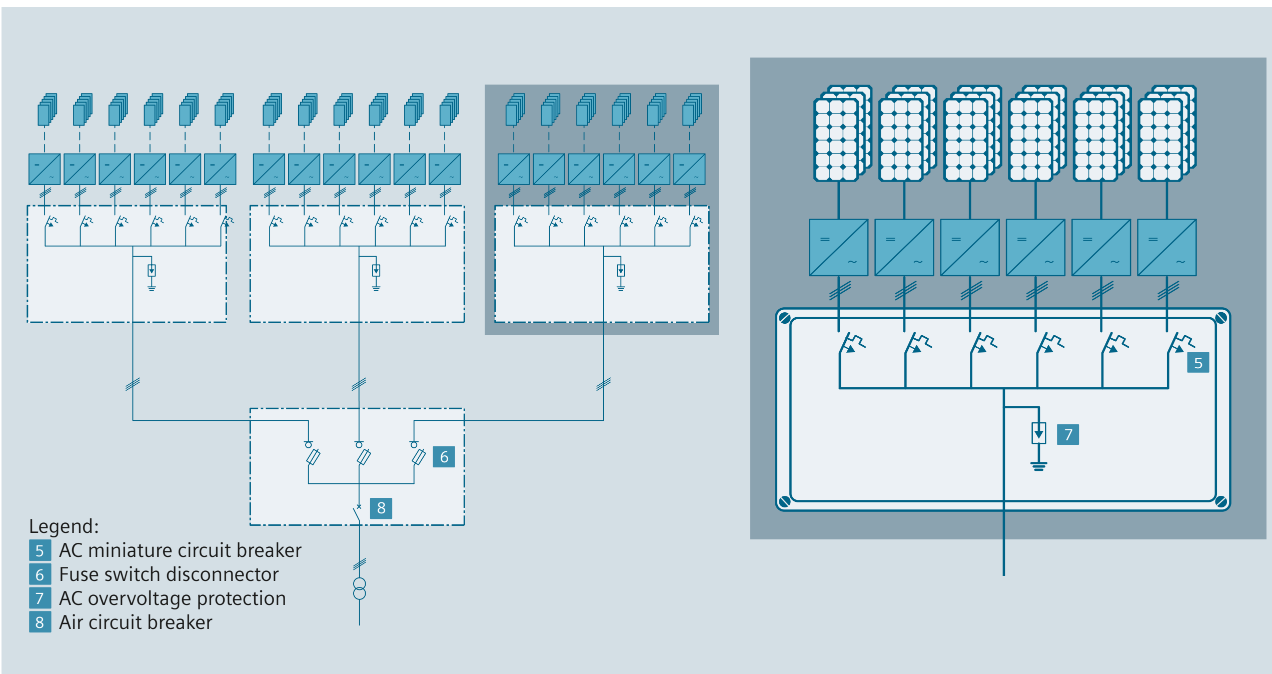

Fig. 3/7: **Single-line diagram for a distributed PV concept**

3

Chapter 4

Drawing Up a Power Supply Concept

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4.3	Supply Concept for a Super Tall Skyscraper	42

4 Drawing Up a Power Supply Concept

When the power demand, and above all the load centres have been established, a suitable power supply concept needs to be drawn up. An optimum of reliability of supply, future orientation, economic efficiency, flexibility and communication capability is aimed at.

4.1 Essentials of the Power Supply Concept

Prior to concept finding it is recommended to aim at close cooperation between developers, architects, structural engineers, surveyors, power suppliers, contractors for external installations, and users. This helps avoiding disagreeable surprises.

Some influencing factors that might require harmonization:

- Developer:
  Cost frame, security of investment, usage period, flexibility requirements (a high flexibility is often called for, when the user or tenant is not known yet), efficiency, power management, Green Building, Smart Grid, power cost allocation / billing to users etc.
- Architect:
  Size and layout of the technical equipment rooms in relation to load centres, architectural specifications regarding the routing of cables and lines and the placement of power distribution boards/cubicles in the usable area, heights of ceilings (e.g. to meet installation rules for switchgear in the event of a fault), technical installation shafts, integration of a PV facade, etc.
- Structural engineer:
  Ground loading (weight of transformers, generators, UPS batteries etc.), wall and floor breaches, fastening arrangements for cable ladders etc.
- Surveyor:
  Fire protection specifications (compartmentalisation, fire load), exhaust gas routing, redundancy, selectivity in the network, regional provisions, how to proceed with work-monitoring appraisal, approvals and inspections of the technology used etc.
- Distribution system operator:
  Scope for provision of power, coordination of the SPS (if need be, the diesel-supported standby power supply can be of a reduced dimension or even done away with completely, given that a second secure feed-in from another transformer sub-station is available), configuration of the medium-voltage protection system (note impact on selective configuration in the low-voltage grid) etc.
- Third-party works supplier:
  Distribution cabinets, pipe and duct routings (for water, ventilation, heating etc.), allowance made for existing energy supply concepts (heat production, refrigeration, ambient conditions) etc.
- User:
  Requirements placed on convenience, reliability of supply, flexibility, economic efficiency, contractual term, technical engineering provisions, etc.

Having gained an overview of the planning tasks to tackle and having coordinated the boundary conditions/ specifications with all those involved, the next step ahead is setting up a power supply concept.

4.2 Power System Concept

Electric power systems are to be designed and implemented according to the current state of technology reached and the regulations in force. Project-specific requirements (data centres, meeting areas, workplaces, hospitals etc.) are to be met.

Not all detailed information is usually on hand in the planning phase and the time passed between planning and implementation is often one of several months if not years. It is therefore absolutely necessary to continuously compare planning content and the requirements envisaged for actual implementation. Completion date of the system to be delivered should be paid attention to so as to adhere to the transition periods of regulations and deadlines of authorisation approvals. The main emphasis in preparing a power system concept for setting up an electrical power supply includes the following:

Power system structure/configuration

This involves examining whether others involved in planning have changed the placement of load centres. The concept may have to be revised (in line with the samples from the Power distribution planning manual volume 1: Planning principles, Siemens AG, 2011). In addition, our Siemens TIP Consultant Support can undertake project-specific support.

Handling the central earthing point and EMC

The following points are to be observed in order to meet EMC requirements, when setting up low-voltage electrical installations conforming to IEC 60364-1 (VDE 0100-100) and the relevant EMC standards:

- Provide for symmetrical arrangement of single conductors
- Small clearances between conductors
- Symmetrical conductor loads
- Provide considerable clearances between conductors and potentially susceptible equipment

- Separate data/communication lines from high-voltage lines
  (busbars can be installed without any problems, and they facilitate planning an EMC-compliant installation)
- Design the entire low-voltage grid as a TN-S system
- Configure a Central Earthing Point (CEP)

Note the following as regards the CEP:
- Never connect two earthing bridges to each other across two conductors
- PEN or PE conductors must never be switched
- 4-pole switches must be used if two TN-S subsystems are connected to each other. In both operating instances, only one earthing bridge is to be active
- A PEN conductor on being installed is to be insulated over its entire course – this includes the distribution
- The magnitude of the 1-pole short-circuit current depends on the position of the CEP.

ATTENTION: The 1-pole short-circuit current can be extremely low given supply systems with only one splitter bridge.

4.2.1 Network dimensioning

The drafted power system concept is now translated into a network model for the network calculation. The network calculation findings reveal the dimensioning needed for cables and equipment and which technical engineering regulations, such as protective and tripping conditions need to be kept to. The regulations to be mapped in the network calculation and their interrelationships with the standards are shown in a diagram in Fig. 4/1.

In power systems for buildings, selective disconnection is gaining more and more importance, as this results in a higher supply reliability and quality. Whereas standards such as IEC 60364-7-710 or -718 (comparable to DIN VDE 0100-710 or -718) prescribe a selective response of the protective equipment for safety power supply or a spatial separation of different power supply areas, there is an increasing number of buildings whose operators call for selective disconnection to be triggered by the protective equipment during normal power supply as well. Normally, a combined solution using selective and partially selective response in power systems for buildings is applied for the NPS, when economic aspects are considered.

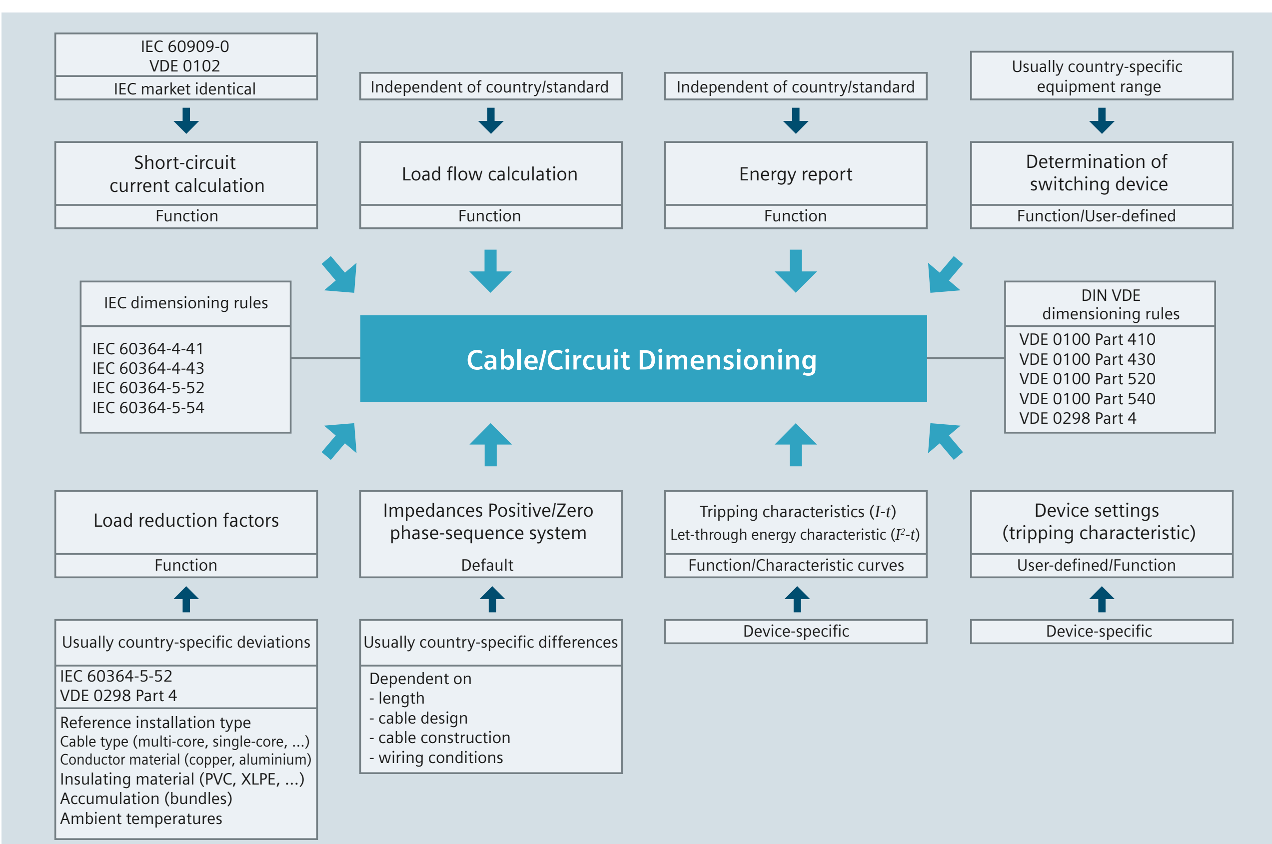

Fig. 4/1: **Network dimensioning factors and related standards**

It is worthwhile universally using the protective devices and switching devices from a single manufacturer, since he tests and guarantees the mutual response of his appliances as regards selectivity. To this end, he provides appropriate selectivity tables. If equipment from several different manufacturers is deployed, tests must be carried out, e.g. as regards circuit-breakers these tests must be based on IEC 60947-2 (VDE 0660-101).

The SIMARIS design software can be used when deploying Siemens equipment. The benefit of SIMARIS design is that devices for the specified concept are selected automatically. The equipment is dimensioned according to the accepted rules of good installation practice and all applicable standards (IEC, VDE). This makes planning reliable and helps saving a considerable amount of time.

In the project example, a model network design was carried out for the power distribution levels. Proceeding on the basis of the electrical power distribution devices described below, selectivity with SIMARIS design was exemplarily determined for the network shown in Fig. 4/2.

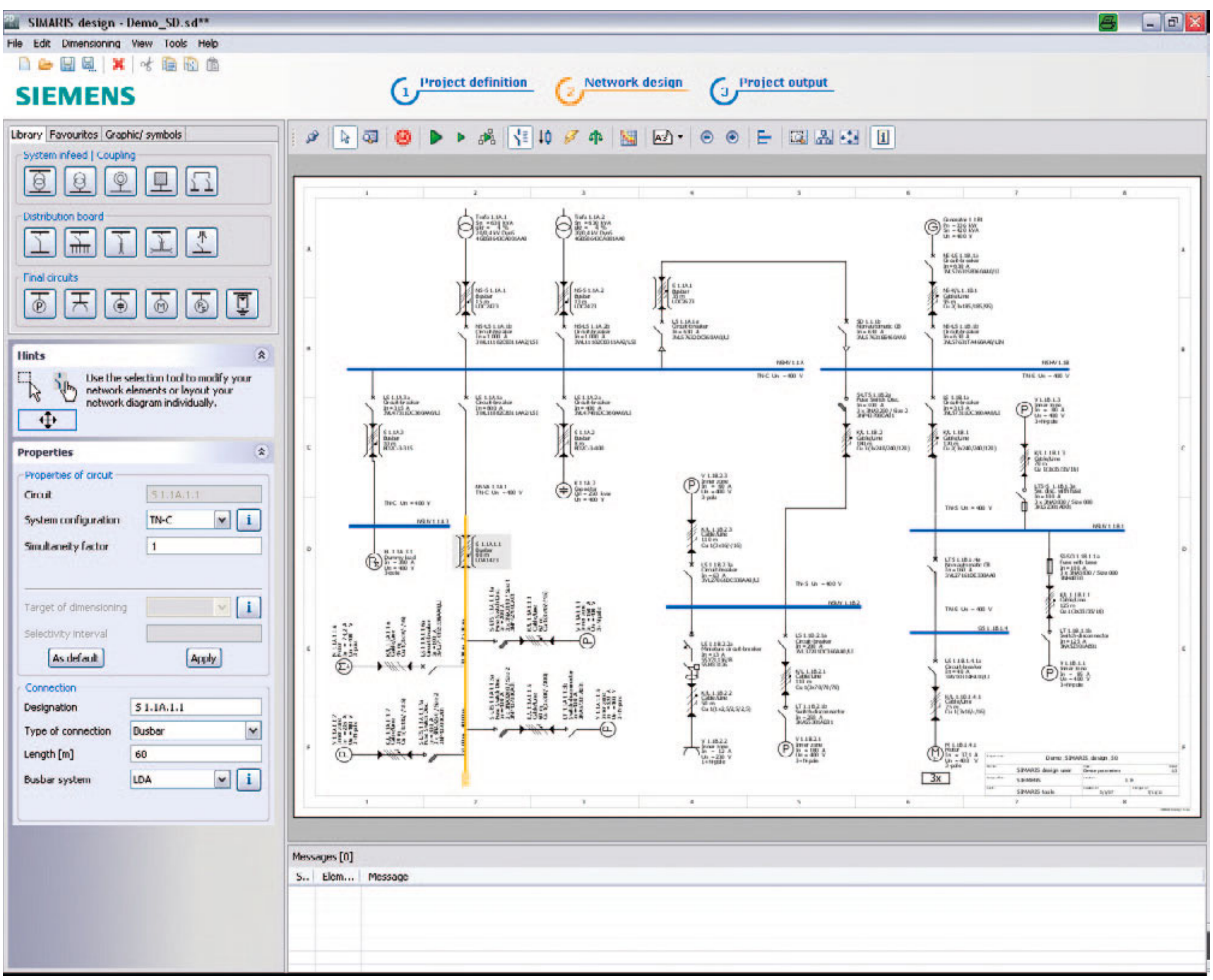

Fig. 4/2: **Network design with SIMARIS design**

4.2.2 Selection of Protective and Switching Devices

Selection of each protective or switching device must be undertaken for the specific application case involved. Important parameters such as nominal voltage, rated current or current breaking capacity can be determined with the aid of automatic network dimensioning by SIMARIS design.

It is for the planner to define the device as regards pole number or releases based on the network topology. When selecting a release, the basic parameters (overload and short-circuit protection), device arrangement in the network and the demand for selectivity all have a major role to play. Making the right selection first allows certain requirements of the power system concept to be put into practice, or economic benefits come to light when the overall solution is considered.

Example: Selection of circuit-breakers and associated releases

There are "air-circuit-breakers" (ACB) and current-limiting circuit-breakers – also referred to as moulded-case circuit-breakers (MCCB). Thanks to its configuration, the ACB can be widely used. The fact that it is able to carry the rated short-circuit current for a comparatively long period (several 100 ms) means a more favourable grading of the other switching and protective levels can be attained in the power system concept as regards disconnection. Whilst MCCBs are more cost-effective, they are current-limiting. This means: the higher the expected short-circuit current is, the quicker the device trips. That is why selective grading with high power grids is practically impossible. Consequently, the use of MCCBs should be restricted to the final circuits.

What very much favours the use of a high-grade and thus expensive release such as an electronic trip unit (ETU) instead of a thermally magnetic overcurrent release (TM), is enhanced utilization of the switching device's technical scope. This brings about both technical and economic benefits for the power system concept. For instance, the finer range of adjustment possibilities of an overload and time-delayed short-circuit release is advantageous for selective grading and for designing neutral conductor protection, earth fault protection and for interfacing it to the communication equipment in the power management system. The use of an instantaneous short-circuit release (I-release) allows, if necessary, smaller cable or busbar cross sections to be implemented (the I^2t value for the let-through energy is reduced).

By using SIMARIS design, network dimensioning variants with various types of equipment can be easily and quickly calculated. Do contact your Siemens TIP Consultant Support if you have any questions or need more assistance.

4.3 Supply Concept for a Super Tall Skyscraper

As described in the Power distribution planning manual volume 1: Planning principles, Siemens AG, 2011, a low-voltage feed-in system is only appropriate up to a connected load of approximately 300 kW. After all, transmitting high quantities of electric power over a considerable distance (the guiding figure is roughly 100 m) in the LV range is both complex and uneconomical. With regard to the roughly 30 MVA capacities established in chapter 3 for the skyscraper under consideration and the corresponding transmission length of around 300 m, preference is given to a medium-voltage network providing the supply. As both 10-kV and 20-kV networks for the medium-voltage feed-in are met with, two exemplary solutions are presented below for supplying the skyscraper with power.

4.3.1 Supply concept involving a 10-kV feed-in

In many countries, distribution system operators provide a 10 kV supply voltage for feed-in at the medium-voltage level. In our project example, feed-in is performed through cables to the so-called "power centre" in the technical equipment area of Basement 1 (see Fig. 3/2). For secured supply of medium voltage, the NPS power demand is split onto a number of supply levels via two rings. The critical consumers are supplied in a similar fashion via an SPS ring. In order to be able to switch between the two rings, a "remote" station is set up in the technical equipment section in the upper storeys of the building. As can be seen in Fig. 4/3, each medium-voltage supply level can be fed from both rings. The medium-voltage ring-main stations of the power supply levels are alternately connected to the two rings.

With an NPS power demand of approx. 19 MVA, the demand is split between four power supply levels plus remote station. This enables the two rings to provide a redundant supply via a total of nine ring-main stations. As the power demands in the building are not evenly distributed over the storeys, the supply levels need to be chosen to ensure that a power demand of approx. 2.1 MVA is covered by each of the NPS ring-main stations.

As can be seen in Fig. 4/3, a supply ring with a comparable split-up to the NPS supply is chosen for the safety power supply (SPS). However, an individual generator supply is of benefit in supplying the UPS installations in the data centre, since this avoids a double voltage conversion – from low voltage to medium voltage and back again. What remains is an safety supply capacity of 4.35 MVA which needs to be distributed in the building as medium voltage.

The standby power generating systems with low-voltage output feed the SPS network with 10 kV by way of transformers. For availability reasons, allowance is made for a redundant block in addition to the two required generator/transformer blocks each of 2.5 MVA.

Numerous reasons favour setting up the standby power generating systems near the ground:
- In view of the 300 metres in height to be overcome, transporting the standby power generating systems to the technical equipment rooms of the upper storeys is both complex and expensive.
- Fuel supply is expensive and can only be mastered with specially protected piping.
- Protective steps against fuel loss are to be envisaged.
- Vibrations of the generators in service result in structural requirements being placed.

The assumption is also one of a redundancy concept for the UPS systems. The UPS installations connected in the LV network are only sketched in Fig. 4/3. A number of UPS systems can, of course, be connected to different LV distribution systems.

For NPS purposes two GEAFOL transformers each of a 1,250 kVA output are chosen in each distributing station – a total of eight GEAFOL transformers with 630 kVA each as nominal output are planned for the 4.35 MVA SPS. Dedicated NPS distribution system transformers supply the data centre UPS installations. This is detailed further in section 4.3.4 with a description of the UPS concepts.

From the supply levels, vertical busbar trunking systems in the utilities hubs are envisaged for supplying the storeys. LV switchgear with circuit-breaker design undertake feed-in at the individual storeys.

Ensure with the power system concept for the low-voltage range that the module capacity (busbar current and short-circuit current of the LV switchgear) is not oversized. LV switchgear with busbar currents in excess of 4,000 A and short-circuit currents in excess of 65 kA produce considerably higher costs (alternative: use a sectionalizer panel to split the busbar and open-run the system under normal non-interrupted operating conditions).

On the storeys, there are horizontal busbar trunking systems between the utilities hubs, which can be electrically isolated in the building centre. Fuse-protected circuit-breakers ensure feed-in from the vertical busbars to the horizontal busbar trunking systems of the individual storeys (reason: more favourable to meet selectivity requirements!) in combination with a circuit-breaker with isolating function (reason: disconnection in case of fault).

All switching devices (circuit-breakers, circuit-breakers with isolating function) are communication-capable and fitted with a motorized drive. This enables a rapid reaction to faults from the central control system. The configuration is to provide a high degree of supply reliability and flexibility. Major consumers, such as the data centre and air-conditioning facilities, are provided with a separate feed-in from the nearest supply level.

4.3.2 Supply concept involving a 20-kV feed-in

A 20 kV supply voltage allows implementation of a more simplified power system concept. This helps reducing the costs and space requirements for the medium-voltage switchgear. In contrast to the 10-kV solution, no two complete rings are needed – in combination with a secure supply solution – for an approx. power demand of 30 MVA. In addition to the one NPS supply ring, all that is needed is a direct medium-voltage feeder line from the power centre to the remote station – as shown in Fig. 4/4.

Thanks to the higher voltage, this switched redundant line is used to effect supply even in the case of a fault without any problems arising from isolating the fault. In respect of the SPS supply and the LV-side components involved, there are only minor differences between the 10-kV and the 20-kV concept.

The 20-kV feed-in has the following benefits over the 10-kV feed-in:
- Reduced cable cross sections by two to three degrees
- Lower power losses
- Improvement of the short-circuit requirements – Reduction of the rated short-circuit breaking current I_{sc} and rated short-circuit making current I_{ma}
- More favourable requirements for the grading times under definite-time overcurrent (DMT) protection

On the SPS side, the assumption here is one for a separate station for the standby power generating sets located near the data centre in Basement 1. Exhaust gas routing is also a decisive planning parameter here. To this end, a UPS concept with rotating systems is proposed in chapter 4.3.4.

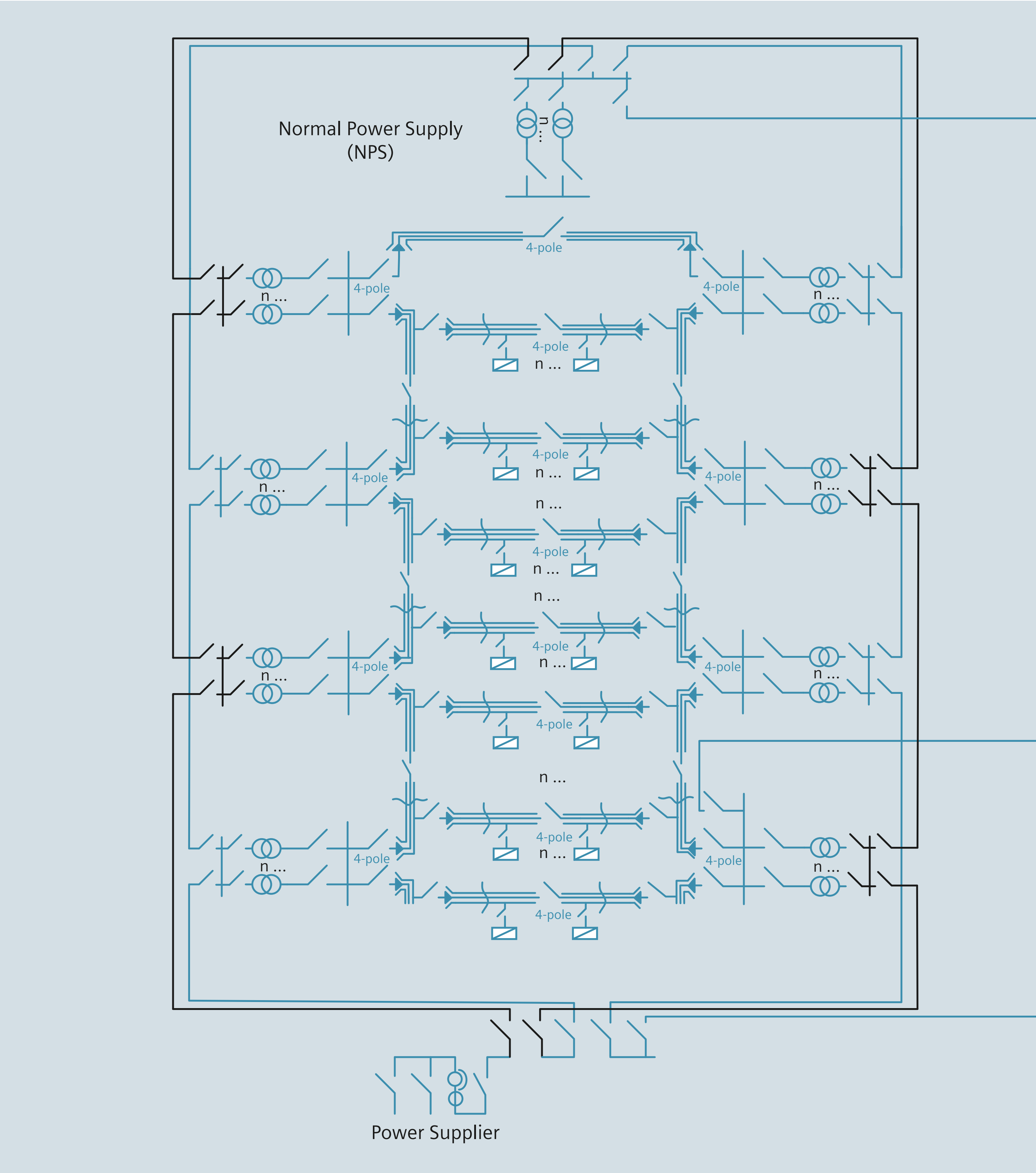

Fig. 4/3: **Power supply concept for a 10-kV medium-voltage feed-in**

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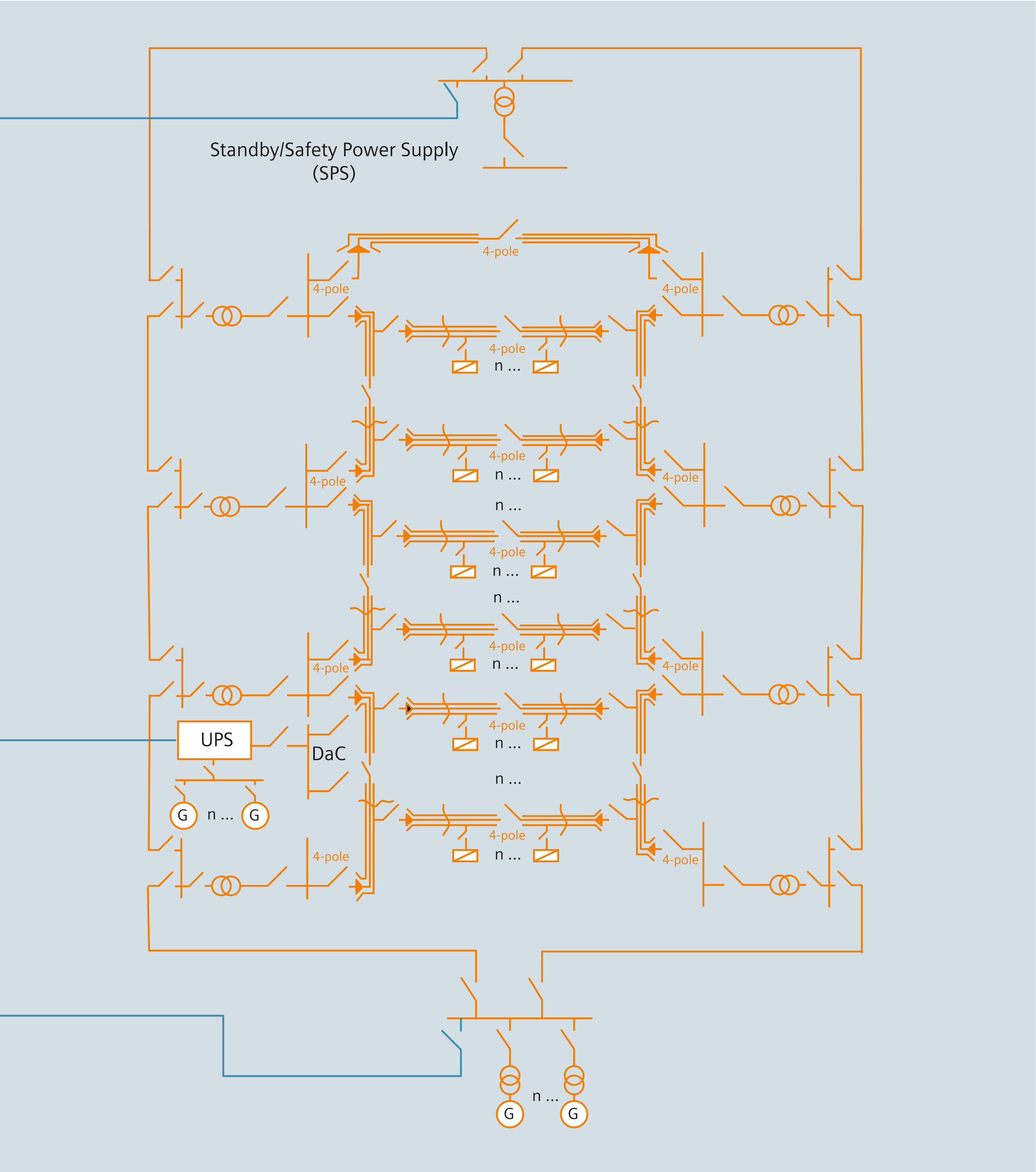

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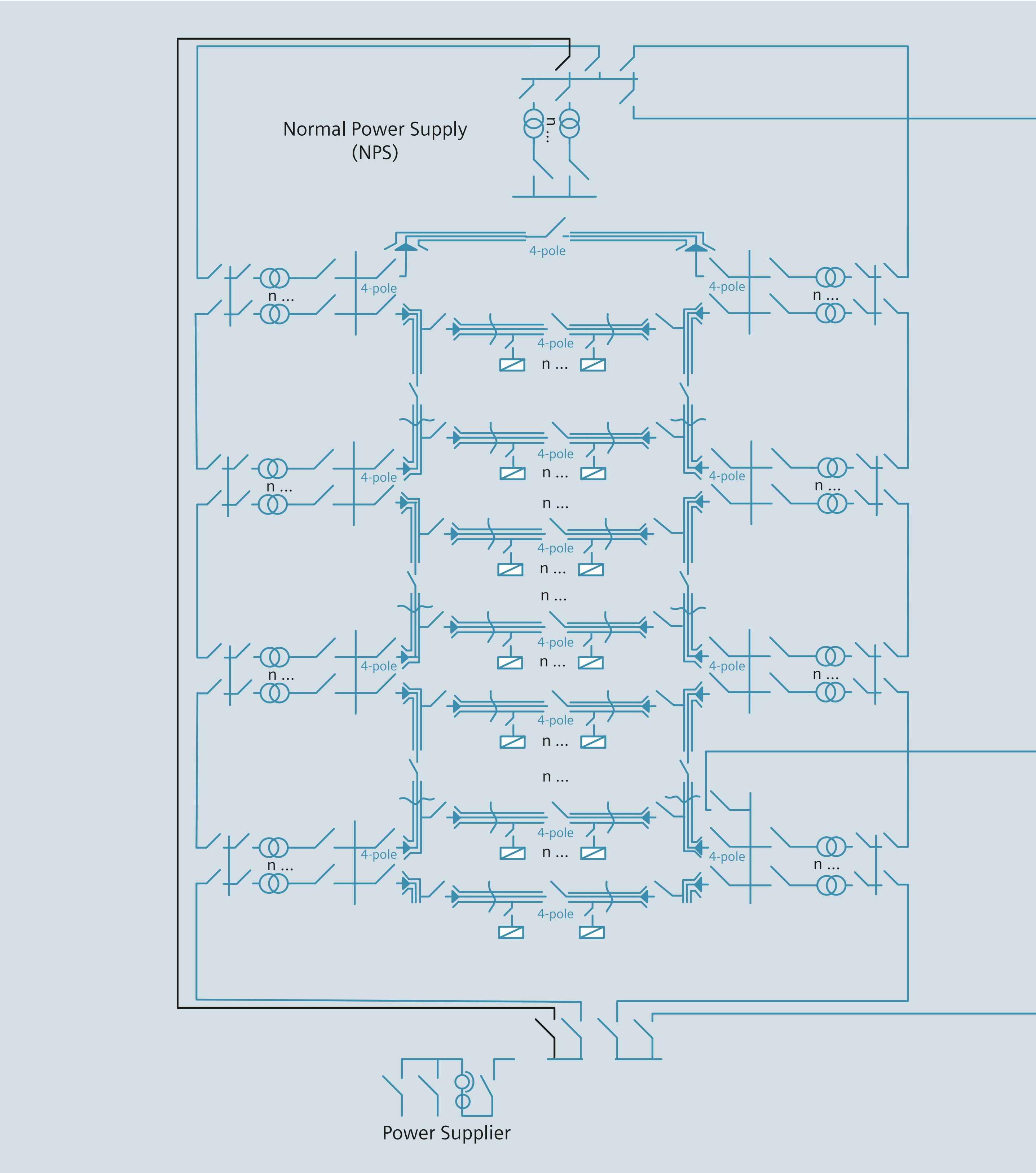
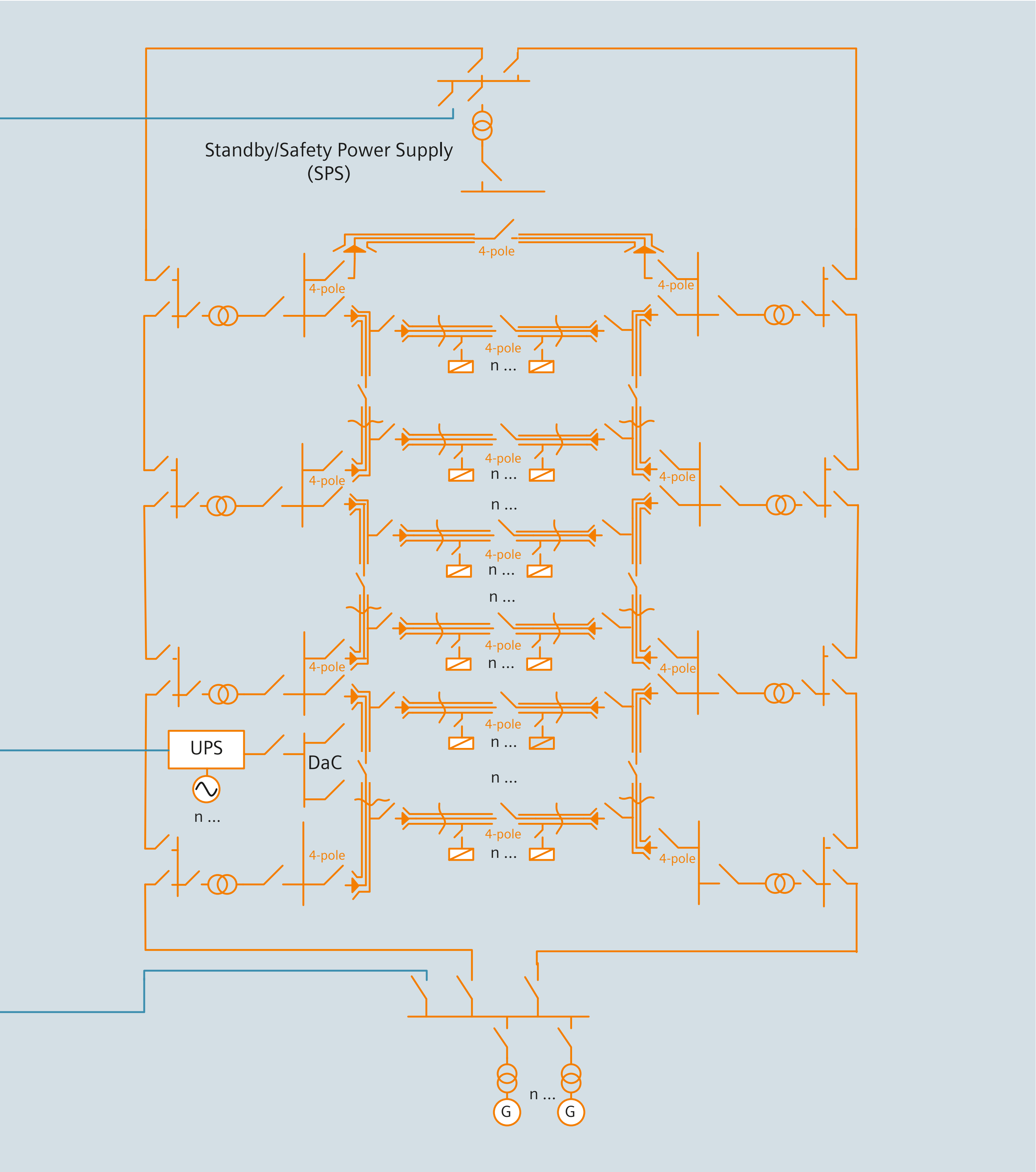


Fig. 4/4: **Supply concept involving a 20-kV feed-in**


Standby/Safety Power Supply (SPS)
4-pole
4-pole
4-pole
4-pole
n ...
4-pole
n ...
n ...
4-pole
n ...
n ...
4-pole
n ...
4-pole
n ...
n ...
4-pole
n ...
UPS
n ...
DaC
n ...
G
G

4

4.3.3 Dimensioning of the Power Distribution Levels and Configuration with SIMARIS design

In this project example, the TÜV-certified SIMARIS design dimensioning software is used to determine the selectivity. A network calculation should always be performed prior to any performance description to endorse the feasibility of the envisaged system solution. In this way, any shortcomings due to incorrect selection, combination or arrangement of equipment can be detected at an early stage.

A model network design is created for one power distribution level. Proceeding on the basis of the electrical power distribution devices described below, the selectivity response is determined in an exemplary fashion for the arrangement shown in Fig. 4/5. In so doing, the assumption is for one distribution level with the two busbar trunking systems on three storeys each. On the storeys, four sub-distribution systems each are connected to the horizontal busbar trunking systems.

The results gained in SIMARIS design can be exported for further processing with the SIMARIS project software. For documentation of the planned installations, SIMARIS project allows – besides the available view drawings, technical descriptions and component lists – also technical specifications to be prepared. The following sections include the descriptions, line diagrams and front views for the products of our project example.

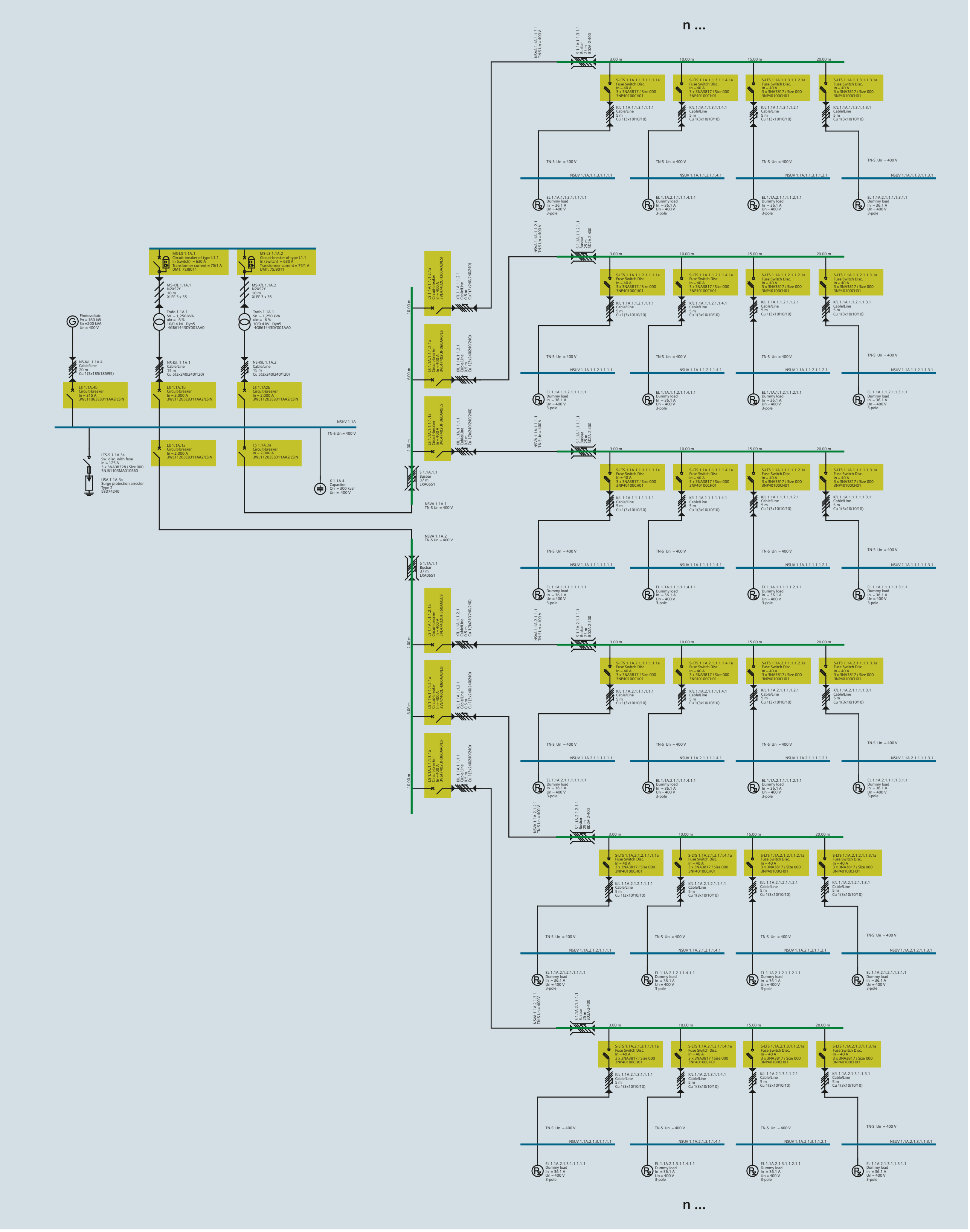


Fig. 4/5: **Selectivity calculation with SIMARIS design exemplified for one distribution level**

4.3.4 UPS Concepts for the Data Centre in the Project Example

As an example for the UPS output required in the data centre, a concept for the use of rotary UPS systems and one for the static UPS systems are presented. Rotating and static can basically be swopped in both concepts. Ambient and utilization conditions always play a vital role in the configuration of a UPS solution.

Concept with static UPS installations

The assumption is that the operators of the data centre prefer a separate UPS supply with static UPS installations. Since the data centre is in Basement 1, the UPS installations and associated generators – as shown in Fig. 4/3 – will be located in the technical equipment rooms of Basement 1.

For reasons of fuel supply and easier installation and maintenance, the standby power generating sets (SPG) – as diesel generator blocks – together with the associated LV distribution system are installed in a redundant fashion in the lower equipment rooms.

For reasons of availability, the UPS-privileged devices in the data centre are supplied by means of two UPS parallel systems each with six 800-kVA blocks. With consideration given to the (5+1) redundancy, the maximum UPS output comes to a total of 8,000 kVA.

Whilst the static UPS bypass is served by the NPS supply (blue), the double-transformer path (rectifier – UPS DC link – inverter) would be supplied via the SPG line (orange). This is only possible when the UPS installations permit an uninterruptible change-over from the bypass supply (NPS supply) to the double-transformer path (SPG supply).

Additional supply reliability comes from the use of a redundant generator. Given a problem or a case of maintenance, the redundant generator can be connected to one of the two UPS systems via the normally open (n.o.) circuit-breakers.

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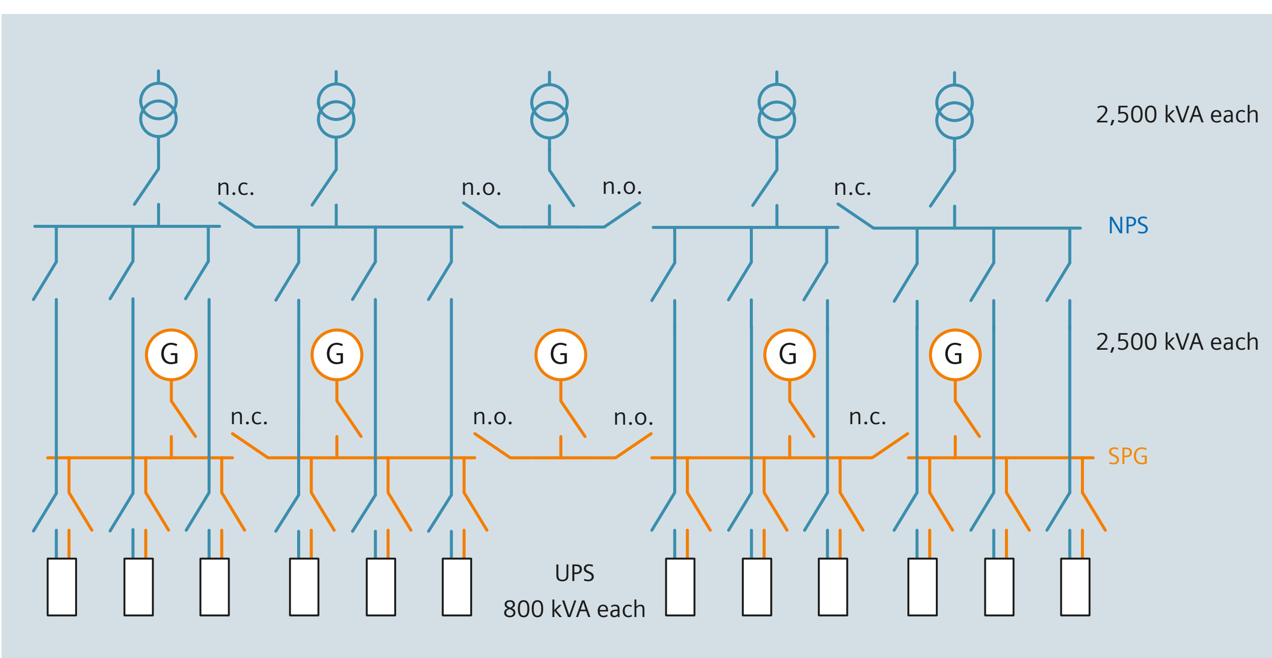

Fig. 4/6: **Power distribution for static UPS installations in the data centre (n.o. = normally open; n.c. = normally closed)**

Concept with rotary UPS installations

The linking of UPS and generator via rotary UPS systems has much to recommend it for the requirements described in the skyscraper with a large data centre needing a high SPG share for the UPS installations. At the same time, the amount of space needed for installation, fuel supply and especially exhaust gas routing must be kept in mind. Benefits accrue in terms of moving the UPS in, power system link-up, supply, protection, maintenance – to name but just a few – when rotary UPS installations directly feed into the LV distribution system for the data centre. To avoid lengthy cable stretches, a room adjoining the data centre is needed for the generator-supported UPS installations with appropriate exhaust gas routing.

The redundancy of the UPS systems becomes obvious in Fig. 4/7, since three of the four available systems for supplying the data centre are quite adequate. A standby transformer is also integrated, which – in the event of failure or a malfunction of a transformer of the four UPS systems – can be connected into supply.

A separate medium-voltage ring – as depicted in Fig. 4/4 – is used for the SPS supply in the skyscraper which is not connected to the data centre. This means that under the circumstances considered, two generators – or three generators when taking the redundancy principle into consideration – with a 2,500 kVA output should be sufficient to supply the SPS medium-voltage ring, forming a block with a GEAFOL transformer.

4.3.5 Power Management Concept

To bring about the energy transparency with the presentations, characteristic values and evaluations described in chapter 2, a power management system concept is drawn up which is exemplarily limited to the distribution levels and a storey distribution spur. In so doing, the SIMARIS design configuration is resorted to. The core elements from Fig. 4/5 above are shown in Fig. 4/8 in excerpts. Other storeys can be joined up in a similar way – likewise other storey distribution boards.

As the power quality is to be recorded, multi-function measuring instruments of the 7KM PAC4200 type are chosen for the inputs of the SIVACON S8 switchgear in the storey distribution boards. In addition, an Ethernet connection is needed for the communication link-up to the data lines in the building. This entails using the 7KM PAC4200 gateway function. The transferred data is evaluated on a Windows PC with the aid of the *powermanager* software.

The Modbus effects communication to the gateway inside the technical equipment rooms. By way of the 3WL air-circuit-breaker, the photovoltaic system is metrologically incorporated with a COM16 module suitable for Modbus. Two 7KM PAC3200 monitor the supply data at the two outputs of the SIVACON S8 switchgear.

As the data is transmitted by Ethernet to the *powermanager* software from each storey, a 7KM PAC4200 is also needed as a gateway in each instance. It not only monitors the data of the storey distribution boards but also passes on the information transmitted via Modbus from the busbar tap boxes (instruments: 7KM PAC3100) and distribution boards (7KT PAC1500 3-phase meter).

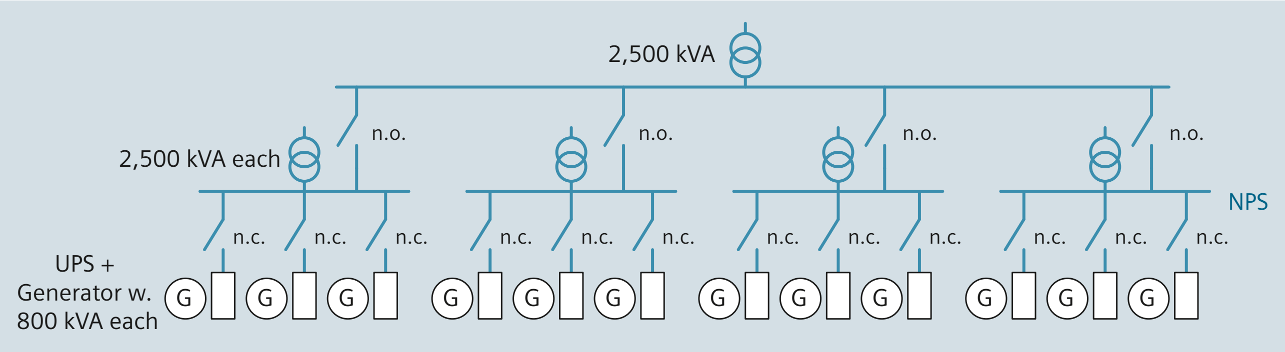

Fig. 4/7: **Power distribution for rotary UPS installations in the data centre (n.o. = normally open; n.c. = normally closed)**

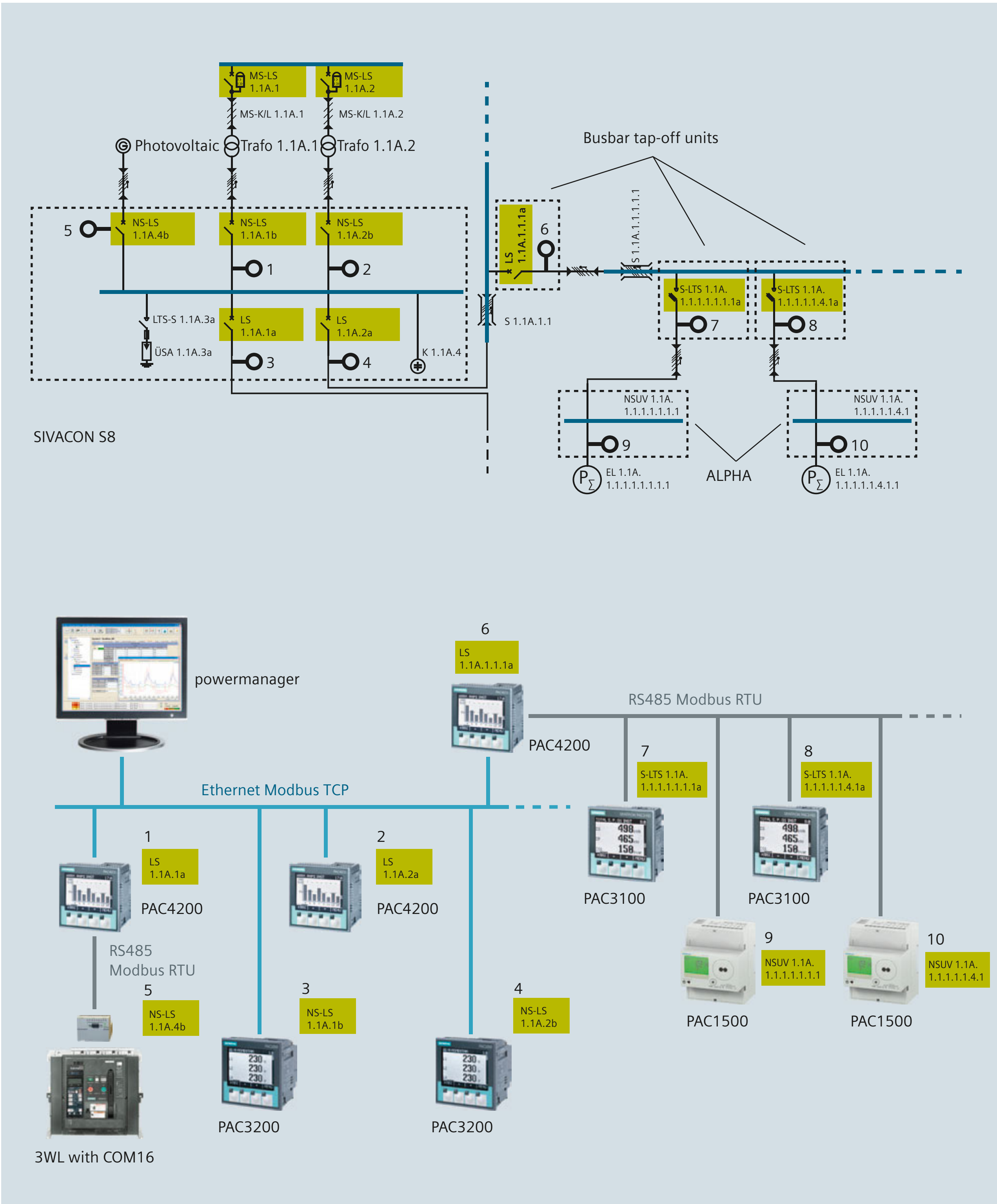

Fig. 4/8: **Power management concept for the power distribution in the ring-main stations and the storey distribution systems. Top: Excerpt of the SIMARIS-diagram Fig. 4/5 with numbered measuring points and dotted marked installation equipment. Bottom: Communication network of the power management equipment and mapping according to the numbering of the measurement points**

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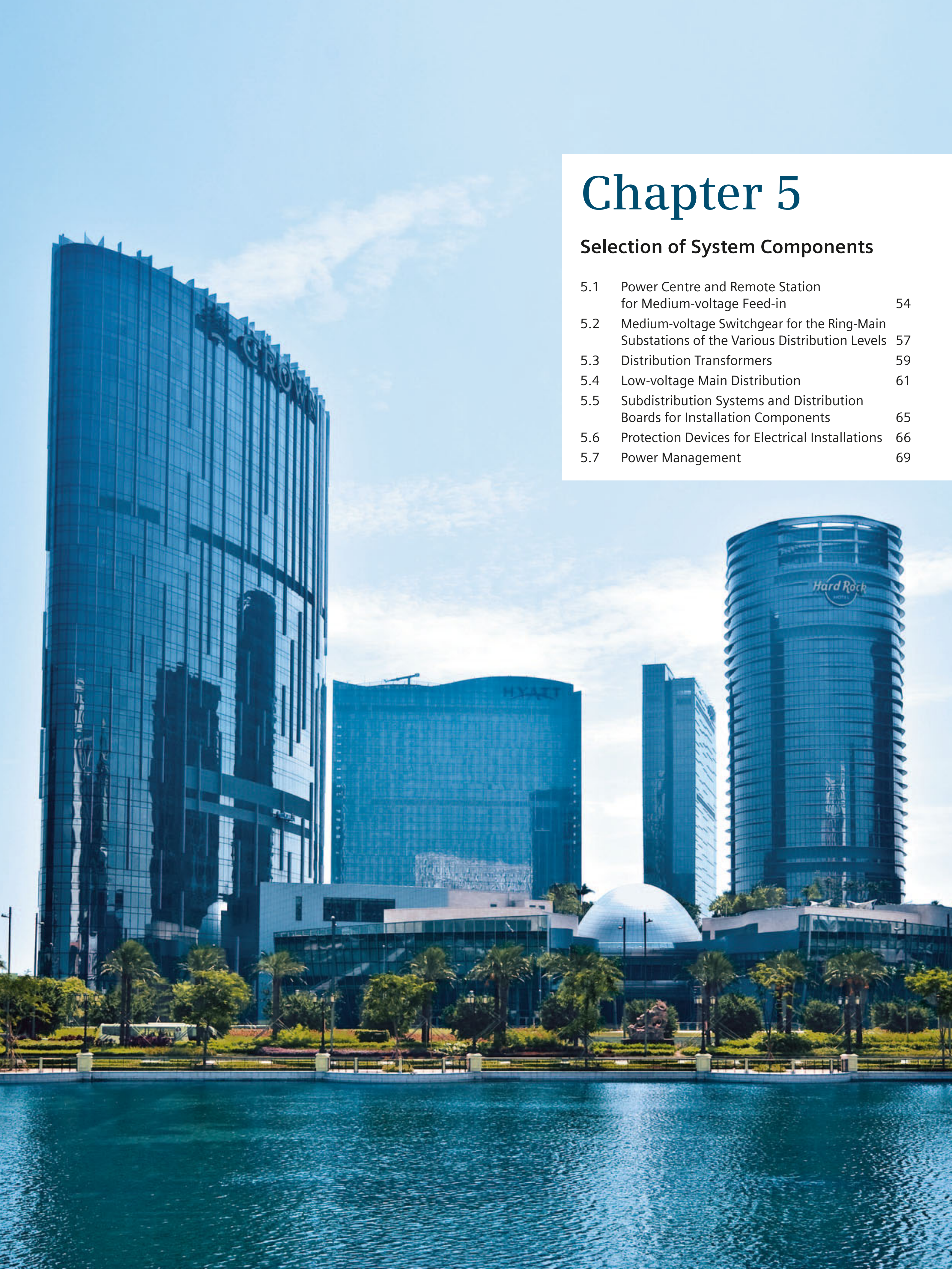

Chapter 5

Selection of System Components

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5 Selection of System Components

5.1 Power Centre and Remote Station for Medium-voltage Feed-in

When the medium-voltage switchgear is selected, the following parameters need to be considered: operating voltage, busbar current, short-circuit breaking current, short-time current and surge current. For reasons of exemption from maintenance, insusceptibility to environmental impact, space requirements and personal safety (internal arcing fault), gas-insulated switchgear of the NXPLUS C type is chosen as the main switchgear substation for medium-voltage supply from the basement and as the remote station (Fig. 5/1 – Fig. 5/4) in the topmost building storeys. The medium chosen for insulation is SF_6, which insulates three times better than air. Laser welding allows for hermetically sealed primary encapsulation in the IP65 degree of protection. It provides the following advantages for the switchgear:

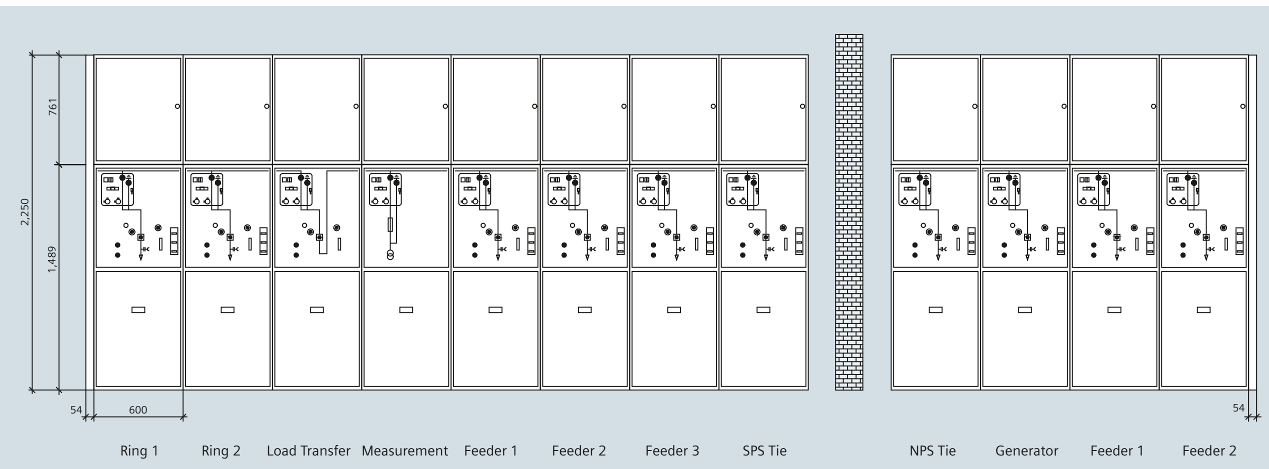

Fig. 5/1: **NXPLUS C medium-voltage switchgear with single-busbar panels for normal and safety distribution in the power centre of the 20-kV concept**

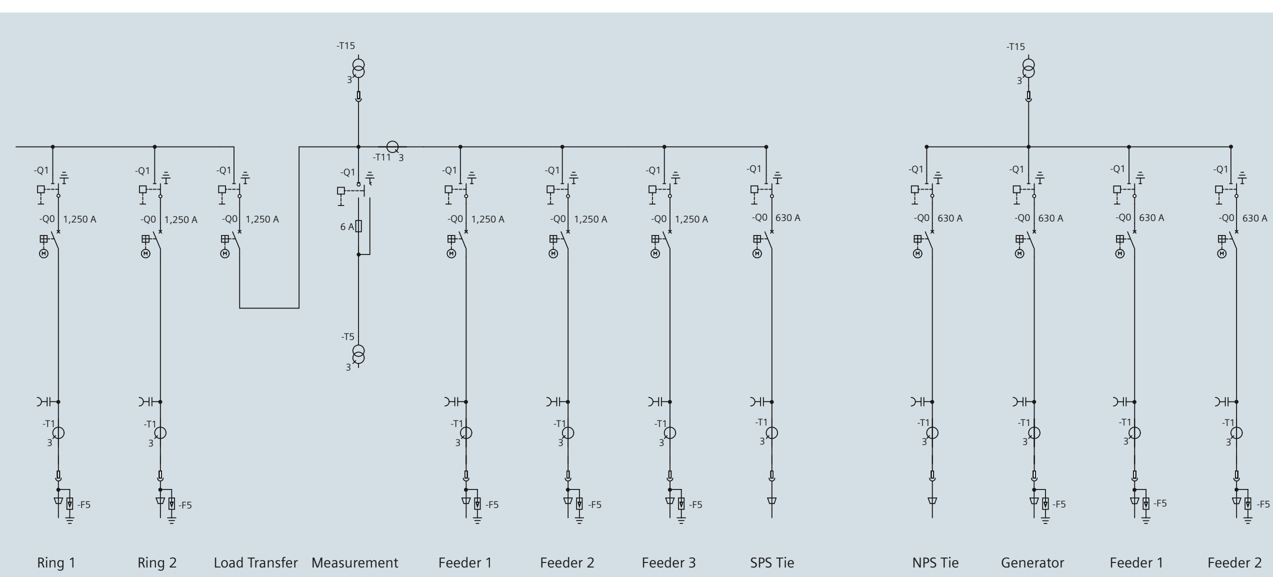

Fig. 5/2: **Line diagram for NXPLUS C medium-voltage switchgear for normal and safety distribution in the power centre of the 20-kV concept**

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- Compact dimensions,
  normally between 25 and 50% (depending on voltage level) under that of a comparable air-insulated model.
- No maintenance required,
  seal-tightness for life in accordance with IEC 62271-200 (hermetically sealed pressure system) allows for installation, operation, expansion, and replacement without requiring SF_6 gas work, thus cutting operating costs
- High degree of personal safety,
  shock-hazard-proof primary encapsulation and arcing-fault-tested panels up to 31.5 kA
- Operational safety,
  not subject at all to environmental effects such as dirt, moisture and ingress of small animals; minimum fire load
- Reliability,
  type-tested and routine-tested, quality assurance in compliance with EN ISO 9001

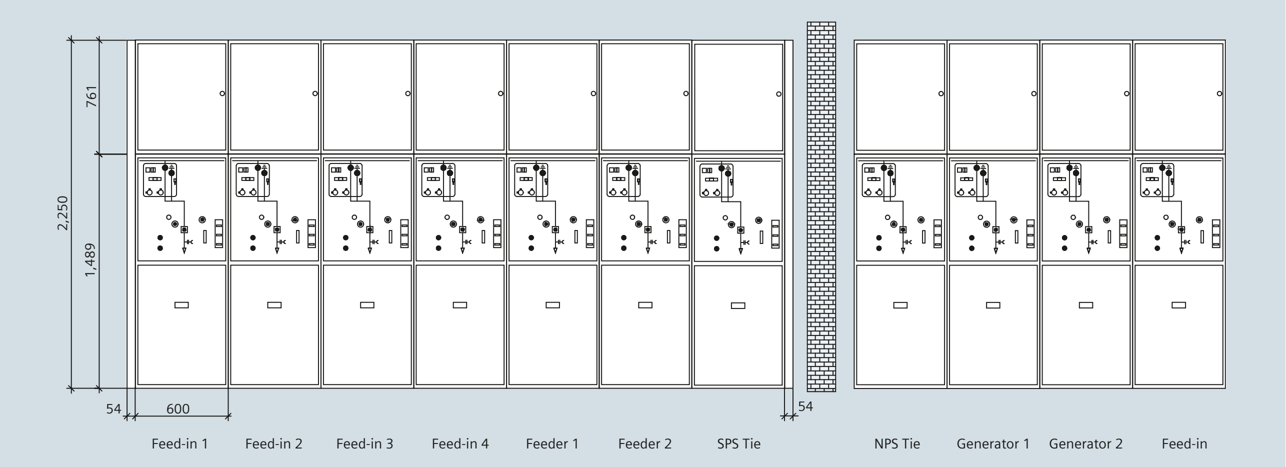

Fig. 5/3: **Front view of the NXPLUS C switchgear for the remote station in the 10-kV concept**

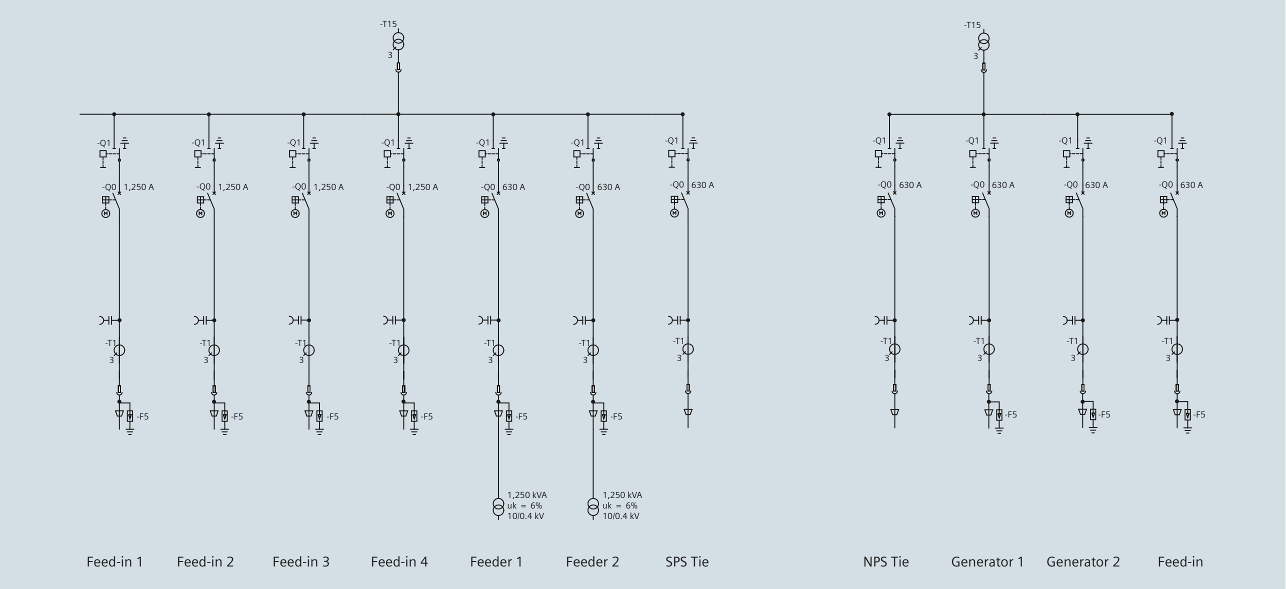

Fig. 5/4: **Line diagram for NXPLUS C medium-voltage switchgear with single-busbar panels for normal and safety distribution in the remote station of the 10-kV concept**

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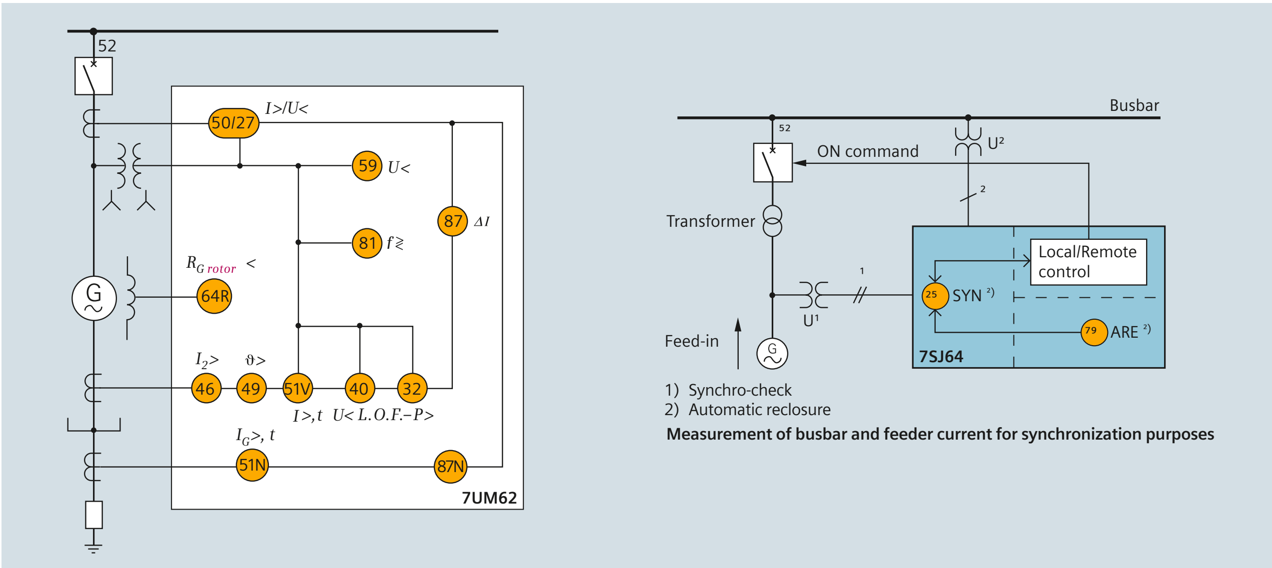

Fig. 5/5: **Block-type schematic diagram for generator protection (L.O.F. = Loss of field / sub-excitation) and the synchro-check measuring busbar and feeder voltages for synchronisation purposes**

- Service life,
  min. 35 years under normal operating conditions, probably 40 to 50 years (constraint: maximum switching frequency of the switching devices used)
- Easier integration into the building,
  in case of an accidental arc, pressure increase is only approx. 30 % compared to air-insulated switchgear technology. As a result, only relatively smaller pressure relief openings need to be provided (see 5.2)
- Modularity,
  panels can be replaced without the need for SF_6 gas work; pluggable ring-main lines.

Machine differential protection must be provided for the safety supply through the generator-transformer sets (Fig. 5/5). SIPROTEC 4 7UM62 devices with full protection in combination with the synchro-check performed by SIPROTEC 4 7SJ64 (Fig. 5/6) for connecting the generator into /disconnecting it from supply are suitable for this task. What is important is that the SIPROTEC definite-time overcurrent-time protection devices ensure directional selectivity and that the total tripping time is kept low. With the aid of a signal connection, a directional comparison protection can be built up which offers fast-response protection for cabling in normally closed ring networks.

5

(The description of the ANSI nomenclature of the individual monitoring functions can be found in the performance descriptions of the SIPROTEC protection relays in section 6.1.4)
- Both protection relays can be integrated into the top part of the NXPLUS C switchgear panels. Our Siemens TIP experts are prepared to support electrical designers in planning this type of protection equipment.

SIPROTEC Compact 7SJ80 protection devices may act as the main protection for the medium-voltage switchgear in the ring-main substations. Their task is cable and line protection of high- and medium-voltage networks with earthed, low-resistance earthed, insulated or compensated neutral point design. Frequency protection or reverse-power protection as well as circuit-breaker control can also be implemented in this way.

Fig. 5/6: **SIPROTEC 4 relay family**

5.2 Medium-voltage Switchgear for the Ring-Main Substations of the Various Distribution Levels

Medium-voltage switchgear for the supply of low-voltage networks from the higher-level medium-voltage grid is considered as part of the secondary power distribution system. Since the same requirements apply here as for the primary switchgear described in section 5.1, a gas-insulated medium-voltage switchgear type 8DJH (Fig. 5/7), which is part of the Siemens product range, is used for the ring-main substations at the distribution levels. The same reasons apply for the choice of the 8DJH switchgear type as listed in section 5.1.

When medium-voltage switchgear is used, pressure relief openings must be provided in the room which ensure sufficient pressure relief in case of accidental arcing faults. If absorbers are used with gas-insulated SF_6 switchgear, the pressure rise in case of fault is far less than with air-insulated switchgear.

In case of a fault within a gas-insulated switchgear station, an arcing fault can occur which heats the surrounding gas to a very high degree resulting in an extreme rise in pressure. The height of the pressure rise depends on spatial geometry, the existence of pressure relief openings and arcing fault energy.

The consequences of such a (rare) fault can be extremely serious not only for the operating personnel, but also for the area involved For this reason, appropriate measures must be taken to relieve pressure, such as pressure relief openings, ducts, absorbers or coolers (see Fig. 5/8). The

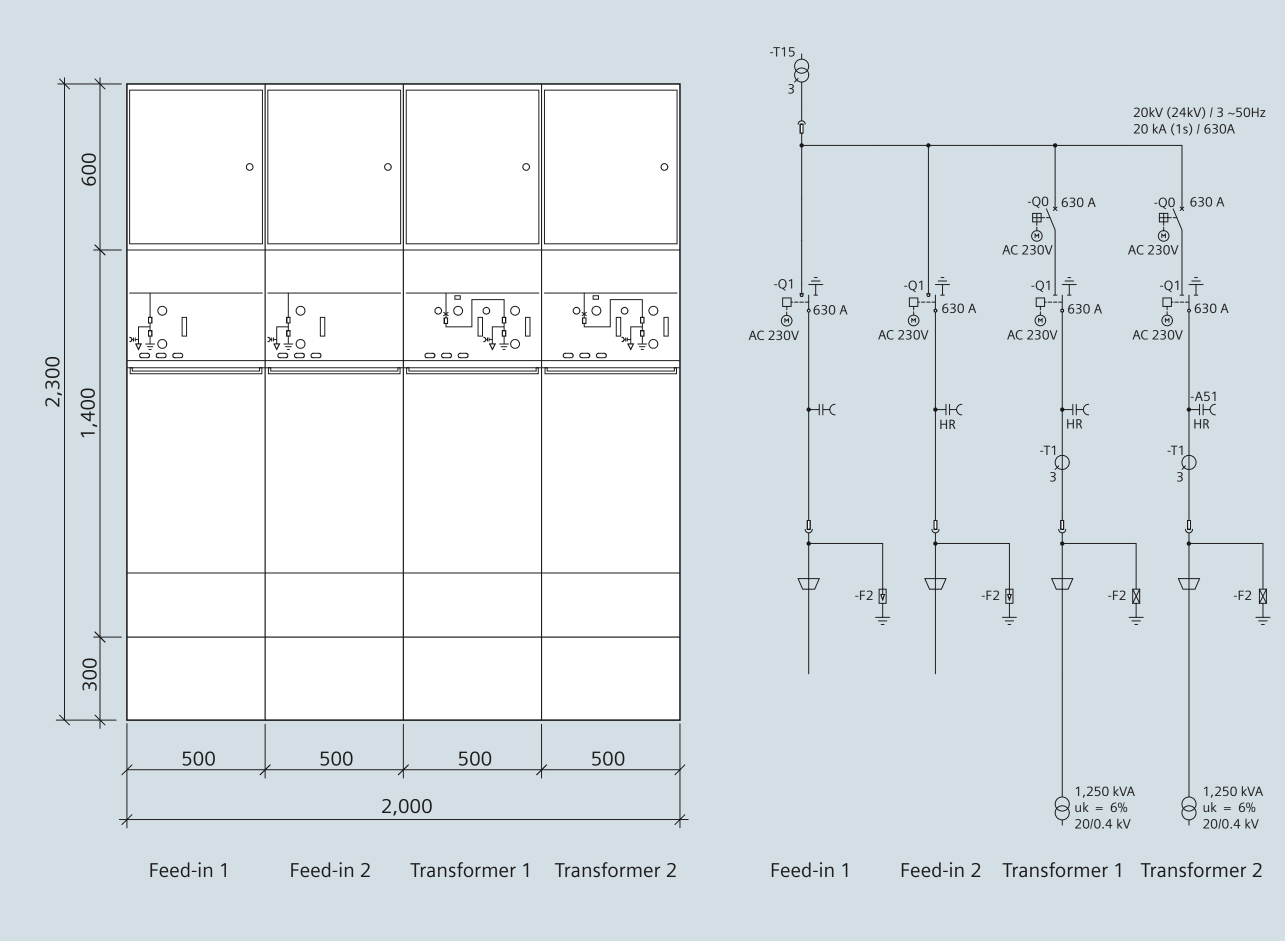

Fig. 5/7: **8DJH medium-voltage switchgear and corresponding line diagram for secondary power distribution of normal supply in the distribution levels**

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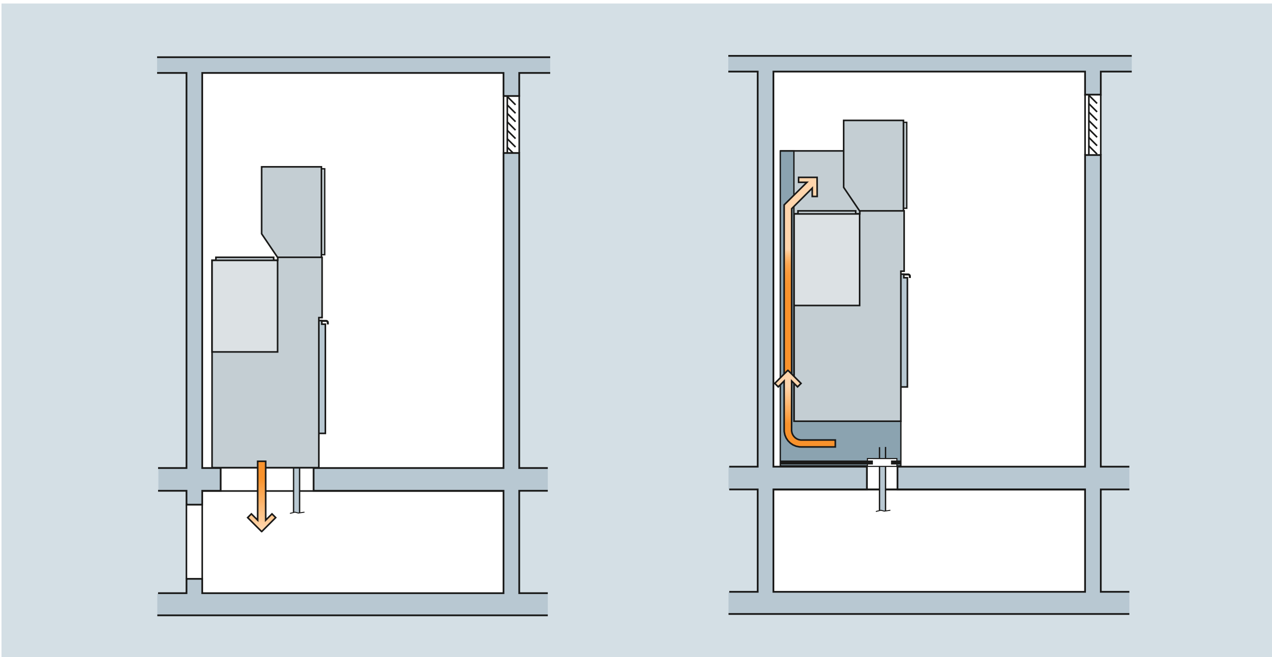

Fig. 5/8: **Downward pressure relief (left) and to the top using a pressure absorber**

actual pressure loadability of the building as well as its structural characteristics are to be inspected and approved by the structural engineer.

For 8DJH switchgear, there is a simplified pressure calculation on hand which is based on Pigler (Fig. 5/9).

It provides a good approximation for enclosed spaces, when the pressure increases uniformly throughout the room. However, the pressure calculation outcome does not provide any information on the pressure load capability of the building and its structural components (e.g. doors and windows). They must be designed by the structural engineer. Responsibility cannot be assumed for any damage resulting from an arcing fault.

In case of highly complex geometries or higher short-circuit powers, it is necessary to perform a detailed pressure calculation applying the numerical 3-D-Finite-Elements method for DP-based calculations that also takes the dynamic pressure development into account. Please contact the Siemens TIP consultant promoters for more details.

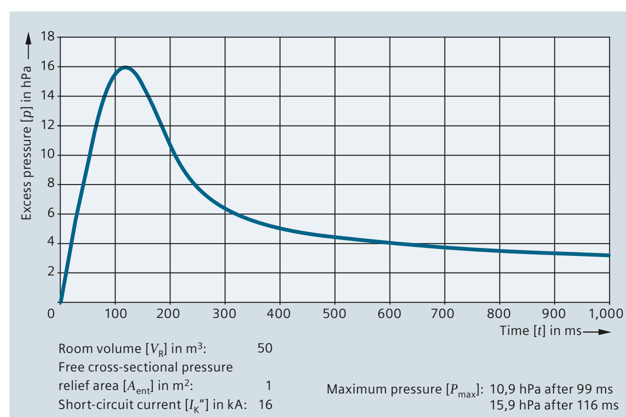

Fig. 5/9: **Graphical representation of a pressure calculation according to Pigler for the 8DJH switchgear type without absorber**

5

5.3 Distribution Transformers

In the ring-main substations at the distribution levels, medium voltage is transformed from 10 or 20 kV to low voltage at 400/230 V AC. Since the supply centres are located in a building with people entering and leaving all the time, dry-type transformers in compliance with IEC 60076-11 (VDE 0532-76-11) are preferably used. On top of that, the generator-transformer sets for safety supply are additionally equipped with GEAFOL transformers each with 2.5 MVA output, to raise the generator voltage to 10 kV, or respectively 20 kV.

GEAFOL cast-resin transformers (Fig. 5/10) have proven themselves for decades and feature the following benefits:
- Safety: they meet all the requirements placed on communal facilities, workplaces and electrical operating areas
- Environmental compatibility: low noise, no insulating fluids, recycling capability, advantages in terms of EMC, efficiency
- Flexible use: GEAFOL transformers meet the requirements regarding fire protection and water pollution control (low flammability, self-extinguishing); they can be adapted to extreme climates (resistant to moisture and tropical conditions, suitable for high and low temperatures)
- Performance: Performance increase possible by using additional ventilation (Fig. 5/11)
- Economic efficiency / long service life: Models with different loss characteristics, use of aluminium windings possible
- Ease of operation: no maintenance, low footprint

GEAFOL transformers with a power rating of 1,250 kVA are chosen for the power supply concept of the super tall skyscraper, since transformer dimensions and weight are to be matched to the structural conditions (e.g. floor load). GEAFOL transformers require almost no maintenance. For this reason, there is no need to consider a backup transformer for maintenance work .

ATTENTION: A possible additional power reserve of 40 % on account of the optional cross-flow fans must be factored in when selecting the switching devices. Consequently, higher nominal currents must be used for project planning. The long-term utilization of such performance increases may also affect transformer ventilation, since losses will rise disproportionately. As an alternative, an energy management system to curb power peaks during normal operation should already be discussed at the planning stage, if this perhaps helps to avoid subsequent additional investment in cross-flow fans for the transformers. Bear in mind that dimensions may increase by an extra 10 cm in width and length if cross-flow fans are used.

Fig. 5/10: **GEAFOL cast-resin dry-type transformer**

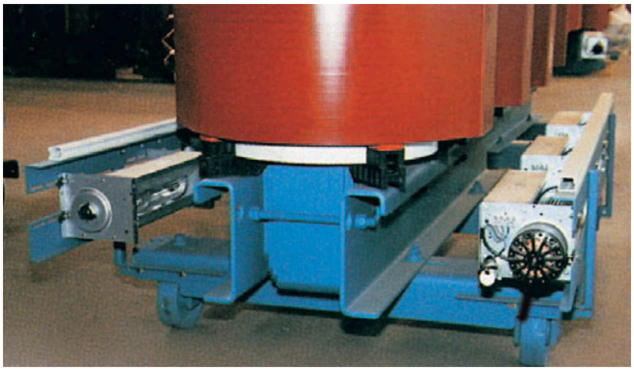

Fig. 5/11: **Cross-flow fan for GEAFOL transformers**

5

Numerous enclosures for indoor transformer use (Fig. 5/12) are available with different degrees of protection. For installing compact substations in enclosed buildings, pre-fabricated protective enclosures are available which can accommodate the transformer plus the low or medium-voltage switchgear station.

Regarding transformer ventilation, early coordination with the architect and structural engineer responsible for air conditioning is required, since sufficient air outlets and duct routing for the exhaust air must be planned. A rough estimation can be performed by the Siemens TIP consultant promoters. This estimate will quickly provide an overview of the dimensions required (Fig. 5/13).

Fig. 5/12: **Protective enclosure in IP 20/40 degree of protection for GEAFOL transformer**

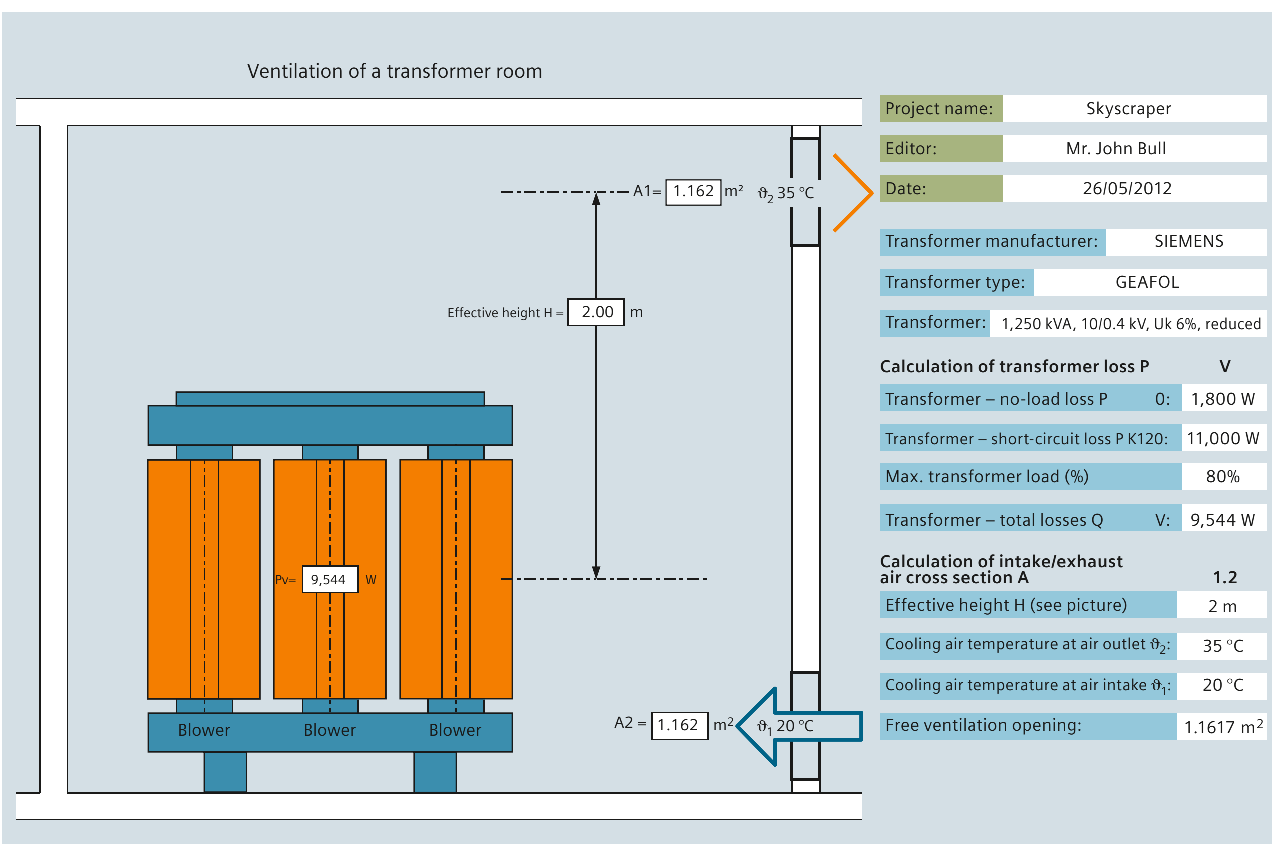

Fig. 5/13: **Calculation of the air vents for the transformer room using a 1,250-kVA transformer as an example**

5.4 Low-voltage Main Distribution

The low-voltage main distribution systems used at the different distribution levels must have been developed, assembled and tested in compliance with IEC 61439-1/-2 (VDE 0660-600-1/-2). Type tests and routine tests are required for verification. The SIVACON S8 low-voltage switchboard (Fig. 5/14) is a Power Switchgear and Controlgear (PSC) Assembly conforming to standard; design verification is accomplished by testing.

Since the low-voltage switchgear is the most frequently operated part of power supply inside the building, reliability of supply and operator protection must be provided for with particular care. Test verification under arcing fault conditions in accordance with IEC/TR 61641 (VDE 0660-500-2) ensures maximum safety for persons. Active protection measures such as high-quality insulation of live parts (e.g. busbars), uniform and simple handling, integrated operator fault protection and reliable plant dimensioning prevent arcing faults and thus injuries. Passive protection measures increase the safety of man and machine many times over. They include arcing-fault-proof hinge and lock systems, safe handling of withdrawable units or circuit-breakers only if the door is closed and patented flap traps behind front air vents, arc barriers or an arcing fault detection system in combination with a faster interruption of arcing faults.

The issue of arcing fault detection or interruption is being discussed thoroughly and at the moment, technically sophisticated solutions are being advanced. For years, Siemens has preferred stopping an arc by completely insulating all conductive parts inside the plant or the panels. This passive precaution makes sure that no arc is generated which would have to be detected and quenched. This means that no expensive equipment needs to be installed which would require regular inspection and maintenance and would have to be replaced after every tripping on fault. This is also beneficial for plant availability.

5.4.1 SIVACON S8 Low-voltage Switchboard

SIVACON low-voltage switchgear
- provides maximum plant safety owing to type-tested switchgear assemblies
- is space saving with an installation area of 400 to 500 mm^2 or above
- offers a choice as to busbar position (top/rear)
- enables cable/busbar connection from the top, bottom or rear
- allows a combination of different mounting techniques within one panel
- has a switch-test and disconnection position with closed door while maintaining the same degree of protection (max. IP54)
- ensures maximum operator safety thanks to an arc-fault-proof locking system
- allows flexible adjustments of its inner compartmentalization to customer needs
- has a uniform operator interface for all withdrawable units
- has a universal hinge for ease of subsequent changes of the door hinge (left/right).
- has a high-efficiency ventilation system that provides benefits in maintenance work

Fig. 5/14: **SIVACON S8 low-voltage switchboard**

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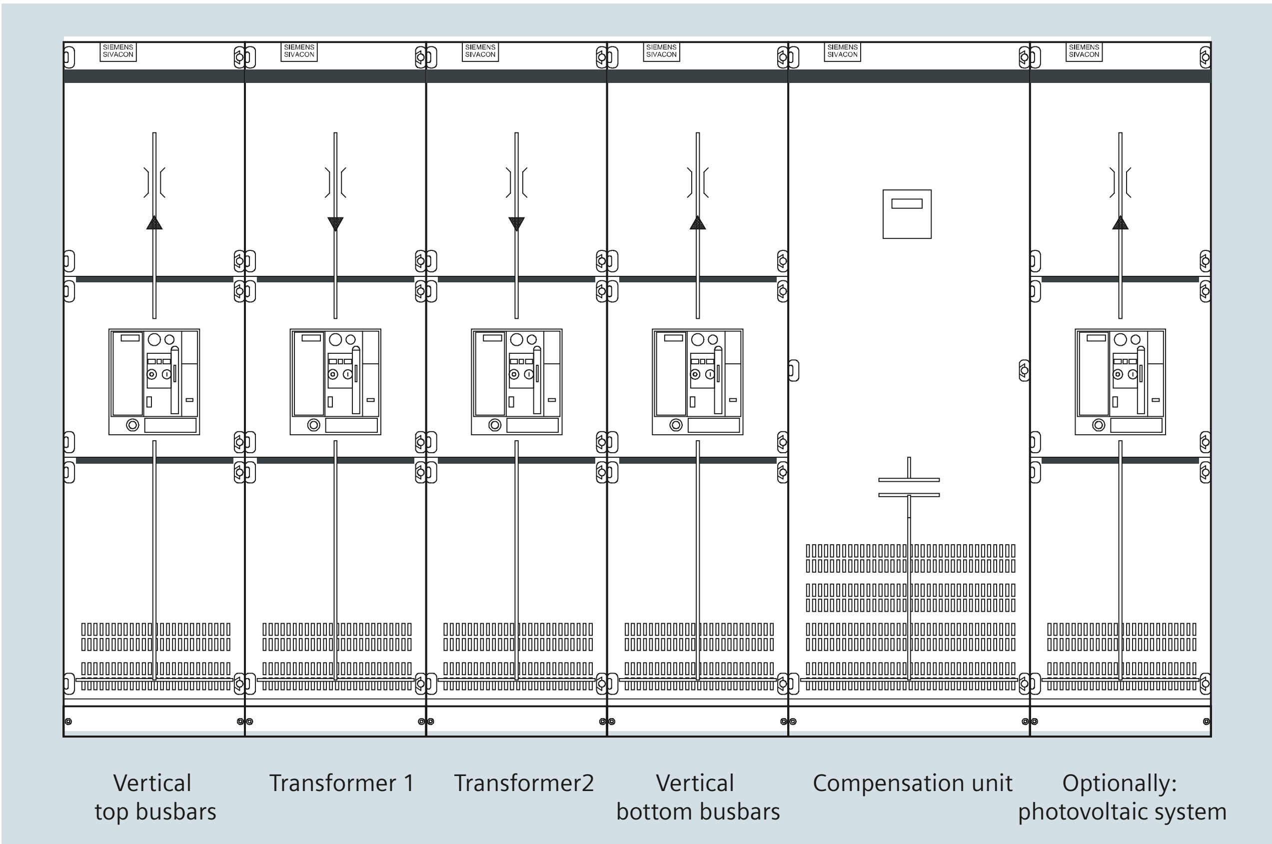

Fig. 5/15: **Front view of SIVACON S8 switchgear**

- is of a high-quality industrial design for precision-fit integration into modern spatial concepts
- boasts of a worldwide network of SIVACON licensed manufacturing partners that ensure service and system availability

For our example, we have chosen a 4,000-ampere installation in withdrawable unit design for the circuit-breakers and a compensation system for every storey distribution board (Fig. 5/15, Fig. 5/16).

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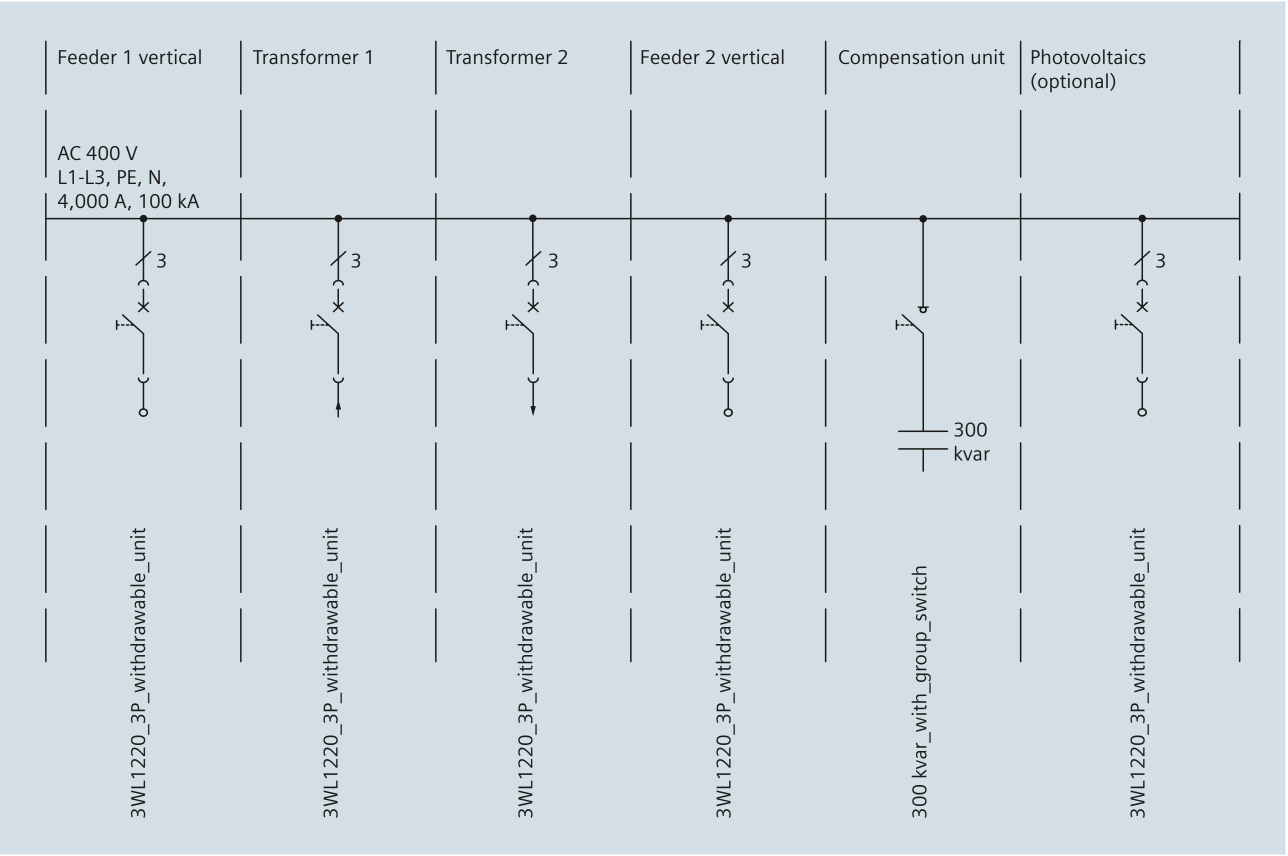

Fig. 5/16: **Line diagram for SIVACON S8 switchgear**

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5.4.2 Busbar Trunking Systems

By splitting voltage transformation to individual distribution levels, the storeys are vertically supplied section by section with busbar trunking systems (Fig. 5/17). In addition, horizontal distribution is planned using busbars to the individual floors. It is in particular the high flexibility of the busbar systems that ensures long-term cost effectiveness of such a solution in case of changes in the room allocation plan. Further advantages of SIVACON 8PS busbar trunking systems compared to cable laying are:

- Fire load reduced by approx. 20 % compared to cables
- Easy installation and expansion – no complex support structures (cable racks, shelves) and fastening techniques required; the bending radius of cables is reduced by angle pieces and adapters; type-tested components for fire bulkheads are available ex works
- More favourable EMC conditions
- Lower weight (aluminium conductors)
- Cost effectiveness owing to easy installation and the use of aluminium instead of copper wires
- Clear, visible current routing, also when the system is in operation
- Standard short-circuit strength corresponds to that of short-circuit-proof cabling –no additional precautions required as compared to cables
- High degree of operating safety
- High degree of flexibility owing to short intervals between tap points (possible every 0.5 m) and the straightforward use of measuring and communication equipment (PROFIBUS, Ethernet)
- Part of the Siemens integrated power supply as a complete system

The LXA busbar system is used for vertical power distribution from the distribution levels to the individual floors. The 5-conductor aluminium system transmits up to 5,000 A. There are connection pieces for sideways or top connection of busbars to the distribution transformers and distribution boards (Fig. 5/18).

For distribution to subdistribution boards at the individual floors, BD2A busbar trunking systems can be used. They can be loaded up to a rated current of 1,000 A. Here too, aluminium is used as the conductor material.

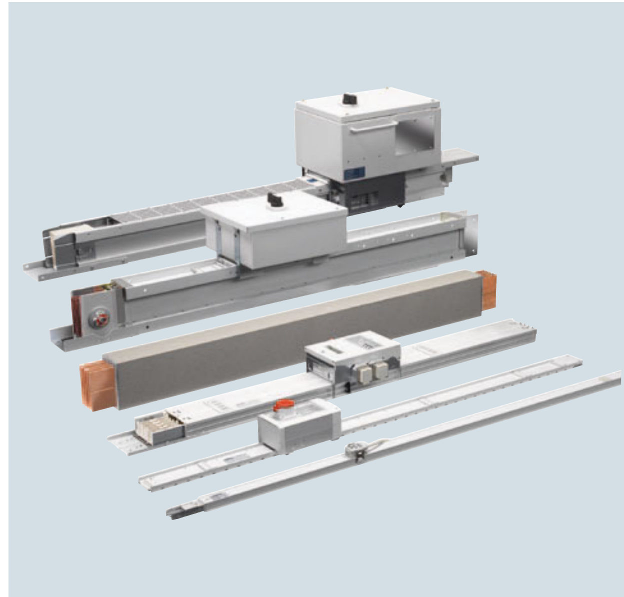

Fig. 5/17: **SIVACON 8PS busbar trunking systems**

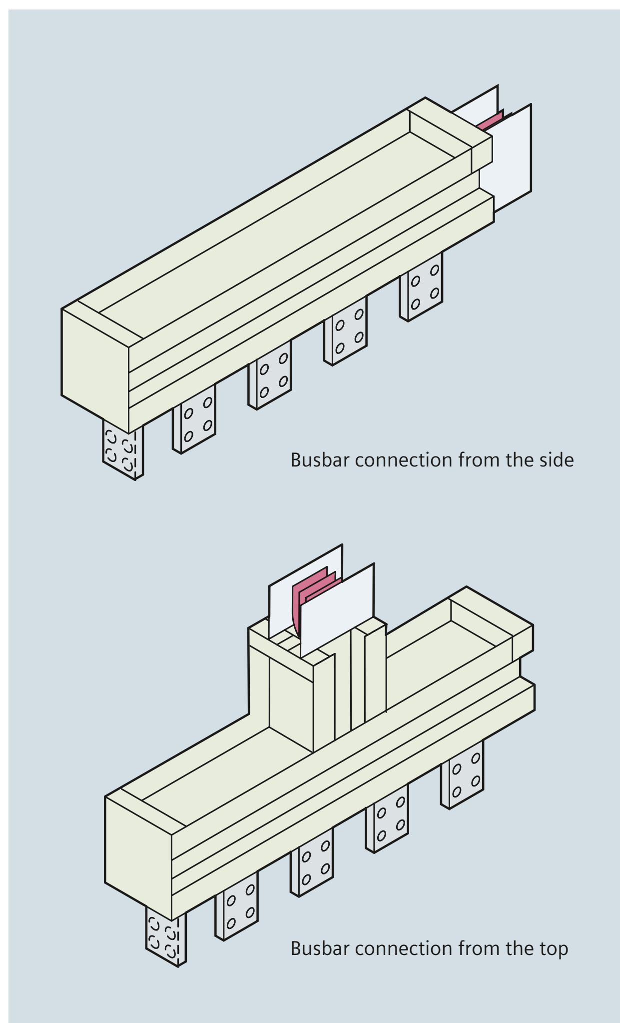

Fig. 5/18: **Connection pieces for LX busbar system**

5.5 Subdistribution Systems and Distribution Boards for Installation Components

To distribute electrical energy to the individual floors, subdistribution systems are provided which can be equipped with appropriate protective devices (miniature circuit-breakers, residual current devices, overvoltage protection devices, etc.) and measuring instruments depending on the connected applications and consumers. Depending on location and the desired equipment either wall-mounted cubicles or floor-mounted distribution cabinets can be used. Relevant standards, such as IEC 60364-1 (VDE 0100-100) and IEC 60364-5-51 (VDE 0100-510), must be complied with.

For demonstration purposes, the ALPHA 630 distribution board (Fig. 5/19, Fig. 5/20) is used in the SIMARIS model for floor distribution purposes. Its advantages are open side walls to enable busbars to be routed through several cabinet sections.

Fig. 5/19: **View of an open ALPHA 630 subdistribution board**

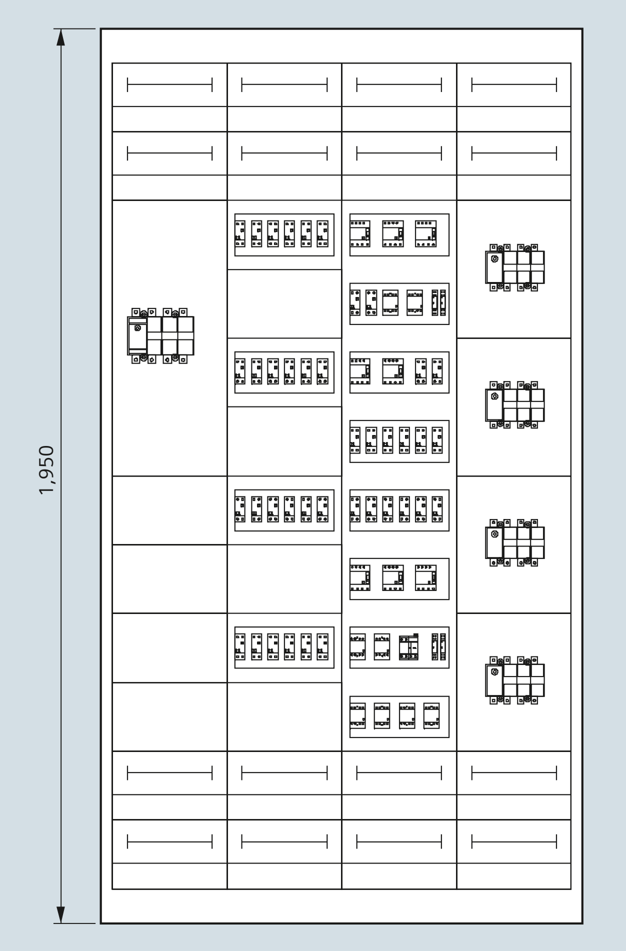

Fig. 5/20: **ALPHA 630 distribution board mapped with SIMARIS tools**

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5.6 Protection Devices for Electrical Installations

Fault protection and fire protection are issues of particular importance, when protective systems for electrical installations in high-rise buildings are to be selected. Protection against electric shock under fault conditions is called fault protection (protection in case of indirect contact). This kind of protection requires that the power supply be automatically disconnected in case of human contact with a normally non-live, but electrically conductive part if a fault may cause a hazard owing to the magnitude and duration of the touch voltage that may occur in such a situation.

Residual current protective devices (RCDs) are capable of detecting a leakage current that may occur due to an insulation fault or unintentional human contact with live parts, and can thus contribute to personal and fire protection. A summation current transformer compares all currents flowing through the conductor, or the differences between the phase current and the neutral conductor, with a trip threshold.

A majority of electrical accidents is caused by faults in the final circuit. The reasons are a high stress on the wiring (leading to the equipment, missing strain relief, bending radius, ...) as well as improper handling and lack of maintenance. Thanks to the use of residual-current-operated circuit-breakers and recently developed arc fault detection units by Siemens, human safety and building safety are significantly increased.

5.6.1 Residual Current Operated Circuit Breakers

Protection against electric shock is described in IEC 60364-4-41 (VDE 0100-410). In a majority of application cases, type A residual-current-operated circuit-breakers (for AC currents and pulsating DC currents) are chosen for day-to-day use. However, type A does not provide a sufficient degree of protection for those increasingly used

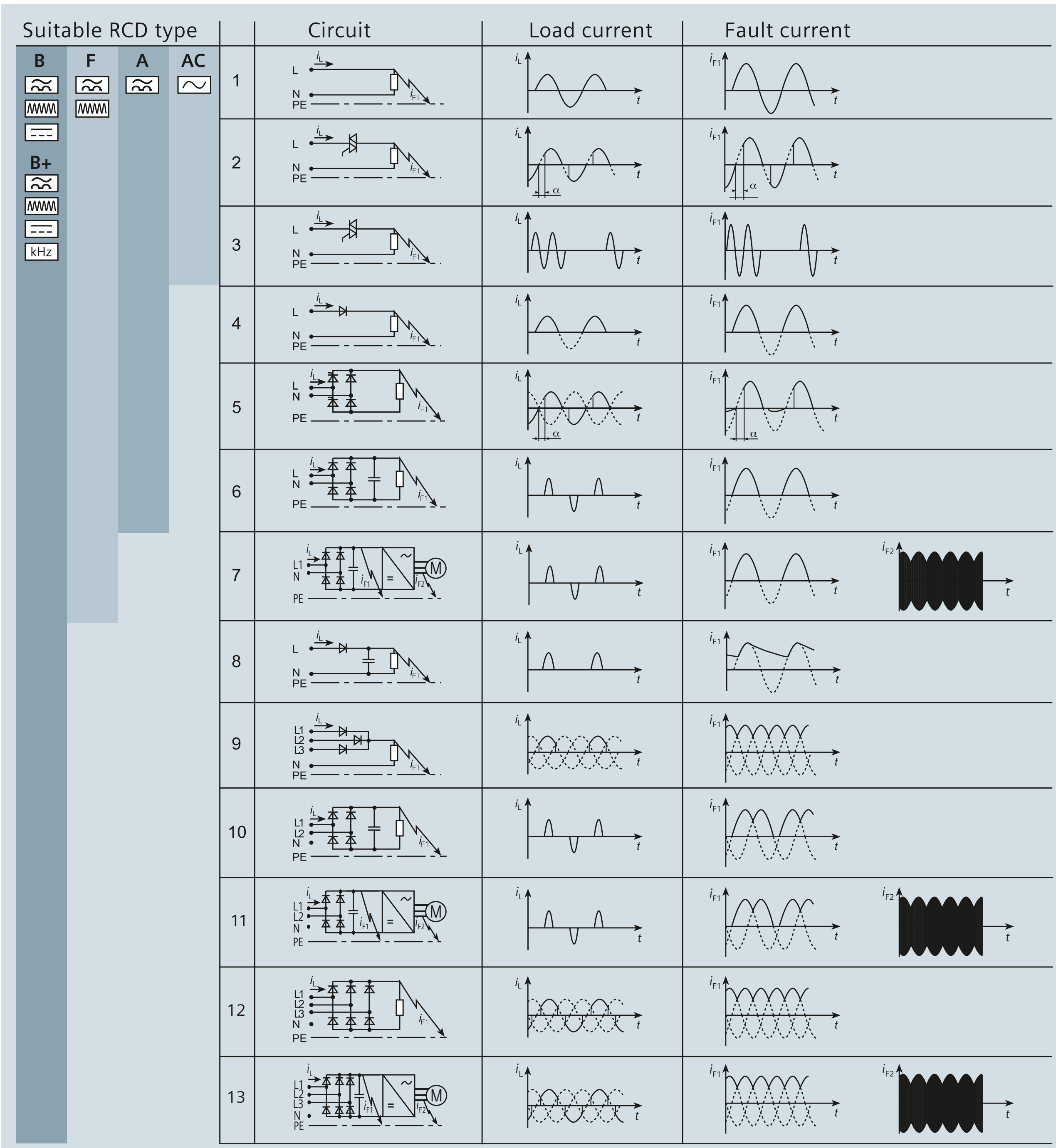
Fig. 5/21: **Residual Current Protective Device Type F**

Current type	Type / Current form	AC	A	F	B	B+ (kHz)	Type / Tripping current
Alternating current	~	■	■	■	■	■	0.5 ... 1.0 $I_{\Delta n}$
Pulsating direct fault currents (positive or negative half-waves)			■	■	■	■	0.35 ... 1.4 $I_{\Delta n}$
Cut half-wave currents			■	■	■	■	Phase angle 90 °: 0.25 ... 1.4 $I_{\Delta n}$
			■	■	■	■	Phase angle 135°: 0.11 ... 1.4 $I_{\Delta n}$
Half-wave current overlaid with smooth direct current			■ + 6 mA	■ + 10 mA	■ + 0.4 mA	■ + 0.4 $I_{\Delta n}$	max. 1,4 $I_{\Delta n}$ + DC
Fault current resulting from mixed frequency				■	■	■	0.5 ... 1.4 $I_{\Delta n}$
Smooth direct current					■	■	0.5 ... 2.0 $I_{\Delta n}$

Tab. 5/1: **Types of residual current protective devices and their tripping ranges** power consumers with built-in semiconductors (e.g. power supply units for computers, charging units, frequency converters).

Depending on the requirements, a type as listed in Tab. 5/1 must be selected, since otherwise users would run the risk that the fault is not cleared, or at least not within the limits defined. Besides type B, Siemens now also offers a type F (see Fig. 5/21), which additionally detects mixed frequencies, e.g. occurring in frequency converters in single-phase AC networks, and disconnects them safely.

A type classification according to the different forms of fault currents that may occur is given in Tab. 5/2).



Tab. 5/2: **Types of residual current protective devices (RCD) and possible forms of fault currents**

5.6.2 Arc Fault Detection Unit

More than a hundred thousand fires are reported in Europe every year. The horrifying toll are numerous casualties and injuries and damage to property amounting to billions of euros. More than 25 % of these fires can be attributed to deficiencies in the electrical installation – often caused by hazardous arcing faults.

They can, for example, be caused by damaged cable insulation, squeezed cables, kinked plugs or loose contacts in the electrical installation. This leads to excessive heating up, which may eventually result in cable fires and consequently in a fire in the building.

Glowing contacts or connections or arcing faults cannot be detected by conventional protective devices, since they have little impact on the load current. In order to be able to detect such faults, the arc fault detection unit continuously measures the high-frequency noise of voltage and current as well as their intensity, duration and in-between gaps. Integrated filters incorporating intelligent software analyse these signals and initiate the disconnection of the connected circuit within split seconds in case of irregularities.

Harmless sources of interference, occurring when power drills or hoovers are operated, for instance, are reliably distinguished from hazardous electric arcs by the arc fault detection unit. The 5SM6 arc fault detection unit can be regarded as a complement to residual-current-operated and miniature circuit-breakers, increasing the safety of persons and material assets and closing a gap in the protection against electrically triggered fires. In the future, this gap will also be closed in the IEC corpus of standards by the Draft IEC 62606 (Draft VDE 0665-10).

The arc fault detection unit responds to the following faults:
- Serial arcing fault
- Parallel arcing fault
- Overvoltage (but self-protection at voltage greater than 275 V)

If one of these faults is detected, the arc fault detection unit (AFD) triggers the built-on miniature circuit-breaker (MCB) or respectively, the combined RCCB/MCB. The detected fault is then displayed on the status LED of the AFD unit. The fault display can be reset by switching the device on, off and on.

For more information, see www.siemens.com/sentron

Fig. 5/22: **Arc Fault Detection Unit 5SM6**

5.7 Power Management

In the switching rooms and distribution facilities close to applications, measured values are acquired with the aid of communication-capable circuit-breakers, multi-functional measuring instruments (PAC) or distributed I/Os and processed in power management software mostly for visualization purposes (Fig. 5/23).

Depending on power management requirement, Siemens offers application-minded solutions for monitoring, data transmission, archiving, surveillance and analysis of all relevant parameters of electrical power distribution in buildings. The *powermanager* software is a PC-based system which is also capable of integrating data from communication-capable protection devices (Fig. 5/24), such as 3WL and 3VL, through the PAC measuring instruments and their gateway from Modbus RTU (RS485) to Modbus TCP (Ethernet).

With SIMATIC powerrate, Siemens provides a rugged SIMATIC-based solution for visualization and control in industrial environments. In order to fully integrate low-voltage consumers, switching and protection components into process and SCADA systems, PROFIBUS DP interfaces and module libraries are available, such as the 7KM PAC3200 module library for SIMATIC WinCC and PCS 7 or the 3WL/3VL module library for SIMATIC PCS 7. These software options allow all data supplied from the various devices to be displayed without much engineering outlay. In addition, the 7KM PAC3200/4200 measuring instruments can also be integrated into Totally Integrated Automation (TIA) via Profinet.


Fig. 5/23: **Components for the power management solution**

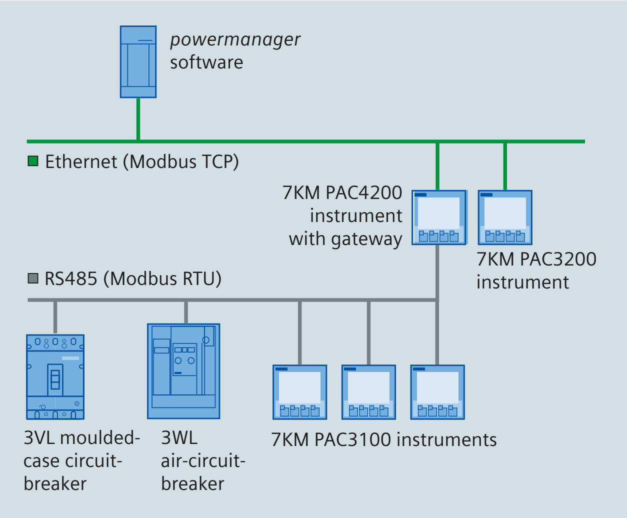


Fig. 5/24: **Schematic overview of power management using the powermanager software**

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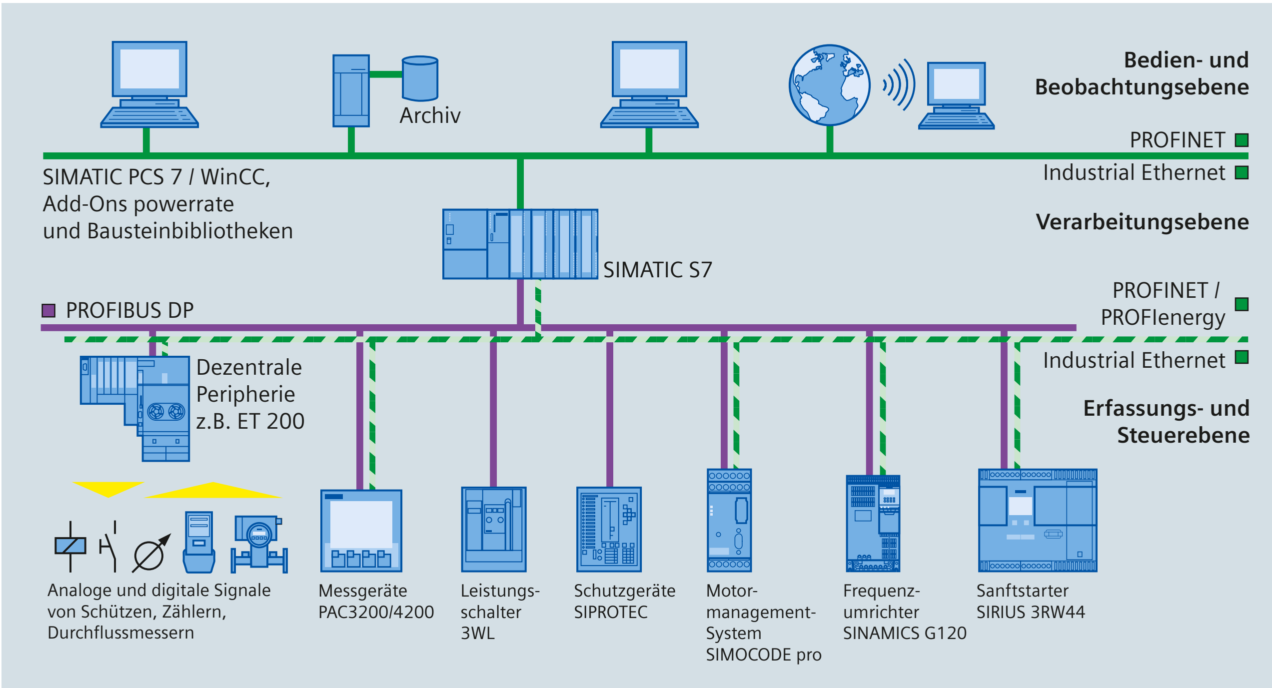

Fig. 5/25: **Schematic overview of a SIMATIC-based power management system**

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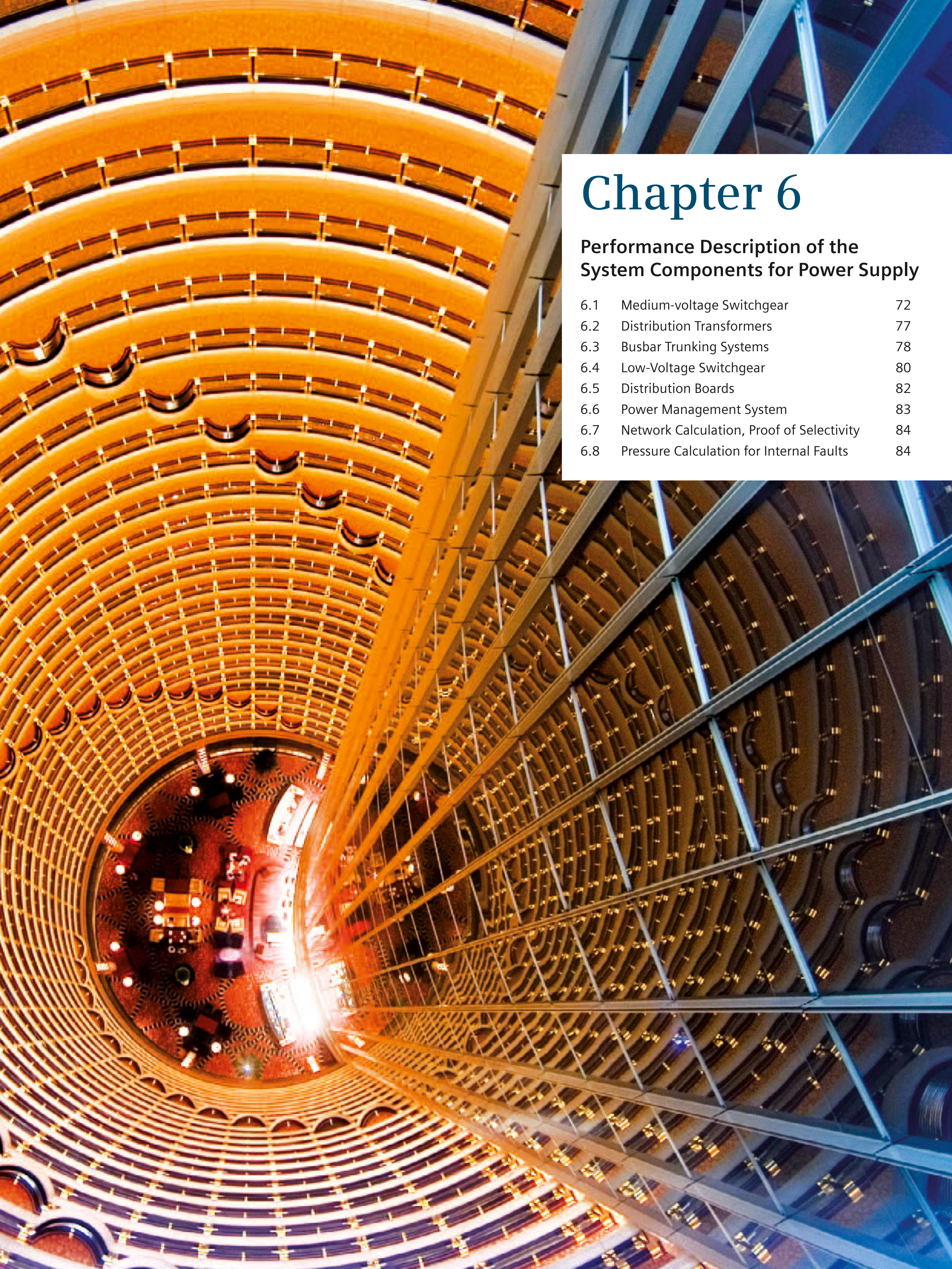

Chapter 6

Performance Description of the System Components for Power Supply

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6 Performance Description of the System Components for Power Supply

To prepare concept planning and the associated functional specification, the system components for power supply are outlined in a brief performance description. Such performance descriptions are product-specific and can be used as a basis for creating tender specifications (bills of quantities).

6.1 Medium-voltage Switchgear

6.1.1 Switchgear for Power Centre and Remote Station

NXPLUS C switchgear (Tab. 6/1)

- Compact medium-voltage switchgear for the primary and secondary distribution level
- Factory-assembled type- and routine-tested switchgear for fixed-mounted circuit-breakers
- SF_6-insulated, metal enclosed or with metal partitions
- Hermetically sealed, welded containers made of stainless steel and single-pole solid insulation make the live parts of the station in the primary current path, which are subject to high voltage, insusceptible against certain aggressive ambient conditions (salty air, air humidity, condensation, etc.) and tight against the ingress of solid bodies (dust, small animals etc.) and moisture. This permits installation at any altitude above sea level.
- Max. busbar operating current 2,500 A
- Single and double busbar applications in case of indoor installation
- At the wall or free-standing
- Cable terminals accessible from the front
- Installation and expansion without requiring gas work thanks to modular design
- Safety of persons and reliability of supply owing to hermetically sealed pressure system, no-maintenance switching devices and encapsulated cable connectors (tightness for life in accordance with IEC 62271-200, VDE 0671-200)
- Absolutely no maintenance required when installed in indoor climatic conditions (IEC 62271-1, VDE 0671-1)
- Operation is only possible if the enclosure is fully sealed (and any doors closed) as system requirement
- Make-proof earthing using the circuit-breaker
- Partition class PM (metallic partition)
- Accidental arc qualification:
  - 7.5 kV to 15 kV IAC A FL 31.5 kA, 1 s
  - 17.5 kV to 24 kV IAC A FLR 25 kA, 1 s
- Standard degree of protection IP65 for all high-voltage parts in the primary current path, IP3XD for switchgear encapsulation in accordance with IEC 60529 (VDE 0470-1)
- Locks in accordance with IEC 62271-200 (VDE 0671-200)
- Options: Earthquake-proof system; flexible pressure relief systems, electromagnetic interlocking etc.

Rated voltage	kV	7.2	12	15	17.5	24
Rated frequency	Hz	50/60	50/60	50/60	50/60	50/60
Rated short-duration power-frequency withstand voltage	kV	20[1)]	28[2)]	36	38	50
Rated lightning impulse withstand voltage	kV	60[1)]	75[2)]	95	95	125
Rated surge current	kA	80	80	80	63	63
Rated short-circuit making current	kA	80	80	80	63	63
Rated short-time current, 3 s	kA	31.5	31.5	31.5	25	25
Rated short-circuit breaking current	kA	31.5	31.5	31.5	25	25
Rated operating current of busbar	A	2,500	2,500	2,500	2,500	2,500
Rated operating current of branch circuits	A	2,500	2,500	2,500	2,000	2,000
Partitioning	mm	600[3)]	600[3)]	600[3)]	600[3)]	600[3)]
Depth – without rear pressure relief duct – with rear pressure relief duct	 mm mm	 1,100 1,225	 1,100 1,225	 1,100 1,225	 1,100 1,225	 1,100 1,225
Height – Panels 600 mm – Panels 900 mm	 mm mm	 2,250 2,550	 2,250 2,550	 2,250 2,550	 2,250 2,550	 2,250 2,550

1) 32 kV/60 kV in accordance with some national specifications
2) 42 kV/75 kV in accordance with some national specifications
3) 900 mm for rated branch circuit currents of 2,000 A and 2,500 A

Tab. 6/1: **Electrical data and dimensions of the NXPLUS C switchgear**

6

6.1.2 Medium-voltage Protection Relay for Generator-Transformer Sets

The following applies to the multi-functional SIPROTEC 4 7UM62 relays for machine protection:

The multi-functional machine protection device is to be adaptable to different areas of application owing to various function packages that can be selected. The protection algorithms shall be effective in a frequency range from 11 Hz to 60 Hz, so that they are capable of detecting faults during generator start-up.

The functional scope of protection of a relay equipped with the "Generator Basis" package, shall be as follows:
- Differential current protection (87G/M/T)
- Stator earth fault protection: non-directional and directional (59N, 64G, 67G)
- Sensitive earth fault protection (also as rotor earth fault protection) (50/51 GN (64R))
- Sensitive earth current protection I_{EEb}> (e.g. as wave current) (50/51 GN)
- Overload protection (49)
- Overcurrent-time protection while maintaining the voltage
- Overcurrent-time protection, directional (50/51/67)
- Inverse-time delayed overcurrent-time protection (51V)
- Overvoltage protection (59)
- Undervoltage protection (27)
- Frequency protection (81)
- Reverse-power protection (32R)
- Over-excitation protection (24)
- Detection of measuring voltage fault (FFM = Fuse failure monitor 60FL)
- Coupling of external trip signals
- Trip circuit monitoring (74TC)
- Forward power monitoring (32F)
- Under-excitation protection (40)
- Unbalanced load protection
- Switch failure protection (50BF)
- Starting time monitoring (48)
- Reclosing lockout (66, 49 rotor)
- Rotor earth fault protection with line-frequency voltage (64R (fn))
- Earth-current differential protection (87GN/TN)
- Out-of-step protection (78)
- Sensitive rotor earth fault protection with 1 Hz to 3 Hz square-wave voltage (64R) can optionally be selected for all function packages
- 100 % stator earth fault protection with 20-Hz voltage (64G) can optionally be selected for all function packages
- Frequency change protection (81) can optionally be selected for all function packages
- Vector jump (voltage) can optionally be selected for all function packages
- Phase-sequence monitoring (47)
- Undercurrent via Continuous Function Chart (CFC) programming (37)
- External temperature monitoring via interface (38)

The functional scope of protection of a relay equipped with the "Generator Standard" package shall be as follows:
- Differential current protection (87G/M/T)
- Stator earth fault protection: non-directional and directional (59N, 64G, 67G)
- Sensitive earth fault protection (also as rotor earth fault protection) (50/51)
- GN (64R))
- Sensitive earth current protection I_{EEb}> (e.g. as wave current) (50/51 GN)
- Overload protection (49)
- Overcurrent-time protection while maintaining secondary voltage
- Overcurrent-time protection, directional (50/51/67)
- Dependent overcurrent-time protection (51V)
- Overvoltage protection (59)
- Undervoltage protection (27)
- Frequency protection (81)
- Reverse-power protection (32R)
- Over-excitation protection (24)
- Fuse failure monitor FFM (60FL)
- Coupling of external trip signals
- Trip circuit monitoring (74TC)
- Forward power monitoring (32F)
- Under-excitation protection (40)
- Unbalanced load protection
- Switch failure protection (50BF)
- Starting time monitoring (48)
- Reclosing lockout (66, 49 rotor)
- Rotor earth fault protection with line-frequency voltage (64R (fn))
- Protection against inadvertent energization (50/27)
- 100 % stator earth fault protection with 3rd harmonic (59TN, 27TN (3rd H))
- Impedance protection with (I>+U<)-excitation (overcurrent starting while maintaining the voltage) (21)
- Winding fault protection (59N(IT))
- Earth-current differential protection (87GN/TN)
- Out-of-step protection (78)
- Sensitive rotor earth fault protection with 1 Hz to 3 Hz square-wave voltage (64R)

can be selected as separate function for all function packages
- 100 % stator earth fault protection with 20-Hz voltage (64G)
- Frequency change protection (81)
- Vector jump (voltage)
- Phase-sequence monitoring (47)
- Undercurrent via CFC (37)
- External temperature monitoring via interface (38)
- IEC61850 protocol implementation shall be certified by means of a KEMA Class A certificate [1].

Housing design:
- Built-in housing 1/2 and 1/1 19“ with screw terminals or
- Surface-mounted housing 1/2 and 1/1 19“ with top/bottom two-tier terminals

The following applies to the SIPROTEC 4 7SJ64 relays for multi-functional machine protection:

The multi-functional overcurrent-time protection unit shall be equipped with the following features:
- The unit should have a large back-lit graphical display
- Optionally, the unit can be delivered with a detached display
- The unit should have at least 16 LEDs, 14 of which to be user-programmable
- The unit should have at least 4 voltage inputs
- The unit should have a minimum of 20 user-programmable binary inputs and 8 user-programmable output contacts The unit should be equipped with a minimum of 4 power relays
- The unit should have 2 key-lock switches which ensure fast and safe change-over between local and remote control and between locked and unlocked operating mode
- In addition, the unit should have an interface for linking up a maximum of 2 temperature sensing devices
- The unit must be capable or controlling at least one circuit-breaker To this end the unit must have a user-defined protective lock

The protection device shall be equipped with the following scope of protection:
- Overcurrent-time protection (50, 50N, 51, 51N)
- The minimum tripping time for the rapid-trip stage shall be 25 ms
- Determination of the direction of current flow for overcurrent phases and earth (67, 67N)
- Switch failure protection (50BF)
- Automatic reclosure (79)

It must be possible to set different programs for phase and earth faults.
- Synchronisation function (25)
- Unbalanced load protection
- Overload protection (49)
- Reclosing lockout (66)
- Starting time monitoring, locked rotor (48/14)
- Undercurrent monitoring (37)
- Temperature monitoring using a "thermo-box" (38)
- 1-phase time-overcurrent protection (87N)

The unit shall have a 1-phase definite-time overcurrent protection which can be utilized to implement high-impedance differential protection with the aid of the sensitive earth input.
- Intermittent earth fault protection
- Trip circuit monitoring (74TC)
- ON command locking (86)
- Overvoltage protection (59)
- Undervoltage protection (27)
- Fault detector (21FL)
- Frequency protection (81O/U) for load shedding programs
- Sensitive direction of earth fault detection function (67N/67Ns), suitable for detecting earth faults up to a max. sensitivity of 1 mA. It shall also be possible to operate this function in an insensitive manner as additional directional short-circuit protection.

IEC 61850 protocol implementation shall be certified by means of a KEMA Class A certificate [1].

Enclosure design:

- Built-in housing 1/2 and 1/1 19“ with screw terminals or
- Surface-mounted housing 1/2 and 1/1 19“ with top/bottom two-tier terminals

6

1 Certificate of DNV KEMA Energy & Sustainability: a global, leading authority in business and & technical consultancy, testing, inspections & certification, risk management, and verification, along the energy value-chain

6.1.3 Medium-voltage Protection Relays for Secondary Medium-voltage Distribution Systems

The following applies to the multi-functional SIPROTEC 4 7SJ80 protection device:

The protection device must be capable or controlling at least one circuit-breaker To this end, the device must have a user-defined protective lock. A maximum of 30 status messages and max. 8 fault records can be recorded. The device has pluggable current and voltage terminals.

The following protection functions shall be part of the minimum scope of protection:

Overcurrent-time protection (50, 50N, 51, 51N)
- Switch failure protection (50BF)
- Automatic reclosure (79)
- Unbalanced load protection
- Overload protection (49)
- Reclosing lockout (66)
- Starting time monitoring, locked rotor (48/14)
- Undercurrent monitoring (37)
- Temperature monitoring via external "thermobox" (38)
- 1-phase overcurrent-time protection (87N)
- Trip circuit monitoring (74TC)
- ON command locking – Lock out (86)
- Overvoltage protection (59)
- Undervoltage protection (27)
- Synch-check (25)
- Frequency protection (81O/U) for load shedding programs
- Sensitive direction-of-earth-fault detection function (67N/67Ns)
- Special features:
- Pluggable current and voltage terminal blocks
- DIGSI-set binary input thresholds (3 steps)
- DIGSI-set secondary current transformer value (1A/5A)
- Nine parameterizable function keys
- Six-line display
- Buffer battery can be replaced from the front
- Front USB port
- Two extra communication interfaces
- IEC 61850 with integrated redundancy (electrical or optical)
- Cross-communication between devices via Ethernet
- (IEC 61850 GOOSE)
- Precise time synchronisation on per millisecond basis via Ethernet using SNTP
- Degree of protection acc. to IEC 60529, front IP51/rear IP50

Housing design:

- Built-in housing 1/6 19“ with screw terminals or
- Surface-mounted housing 1/6 19“ with screw terminals

6.1.4 Medium-voltage Switchgear for Ring-main Stations

8DJH switchgear (Tab. 6/2, Tab. 6/3)

- Compact medium-voltage switchgear for the secondary distribution level up to 24 kV
- Factory-assembled type- and routine-tested switchgear
- SF_6-insulated and metal enclosed switchgear suitable for indoor installation in accordance with IEC 61936 (VDE 0101)
- Welded containers without gaskets, made of stainless steel and welded-in bushings for electrical connections and mechanical parts make this hermetically sealed primary encapsulation insusceptible against certain aggressive ambient conditions (salty air, air humidity, condensation, etc.) and tight against the ingress of solid bodies (dust, small animals etc.) and moisture. This permits installation at any altitude above sea level.
- Rated busbar operating current up to 630 A
- Installation at the wall, optionally stand-alone
- Cable connection for bushings with outer cone
- Installation and expansion without requiring gas work thanks to modular design
- Operational and human safety owing to 3-pole, panel-wise hermetically sealed primary encapsulation (tightness for life acc. to IEC 62271-200, VDE 0671-200), drive parts requiring no maintenance (IEC 62271-1, VDE 0671-1) and encapsulated cable plugs
- Earthing of branch circuits thanks to make-proof earthing switches
- Use of vacuum circuit-breakers
- Three-position switch-disconnectors with load isolation function and make-proof earthing function
- Use of metal coated or metal enclosed voltage transformers and three-phase current transformers as toroidal-core transformers
- Pressure relief to the bottom (optionally using absorber systems for pressure relief to the top)
- Compartmentalization class PM
- Low-voltage cubicles available in four heights
- In arcing-fault-tested design (IAC A FL for installation at the wall, or FLR for stand-alone installation)
- Standard degree of protection IP65 for gas-filled containers; IP2X/3X for switchgear encapsulation and IP3X/4X for optional low-voltage cubicles (type-dependent)
- Options: Resistance to earthquakes; pressure absorber system for pressure relief to the top, pluggable voltage transformers, lockable operator panel covers, motorized control of three-position switch, etc.

Rated voltage		kV	7.2	12	15	17.5	24
Rated frequency		Hz	50/60	50/60	50/60	50/60	50/60
Rated short-duration power-frequency withstand voltage		kV	20	28[1]	36	38	50
Rated lightning impulse withstand voltage		kV	60	75	95	95	125
Rated operating current for ring-main feeder cables		A	400 or 630				
Rated operating current of busbar		max. A	630				
Rated operating current for circuit-breaker feeder panels		A	250 or 630				
Rated operating current for transformer feeder panels		A	200[2]				
Rated short-time current, 1 s	50 Hz	max. kA	25	25	25	25	20
Rated short-time current, 3 s	50 Hz	max. kA	20	20	20	20	20
Rated surge current	50 Hz	max. kA	63	63	63	63	50
Rated short-circuit making current	50 Hz						
for ring-main feeder cables	50 Hz	max. kA	63	63	63	63	50
for circuit-breaker feeders	50 Hz	max. kA	63	63	63	63	50
for transformer feeders	50 Hz	max. kA	25	25	25	25	25
Rated short-time current, 1 s	60 Hz	max. kA	21	21	21	21	20
Rated short-time current, 3 s	60 Hz	max. kA	21	21	21	21	20
Rated surge current	60 Hz	max. kA	55	55	55	55	52
Rated short-circuit making current	60 Hz						
for ring-main feeder cables	60 Hz	max. kA	55	55	55	55	52
for circuit-breaker feeders	60 Hz	max. kA	55	55	55	55	52
for transformer feeders	60 Hz	max. kA	26	26	26	26	26

[1] 42 kV in accordance with national specifications
[2] dependent on the HV HRC fuse-link

Tab. 6/2: **Electrical data of the 8DJH switchgear**

8DJH dimensions in block design (excerpt)		Dimensions in mm
Width	Number of feeder panels	
	2 feeder panels (e.g. ring-ring)	620
	3 feeder panels (e.g. ring-ring-transformer)	1,050
	4 feeder panels (e.g. 3 rings + 1 transformer)	1,360
Height	Blocks without low-voltage cubicle	1,200/1,400/1,700
	Blocks with low-voltage cubicle (option)	1,400 – 2,600
	Switchgear with pressure absorber (option)	1,800 – 2,600
Depth	Standard switchgear	775
	Switchgear with pressure absorber (option)	890

Dimensions for individual 8DJH panels (excerpt)		Dimensions in mm
Width	Ring-cable feeder panel	310/500
	Transformer feeder panel	430
	Circuit-breaker feeder panel	430/500
	Busbar sectionalizer panel	430/500/620
	Metering panel for billing purposes	430/500/840
Height	Blocks without low-voltage cubicle	1,200/1,400/1,700
	Blocks with low-voltage cubicle (option)	1,400 – 2,600
	Switchgear with pressure absorber (option)	1,800 – 2,600
Depth	Standard switchgear	775
	Switchgear with pressure absorber (option)	890

Tab. 6/3: **Dimensions of the 8DJH switchgear**

6.2 Distribution Transformers

GEAFOL cast-resin dry-type transformers with aluminium windings for indoor installation are characterized as follows:

- They are flame-retardant and self-extinguishing in accordance with IEC 60076-11 (VDE 0532 76 11)and meet the requirements C2 (Climate Category), E2 (Environment Category) and F1 (Fire Safety Category). In case of fire, no toxic or explosive gases are emitted except for carbon monoxide. An expert report concerning fire analysis plus flue-gas analysis is available.
- The short-circuit strength meets the requirements of IEC 60076-5 (VDE 0532-76-5).
- The windings are free from partial discharge up to $2 \cdot U_r$; i.e. the basic noise level does not exceed 5 pC
- High-quality winding design:

High voltage (HV) (primary voltage): Resin-cast aluminium foil winding manufactured under vacuum, in Insulation Class F tolerating a permissible over-temperature of 100 K;

Low voltage (LV), secondary voltage: Insulation of aluminium tape winding using "prepreg"[1] in Insulation Class F tolerating a permissible over-temperature of 100 K

- Performance increase to up to 150 % of rated output possible by mounting cross-flow fans for effective blowing
- HV and LV terminals are at the top
- Transformer truck rollers can be swung round for lengthways and sideways travel
- The use of a transformer housing in degree of protection IP23 or higher, which is implemented as safe-to-touch housing in open-access electrical operating areas, reduces the sound power level by up to 3 %.
- Type-tested busbar terminals enable a flexible connection to the low-voltage distribution system.

1 Short form for “preimpregnated fibres”; tissue made of continuous filaments to reduce axial short-circuit forces

Type	Power rating in kVA	Rated primary voltage in kV	Rated secondary voltage in kV	No load losses in W	Losses at rated transformer power in W	Sound power level in dB	Length × Width × Height in mm × mm × mm	Total weight in kg
GEAFOL	630	10	0,4	1,370	9,620	70	1,520 × 830 × 1,305	1,710
				1,100	9,350	62	1,560 × 835 × 1,330	1,850
		20		1,650	9,130	70	1,560 × 860 × 1,365	1,750
				1,250	8,730	62	1,600 × 865 × 1,385	1,900
		30		2,200	9,460	71	1,620 × 940 × 1,640	2,090
	1,250	10		2,400	14,500	75	1,740 × 990 × 1,635	2,780
				1,800	13,900	67	1,770 × 990 × 1,675	3,140
		20		2,700	15,020	75	1,780 × 990 × 1,645	2,740
				2,100	14,420	67	1,810 × 990 × 1,645	3,010
		30		3,600	16,250	75	1,870 × 1,065 × 1,895	3,580
	2,500	10		4,300	24,870	81	2,090 × 1,280 × 2,070	4,840
				3,000	23,570	71	2,160 × 1,280 × 2,135	5,940
		20		5,000	24,800	81	2,150 × 1,280 × 2,165	5,200
				3,600	24,500	71	2,190 × 1,280 × 2,180	6,020
		30		5,800	27,800	81	2,280 × 1,280 × 2,215	5,920

Tab. 6/4: **GEAFOL – technical data (excerpt) and dimensions**

6.3 Busbar Trunking Systems

SIVACON 8PS busbar trunking systems are type-tested low-voltage assemblies (TTA) in accordance with IEC 61439-1 (VDE 0600-660-1) and IEC 60439-2 (VDE 0660-502). All systems have in common:

- Hot-pluggable tap-off units enable retrofitting and changeover without interrupting ongoing production.
- Sheet-metal enclosures (made of steel for BD2A 400 A and aluminium for LXA 2,000 A) ensure high short-circuit strength and a low fire load
- System-specific components make cable connections for changes in direction obsolete
- Certified fire barriers free from asbestos in compliance with fire resistance class S90 (BD2A)/ S120 (BD2A and LXA) of DIN 4102-9 allow safe busbar routing through walls if necessary
- Only a "real" 5-conductor system ensures safe disconnection to be triggered by the protection device in case of a 1-pole short circuit under unbalanced load conditions; the PE conductor must be a separate conductor
- Hose-proof owing to high degree of protection up to IP55
- Suitable for horizontal and vertical mounting without any reduction of current ratings
- Operational transparency owing to communication-capable busbar systems for load acquisition, remote switching and remote monitoring

Tap-off units have the following characteristics in common:

- They are protected against improper mounting
- No load conditions are ensured during dismounting through forced operating procedures
- Varnished sheet steel encapsulation
- Hot mounting and hot dismounting up to 630 A

In addition to the common features, the following applies to the BD2A busbar trunking system (Tab. 6/5):

- The busbar trunking system must be made of listed and factory-assembled system components; optional lengths can be ordered as factory-assembled system components; cutting to length at the customer's premises is not necessary
- The aluminium conductors are nickel- and tin-plated throughout
- Expansion joints are integrated in every trunking unit.
- Sealable tap-off units can be mounted on both sides of the busbar trunking system at regular intervals
- Busbar trunking units are connected by means of a single-bolted terminal which can be mounted easily and quickly. This terminal is designed in such a way that proper busbar connection is ensured by the proper seating of the terminating flange gasket
- Safe mounting owing to twist protection.

Rated insulation voltage	U_i	**690 V AC**
Rated operating current	U_e	690 V AC
Degree of protection		IP52, IP54, IP55
Rated current	I_e	400 A
Rated peak withstand current	I_{pk}	40 kA
Rated short-time withstand current	I_{cw}	(1 s) 16 kA
Number of conductors		5
Fire load		1.32 kWh/m
Fire load (per tap point)		–
Tap point		Single side every 0.5 m, on both sides offset every 0.25 m
Tap-off units		max. 400 A
Connection technique		with integrated expansion joints, plug terminal
Communication capability		GAMMA instabus KNX, AS-Interface
Conductor material		Al
Casing material		Nickel-plated and varnished sheet steel
Casing dimensions		68 × 167 mm^2

Tab. 6/5: **Technical data of BD2A-2-400**

In addition to the common features, the following applies to the LXA busbar trunking system (Tab. 6/6):

- All tap-off units (boxes) are available ex works in standard lengths and customized lengths. Besides the standard lengths, the customer can also order any length to suit individual constructive requirements.
- Feeder units for transformer, distribution board and cable feed-in
- Directional changes are feasible using angle pieces, offset angle pieces, elbows, offset elbows, Z-boxes and T-boxes
- Position and number of tap points can be selected as desired; a maximum of 10 tap points every 3 metres can be implemented. The tap-off units (80 to 630 A) are protected against wrong installation.
- Junction boxes (800 A and 1,250 A) for fixed mounting can only be mounted and dismounted at the feeder terminal blocks and are protected against wrong installation.
- Low fire load and high resistance against corrosion owing to aluminium casing
- Easy and rapid mounting owing to bolted terminal block with shear nut
- Transmission of high currents with low voltage drop thanks to sandwich design

Rated insulation voltage	U_i	**690/1,000 V AC**
Rated operating current	U_e	400/690 V AC
Degree of protection		IP54/IP55
Rated current	I_e	2,000 A
Rated peak withstand current	I_{pk}	158 kA
Rated short-time withstand current	I_{cw}	75 kA/1 s
Number of conductors		5
Fire load of busbar trunking units without tap points		5.33 kWh/m for LXA 0651
Fire load (per tap point)		2.9 kWh
Tap point		Every 0.5 m on both sides
Tap-off unit modifiable when live		max. 630 A
Connection technique		Bolted terminal block with shear nut
Communication capability		instabus KNX, AS-Interface
Conductor material		Al insulated
Casing material		Al varnished

Tab. 6/6: **Technical data of LXA 0651**

6.4 Low-Voltage Switchgear

The SIVACON S8 low-voltage switchboard (Tab. 6/7, Tab. 6/8) is a type-tested power switchgear and controlgear assembly (PSC), which is developed, assembled and tested in compliance with IEC 61439-1/-2 (VDE 0660-600-1/-2) specifications. Its design verification is to be accomplished by testing in compliance with IEC 61439-2 (VDE 0660-600-2). The proof must be made for the combination of busbar trunking connection to the transformer and low-voltage main distribution board. Testing under arcing fault conditions is to be made in accordance with IEC/TR 61641 (VDE 0660-500-2). As for protection against electric shock, the system complies with DIN EN 50274 (VDE 0660-514).

The deployed protective devices are matched to one another regarding their selectivity response, short-circuit and disconnection behaviour. Network calculations and selectivity evaluations are performed using the SIMARIS software tools.

SIVACON S8 configuration matrix		Circuit-breaker design	Universal mounting design	Fixed mounting design	In-line design 3NJ6	In-line design 3NJ4	Reactive power compensation
Mounting and design	Fixed mounting	×	×			×	×
	Withdrawable-unit design	×	× [1]	× [2]			
	Plug-in design		×		×		
Functions	Feed-in	×					
	Motor feeder	×	×				
	Cable feeder	×	×	×	×	×	
	Coupling (tie breaker)	×					
	Central compensation						×
Connection type	Front side			×	×	×	×
	Front and rear side	×	×				
Panel width	400 mm	×					
	600 mm	×	×			×	
	800 mm	×				×	×
	1,000 mm	×	×	×	×	×	
	1,200 mm		×	×	×		
	1,400 mm	×					
Internal separation	1	×		×	×	×	×
	2b	×	×	×		×	×
	3a	×					
	3b		×	×	×		
	4a		×	×			
	4b	×	×	×	×		
	4 Type 7 (BS)	×	×				
Horizontal busbar position	rear	×	×	×	×	×	×
	top	×	×	×	×		×
	without						×
Vertical busbar system (3- and 4-pole)	Rated current	up to 6,300 A	up to 1,600 A	up to 1,600 A	up to 2,100 A	up to 1,600 A	[5]
	Rated peak withstand current	up to 220 kA	up to 143 kA	up to 143 kA	up to 110 kA	-	
	Rated short-time withstand current, 1s	up to 100 kA	up to 65 kA [3]	up to 65 kA [3]	up to 50 kA [3]	[4]	

[1] Fixed mounting with compartment doors [2] Fixed mounting with front masking plates [3] Conditional rated short-circuit current up to 100 kA
[4] Conditional rated short-circuit current up to 50 kA [5] Rated current up tp 600 kvar non-choked; up to 500 kvar choked

Tab. 6/7: **SIVACON S8 configuration matrix**

The following safety levels can be selected regarding resistance to accidental arcs:

- Level 1 Safety of persons
- Level 2 Limitation to one panel
- Level 3 Limitation to one functional zone
- Level 4 Limitation to the place of origin

The sheet-steel-encapsulated low-voltage switchboard is delivered ready for connection for

- side-by-side installation
- double-front installation
- back-to-back installation
- across the corner installation
- and in multi-cabinet design.

Other essential features are:

- Variable busbar positions top or rear
- A combination of different mounting techniques within one panel is feasible
- Flexible adjustments of its inner compartmentalization to customer needs
- Easy change of door hinge thanks to the universal hinge
- High-efficiency ventilation system that provides maintenance advantages
- Cable/busbar connection from the top, bottom or rear
- Requirements-oriented compartmentalization of functional zones from Form 1 to Form 4 acc. to IEC 61439-2 (VDE 0660-600-2) (up to Form 4 Type 7 acc. to British Standard EN 61439-2)
- Cabinet height either 2,000 mm or 2,200 mm
- Base height choice either 100 mm or 200 mm
- Options such as earthquake-proof system, cabinet heating, insulated main busbar and a great variety of communication options (PROFIBUS DP, Profinet or Modbus)
- All feed-in systems, tie breakers (couplings) and feeders with amperages equal to or greater than 630 A must be equipped with a multi-function 7KM PAC 3200 measuring instrument, as described in section 6.6.
- The reactive power compensation panel can be connected to the main busbar, it comes in modular design with individual capacitor modules (MKK capacitors up to 200 kvar); a multi-function display can be used for viewing and setting U, I, f, cos φ, P, S, Q, harmonics). The cos φ can be set from 0.8 ind. to 0.8 cap.

Device rated currents	Circuit breaker 3WL/3VL	up to 6,300 A
	Cable feeders	up to 630 A
	Motor outgoing feeders	up to 250 kW
Main busbars	Rated currents	up to 7,000 A
	Rated peak withstand current (I_{pk})	up to 330 kA
	Rated short-time withstand current (I_{cw})	up to 150 kA, 1s

Tab. 6/8: **Technical data for the SIVACON S8 switchboard**

6.5 Distribution Boards

Either floor-mounted or wall-mounted (in flush- or surface-mounted design) distribution boards in accordance with IEC 61439-1/-3 (VDE 0660-600-1 and VDE 0660-504) may be used to build a distribution system in safety class 1 or safety class 2 with a current rating up to 630 A and a rated voltage of 690 V for the built-in devices, which can be safely accessed by non-instructed ordinary persons for operating purposes.

- The modular ALPHA DIN system allows to choose from three types (Tab. 6/9).
- Its sheet steel material is electroplated and powder-coated. The mounting kits are made of sendzimir-galvanized sheet steel and moulded-plastic covers.

ALPHA dimensions		Height in mm	Width in mm	Depth in mm	Delivery as	Degree of protection acc. to IEC 60529	Nominal current in A
ALPHA 630 DIN	Cabinet dimensions	1,950 incl. base (100 mm)	300	210	Pre-assembled empty cabinet	IP43 / IP55	630
			550	250			
			800		Flat Pack		
			1,050	320			
			1,300				
ALPHA 400 DIN	Surface-mounted distribution board (outer dimensions)	800	550	210	Pre-assembled empty cabinet	IP43 / IP55	400
		950					
		1,250	800				
		1,400					
	Flush-mounted distribution board (outer dimensions / wall-recess dimensions)	858/860	608/610	210/215	Flat Pack	IP31	
		1,008/1,010					
		1,308/1,310	858/860				
		1,458/1,460					
ALPHA 160 DIN	Surface-mounted distribution board (Outer dimensions)	500	300	140	Pre-assembled empty cabinet	IP43 / IP55	160
		650					
		800	550				
		1,100					
	Flush-mounted distribution board (Outer dimensions)	558	358	140		IP31	
		708					
		858	608				
		1,158					

Tab. 6/9: **Dimensions and technical data of ALPHA system distribution cabinets**

6.6 Power Management System

Thanks to its modern server-client structure, the PC-based *powermanager* software enables parallel access of Windows or web clients to the measuring instruments. The physical connection to the measuring instruments is made via Ethernet, either directly or through a gateway (protocol translator). In such a configuration, up to 200 instruments can be interfaced.

Standardized OPC interfaces are available for data exchange with other systems:
- OPC-DA (Data Access) server and client for access to online values (client using Option Expert)
- OPC-AE (Alarm and Events) Server and Client for access to alarms/events (using Option Expert)

Energy data is communicated through a direct instrument connection via Modbus TCP to the PC. Devices using Modbus RTU can be interfaced to the power management software through a gateway, for example, via the 7KM PAC 4200 measuring instruments. Here, measured parameters from multi-function measuring instruments (such as 7KM PAC 3200 etc.), circuit-breakers and any other Modbus-capable signal acquisition devices can be recorded. Besides current characteristics, other media can be acquired as well. Besides mere measured parameters, status bits can be acquired and device memories (like the event memory for device-generated messages) or data logs of measured parameters archived in the device (such as mean power values) can be read. Data should be polled in minimum intervals of 2 seconds from the instruments.

For simplified engineering, data, such as work and power values, is archived as default. Any other measured value, however, can also be included in or excluded from the archiving process. Archiving is performed in an integrated database usable without a separate licence or separate engineering tools.

Measured parameters are displayed in pre-defined technological groups. The following groupings are available:
- Overview showing the most important measured parameters
- Voltage values
- Current values
- Power factor
- THD
- Power / Mean power values
- Energy values
- Device data

Values can either be displayed in IEC or UL notation, together with the associated unit.

Load curves can either be displayed on the basis of archived measured parameters specifying any period of time, or based on values which were acquired online in the system. All of the available measured values can be selected for display. Presented load curves can be printed out and the associated values can be exported.

Besides the acquisition, display and archiving of measured parameters, parameter monitoring is also possible. The following functions are possible:
- Monitoring of pre-defined limit values (e.g. current limits)
- Monitoring of status bits and generation of appropriate messages
- Adoption of messages from the devices themselves tapping their event memory
- Display of anomalous system conditions
- Messages either have to be acknowledged or not
- Messages contain additional information, such as
  - Code
  - Priority
  - Time stamp
  - Description
  - Alarm text
  - Incoming/going
  - Value
  - Acknowledgement (yes/no)
  - Time when acknowledged

Consumption is allocated to user-defined cost centres taking the currently valid rates and tariffs into account. Arithmetical operations (additions, subtractions) can be performed, and constants and archived measured values can be integrated. Consumption values per cost centre are output in tabular form and as bar chart.

The "Expert" option allows to utilize the following assistants:
- Graphic design tools, such as
  - Graphic objects (circle, rhombus etc.)
  - Layout tools for aligning graphic objects
  - Formatting tools for fashioning graphic objects
  - These tools enable you to design your own graphic objects and integrate them into images.
- Graphic objects can be animated using scripts. They can thus be adapted to changing conditions at runtime. These scripts can be generated with the aid of so-called wizards, without the need to use script language.
- However, the script language can also be used directly in the built-in editor.
- User-defined programs for the integration of general functions can be created using a script syntax which is similar to the programming language C. Such programs can be executed on an event- or time-controlled basis. A special script editor and interpreter which also supports the creation of multi-thread applications is available.

Siemens provides telephone and e-mail support, web-based information, training courses and worldwide 24/7 support for its entire scope of software. Technical support can be accessed via the Internet which includes the following scope of services:

- E-mail contact to the Technical Support team
- Knowledge base including search function
- Product catalogues and manuals
- Frequently asked questions (FAQs) about the products
- Software updates
- Application examples
- Application tips

Optionally, a comprehensive maintenance plan incorporating the following features can be utilized:

- Always up-to-date product version(s)
- Continuously updated knowledge base
- Continuously updated electronic manuals

In addition, regular training courses for the power management software are offered in training centres.

6.7 Network Calculation, Proof of Selectivity

Planning an electrical power distribution system requires an arithmetic verification for the selection of protection equipment and cable cross sections, the selectivity evaluation for the supply network (ranging from the medium-voltage side transformer feeder to the final circuit) and an energy balance report for all of the connected consumer systems. Data on network topology (1-pole diagrams), cable lengths and load data are provided by the construction management. The outgoing feeder terminals of the main distribution boards are regarded as the interface for selectivity assessment.

This proof must include the following:

- Energy balance in form of a table
- 1-pole single-line diagram with device parameters (for power sources, protective devices, cable routes)
- 1-pole single-line diagram with load flow and voltage drop representation for each circuit
- 1-pole single-line diagram with representation of the minimum and maximum short-circuit loads
- I^2t characteristic curve diagrams of all circuit-breakers and the largest LV HRC outgoing fuses for each switchgear station and network
  (these characteristic curves must show the circuit-breaker parameters that have actually been set)
- A table listing all protective devices including setting ranges and set values (will also be used for subsequent commissioning documentation)

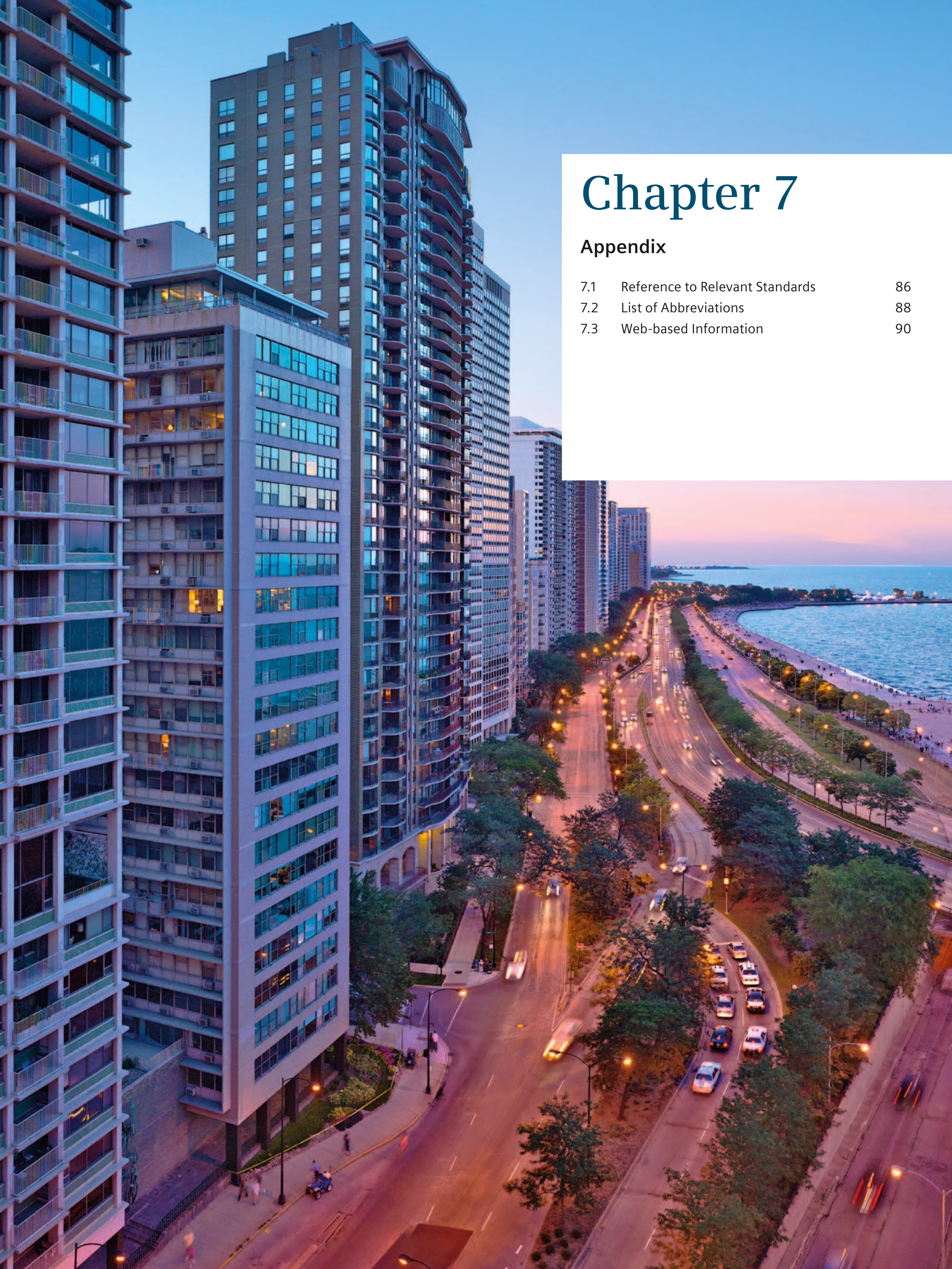
This proof must be produced using an approved software tool. From the diversity of our product portfolio, SIMARIS design dimensions a safe and reliable solution according to accepted rules of good installation practice and valid standards (VDE, IEC) that will meet the requirements specified for the requested electrical power distribution system. The selection of matching components for the supplying power sources, cables and busbars as well as switching and protective devices is made automatically through all circuit levels. In addition, the software calculates the short-circuit current, load flow, voltage drop and the energy balance. Plus, the personal, short-circuit and overload protection settings are performed automatically in line with the calculations made. SIMARIS design is compatible with the Windows XP (SP3), Windows Vista and Windows 7 operating systems and is available for download from the Internet. Online updates are possible.

6.8 Pressure Calculation for Internal Faults

In order to plan the switchgear building as specified by the customer, a pressure calculation, or respectively a 3-D simulation of local pressures to be expected, must be performed that takes account of possible internal arcing faults inside the switchgear station. A representation of pressure profiles over time after a fault has occurred, at ten specified measuring points within the room is required.
Default values:

- Room dimensions
- Position and size of the pressure relief openings
- Location and dimensions of the switchgear
- Switchgear type

A protocol of the calculations including graphic diagrams must be submitted which also includes possible suggestions for constructive measures to be taken if pressure distribution or pressure relief to the outside of the building should be necessary.



Chapter 7

Appendix

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7 Appendix

7.1 Reference to Relevant Standards

International	Germany	English Title	German Title
EN 15232	DIN EN 15232	Energy performance of buildings – Impact of Building Automation, Controls and Building Management	Energieeffizienz von Gebäuden – Einfluss von Gebäudeautomation und Gebäudemanagement
EN 50090	VDE 0829	Home and Building Electronic Systems (HBES)	Elektrische Systemtechnik für Heim und Gebäude (ESHG)
DIN EN 50274	VDE 0660-514	Low-voltage switchgear and controlgear assemblies – Protection against electric shock – Protection against unintentional direct contact with hazardous live parts	Niederspannungs-Schaltgerätekombinationen – Schutz gegen elektrischen Schlag – Schutz gegen unabsichtliches direktes Berühren gefährlicher aktiver Teile
IEC 60076-5	VDE 0532-76-5	Power transformers – Part 5: Ability to withstand short circuit	Leistungstransformatoren – Teil 5: Kurzschlussfestigkeit
IEC 60076-11	VDE 0532-76-11	Power transformers – Part 11: Dry-type transformers	Leistungstransformatoren – Teil 11: Trockentransformatoren
IEC 60364-1	DIN VDE 0100-100	Low-voltage electrical installations – Part 1: Fundamental principles, assessment of general characteristics, definitions	Errichten von Niederspannungsanlagen – Teil 1: Allgemeine Grundsätze, Bestimmungen allgemeiner Merkmale, Begriffe
IEC 60364-4-41	VDE 0100-410	Low-voltage electrical installations – Part 4-41: Protection for safety – Protection against electric shock	Elektrische Anlagen von Gebäuden – Teil 4-41: Schutzmassnahmen – Schutz gegen elektrischen Schlag
IEC 60364-4-43	VDE 0100-430	Low-voltage electrical installations – Part 4-43: Protection for safety – Protection against overcurrent	Errichten von Niederspannungsanlagen – Teil 4-43: Schutzmassnahmen – Schutz bei Überstrom
IEC 60364-5-51	DIN VDE 0100-510	Electrical installations of buildings – Part 5-51: Selection and erection of electrical equipment – Common rules	Errichten von Niederspannungsanlagen – Teil 5-51: Auswahl und Errichtung elektrischer Betriebsmittel – Allgemeine Bestimmungen
IEC 60364-5-52	VDE 0100-520	Low-voltage electrical installations – Part 5-52: Selection and erection of electrical equipment – Wiring systems	Errichten von Niederspannungsanlagen – Teil 5-52: Auswahl und Errichtung elektrischer Betriebsmittel – Kabel- und Leitungsanlagen
IEC 60364-5-54	VDE 0100-540	Low-voltage electrical installations – Part 5-54: Selection and erection of electrical equipment – Earthing arrangements and protective conductors	Errichten von Niederspannungsanlagen – Teil 5-54: Auswahl und Errichtung elektrischer Betriebsmittel – Erdungsanlagen, Schutzleiter und Schutzpotentialausgleichsleiter
IEC 60364-5-56	VDE 0100-560	Low-voltage electrical installations – Part 5-56: Selection and erection of electrical equipment – Safety services	Errichten von Niederspannungsanlagen – Teil 5-56: Auswahl und Errichtung elektrischer Betriebsmittel – Einrichtungen für Sicherheitszwecke
IEC 60364-7-710	DIN VDE 0100-710	Electrical installations of buildings – Part 7-710: Requirements for special installations or locations; Medical locations	Errichten von Niederspannungsanlagen – Anforderungen für Betriebsstaetten, Räume und Anlagen besonderer Art – Teil 710: Medizinisch genutzte Bereiche
IEC 60364-7-712	DIN VDE 0100-712	Low-voltage installations – Part 7-712: Requirements for special installations or locations – Solar photovoltaic (PV) power supply systems	Anforderungen für Betriebsstätten, Räume und Anlagen besonderer Art – Solar-Photovoltaik-(PV)-Stromversorgungssysteme
IEC 60364-7-718	DIN VDE 0100-718	Low-voltage electrical installations – Part 7-718: Requirements for special installations or locations – Communal facilities and workplaces	Errichten von Niederspannungsanlagen – Teil 7-718: Anforderungen für Betriebsstätten, Räume und Anlagen besonderer Art – Öffentliche Einrichtungen und Arbeitsstätten

International	Germany	English Title	German Title
IEC 60439-2	VDE 0660-502	Low-voltage switchgear and controlgear assemblies – Part 2: Particular requirements for busbar trunking systems (busways)	Niederspannungs-Schaltgerätekombinationen – Teil 2: Besondere Anforderungen an Schienenverteiler
IEC 60529	VDE 0470-1	Degrees of protection provided by enclosures (IP code)	Schutzarten durch Gehäuse (IP-Code)
IEC 60909-0	VDE 0102	Short-circuit currents in three phase AC systems	Kurzschlussströme in Drehstromnetzen
IEC 60947-2	VDE 0660-101	Low-voltage switchgear and controlgear – Part 2: Circuit-breakers	Niederspannungsschaltgeräte – Teil 2: Leistungsschalter
IEC 61439-1	VDE 0660-600-1	Low-voltage switchgear and controlgear assemblies – Part 1: General rules	Niederspannungs-Schaltgeräte-kombinationen – Teil 1: Allgemeine Festlegungen
IEC 61439-2	VDE 0660-600-2	Low-voltage switchgear and controlgear assemblies – Part 2: Power switchgear and controlgear assemblies	Niederspannungs-Schaltgeräte-kombinationen – Teil 2: Energie-Schaltgerätekombinationen
IEC 61439-3	VDE 0660-504	Low-voltage switchgear and controlgear assemblies – Part 3: Distribution boards intended to be operated by ordinary persons (DBO)	Niederspannungs-Schaltgeräte-kombinationen – Teil 3: Besondere Anforderungen an Niederspannungs-Schaltgerätekombinationen, zu deren Bedienung Laien Zutritt haben; Installationsverteiler
IEC/TR 61641	VDE 0660-500-2	Enclosed low-voltage switchgear and controlgear assemblies – Guide for testing under conditions of arcing due to internal fault	Niederspannungs-Schaltgerätekombinationen in geschlossener Bauform – Leitfaden für die Prüfung unter Störlichtbogenbedingungen durch einen inneren Fehler
IEC 61850	DIN EN 61850	Communication networks and systems in substations	Kommunikationsnetze und -systeme in Stationen
IEC 61936	VDE 0101	Power installations exceeding 1 kV a.c.	Starkstromanlagen mit Nennwechselspannungen über 1 kV
IEC 61936-1	VDE 0101-1	Power installations exceeding 1 kV a.c. – Part 1: Common rules	Starkstromanlagen mit Nennwechselspannungen über 1 kV – Teil 1: Allgemeine Bestimmungen
IEC 62606	VDE 0665-10	General requirements for Arc Fault Detection Devices (AFDD)	Allgemeine Anforderungen an Fehlerlichtbogen-Schutzeinrichtungen (AFDD)
IEC62271-1	VDE 0671-1	High-voltage switchgear and controlgear – Part 1: Common specifications	Hochspannungs-Schaltgeräte und -Schaltanlagen – Teil 1: Gemeinsame Bestimmungen
IEC62271-200	VDE 0671-200	High-voltage switchgear and controlgear – Part 200: AC metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV	Hochspannungs-Schaltgeräte und Schaltanlagen – Teil 200: Metallgekapselte Wechselstrom-Schaltanlagen für Bemessungsspannungen über 1 kV bis einschließlich 52 kV
ISO 9001	DIN ISO 9001	Quality management systems – Requirements	Qualitätsmanagementsysteme – Anforderungen
	DIN V VDE V 0108-100	Emergency escape lighting systems	Sicherheitsbeleuchtungsanlagen
	DIN EN 1838	Lighting applications – Emergency lighting	Angewandte Lichttechnik – Notbeleuchtung
	DIN 4102-9	Fire behaviour of building materials and elements; seals for cable penetrations; concepts, requirements and testing	Brandverhalten von Baustoffen und Bauteilen; Kabelabschottungen; Begriffe, Anforderungen und Prüfungen
	VDE 0298-4	Application of cables and cords in power installations – Part 4: Recommended current-carrying capacity for sheathed and nonsheathed cables for fixed wirings in and around buildings and for flexible cables and cords	Verwendung von Kabeln und isolierten Leitungen für Starkstromanlagen – Teil 4: Empfohlene Werte für die Strombelastbarkeit von Kabeln und Leitungen für feste Verlegung in und an Gebäuden und von flexiblen Leitungen
	VDI 3807 Blatt 4	Characteristic values of energy and water consumption of buildings – Characteristic values for electrical energy	Energie- und Wasserverbrauchskennwerte für Gebäude – Teilkennwerte elektrische Energie
	VDI 4602 Blatt 1	Energy management – Terms and definitions	Energiemanagement – Begriffe

7.2 List of Abbreviations

A

AC	Alternating Current
ACB	Air Circuit Breaker
AEP	Average Electricity Price
AFD	Arc Fault Detection
ANSI	American National Standards Institute
ASA	Advanced Signal Analysis
ATM	Asynchronous Transfer Mode

B

BA	Building Automation
BACS	Building Automation and Control Systems
BGV	Instruction or rule by Employer's Liability Insurance Association

C

CCTV	Closed Circuit Television
CFC	Continous function chart
CHP	Combined Heat and Power Unit
CPS	Central power system (emergency lights)

D

DaC	Data Centre
DC	Direct Current
DIN VDE	Deutsches Institut für Normung, Verband der Elektrotechnik, Elektronik und Informationstechnik (German Standardisation Institute, German Association for Electrical, Electronic and Information Technologies)
DSO	Distribution System Operator

E

EIB	European Installation Bus
EMC	Electromagnetic compatibility
EN	European standard
EnMS	Energy Management System
EPBD	Energy Performance of Buildings Directive
ETU	Electronic trip unit
EU	European Union

F

FFM	Fuse Failure Monitor

H

HOAI	Honorarordnung für Architekten und Ingenieure (German regulation of architects' and engineers' fees)
HV HRC	High Voltage – High Rupture Capacity

I

IAC	Internal Arc Classification
IEC	International Electrotechnical Commission
ICT	Information and Communications Technology
IP	Ingress protection
ISO	International Organization for Standardization
IT	Information Technology

K

KNX	International standard for building surveillance and management systems (in compliance with IEC 14543-3, EN 50090 and EN 13321-1, and GB/Z 20965)

L

LON	Local Operating Network
LPS	Low-power system emergency lights)
LV HRC	Low Voltage – High Rupture Capacity

M

MCB	Miniature Circuit Breaker
MCCB	Moulded-case circuit-breaker
MHRD	Model High-rise Directive (Muster-Hochhausrichtlinie, MHHR, Germany)

N

NPS	Normal Power Supply

O

OPC	Ole for Process Control

P

PE	1) Polyethylene; 2) Protective Earth conductor
PEN	Protective Earth Neutral
PM	artitions Metallic
PMS	Power management system
PSC	Power Switchgear and Controlgear
PUE	Power Usage Efficiency
PV	Photovoltaic

S

SF_6	Sulphur hexafluoride
SNTP	Simple Network Time Protocol
SPG	Standby Power Generating Set
SPS	Safety Power Supply

T

TAB	Technical supply conditions
TBM	Technical Building Management System
TCP/IP	Transmission Control Protocol / Internet Protocol
THD	Total Harmonic Distortion
TIP	Totally Integrated Power
TN	Transport Network (network configuration)
TN-C	french: Terre Neutre Combiné (network system)
TN-S	french: Terre Neutre Séparé (network system)
TTA	Type-tested Switchgear and Controlgear Assemby

U

UL	Underwriters Laboratories
USB	Universal Serial Bus
UPS	Uninterruptible Power Supply

V

VDI	Verein Deutscher Ingenieure e. V.

X

XLPE	Cross-linked polyethylene

7.3 Web-based Information

7.3.1 Totally Integrated Power

TIP homepage	
www.siemens.de/tip	www.siemens.com/tip
SIMARIS homepage	
www.siemens.de/simaris	www.siemens.com/simaris
Tender specifications (german/english)	
ausschreibungstexte.siemens.com/tiplv	ausschreibungstexte.siemens.com/tiplv

7.3.2 Products and Systems

The web links below, which you also find in the PDF files and the printed copies of this brochure can merely represent the status at the time of going to press. To find the most up-to-date links, you should always visit the site in the next line.	
www.siemens.de/tip/produkte	www.siemens.com/tip/products
Medium-voltage switchgear	
www.siemens.com/mittelspannungsschaltanlagen	www.siemens.com/medium-voltage-switchgear
Medium-voltage protection	
www.siemens.de/siprotec	www.siemens.com/siprotec
Distribution transformers	
www.siemens.de/verteilungstransformatoren	www.energy.siemens.com/hq/en/power-transmission/transformers/distribution-transformers
Low-voltge switchgear	
www.siemens.de/sivacon	www.siemens.com/sivacon
Busbar trunking systems	
www.siemens.de/sivacon	www.siemens.com/sivacon
Distribution boards for installation components	
www.siemens.de/alpha	www.siemens.com/alpha
Measuring instruments and power monitoring	
www.siemens.de/sentron	www.siemens.com/sentron
Building automation	
www.siemens.de/gamma	www.siemens.com/gamma
Photovoltaics and solar power	
www.siemens.de/lowvoltage/photovoltaik	www.siemens.com/lowvoltage/photovoltaic

7.3.3 Configurators

The following web links merely represent the status at the time of going to press. To find the most up-to-date links, you should always visit the site in the following line.	
www.siemens.de/softwaretools	www.siemens.com/softwaretools
Industry Mall with the Configurators page a. o. for busbar distribution systems CD-K, BD01, BD2 and circuit breakers 3VL, 3WL	
www.siemens.de/industrymall	www.siemens.com/industrymall
Planning and project design software ALPHA SELECT	
www.siemens.de/alpha-select	www.siemens.com/alpha-select
Planning software Profix NXPLUS C medium-voltage switchgear	
www.siemens.de/profixnxplusc	www.siemens.com/profixnxplusc
Planning software Profix 8DJH	
www.siemens.de/profix8djh	www.siemens.com/profix8djh

7.3.4 Topical Links

Total Building Solutions	
www.siemens.de/tbs	www.siemens.com/tbs
Totally Integrated Automation	
www.siemens.de/tia	www.siemens.com/tia
Fire protection	
www.siemens.de/brandschutz	www.siemens.com/firesafety
Security	
www.siemens.de/sicherheit	www.siemens.com/security
Energy efficiency	
www.siemens.de/energieeffizienz	www.siemens.com/energyefficiency
Power management	
www.siemens.de/powermanager	www.siemens.com/powermanager
Smart grid	
www.siemens.de/smartgrid	www.siemens.com/smartgrid

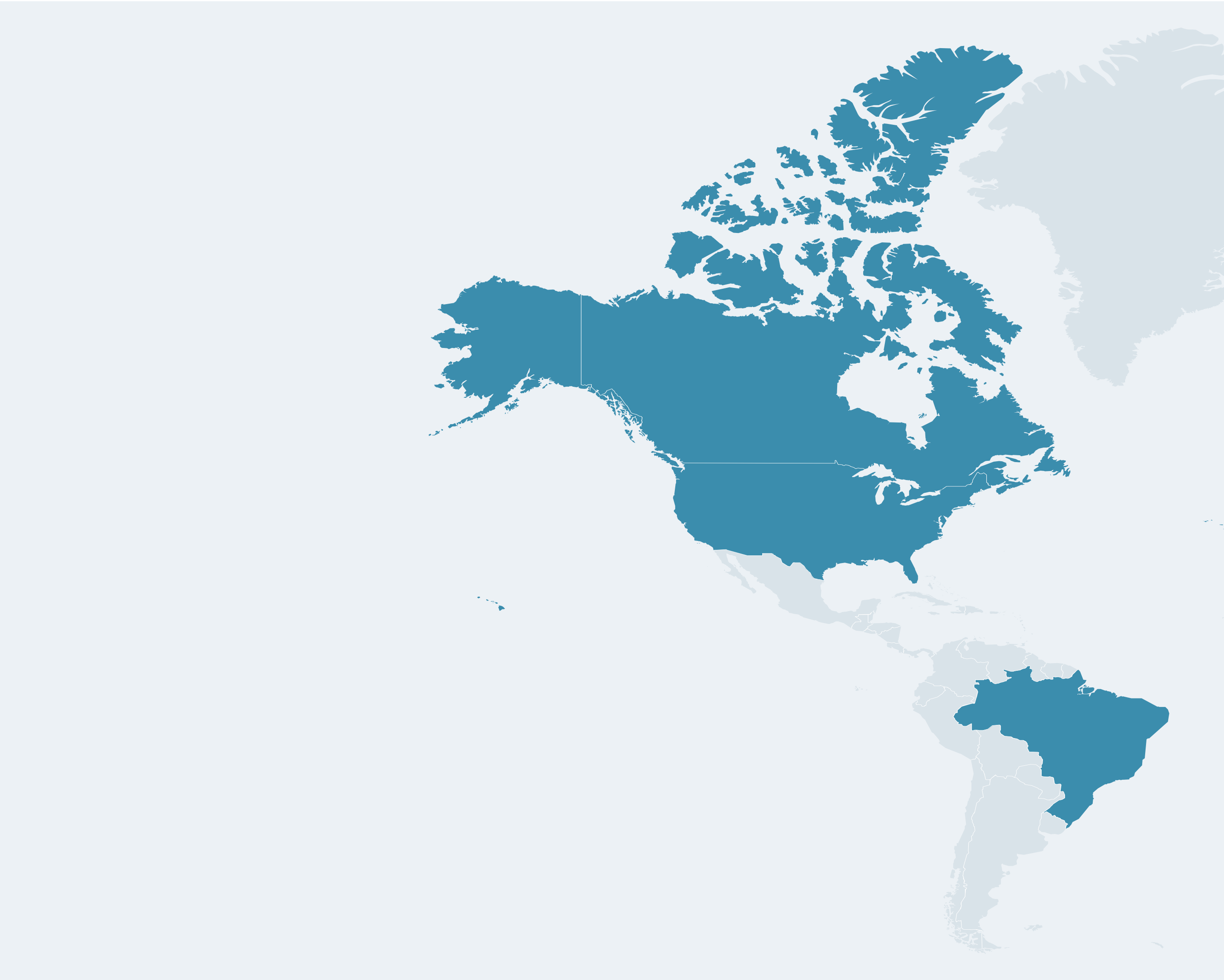

Abb. 7/1: **World-wide support for the planning of power distribution solutions by Siemens TIP**

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