



Switchgear (TPEM)

Operating Manual

EN

2019-08

Competence level CL Q

This document is a component of the operating manual in accordance with Machinery Directive 2006/42/EC.

This is a translation of the German original. All translations are based on the German original.



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The document contains information that is necessary for maintenance work and repair work on the product. When carrying out the work listed in the maintenance schedule, only original parts or parts and operating media approved by the manufacturer may be used.

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1 Information about these instructions

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1.1 Introduction

1.1.1 Target group

The document is aimed at authorized specialist personnel with the competence level Q. Only authorized specialist personnel may perform the described activities.



For further information on the requirements and qualifications of the authorized specialist personnel, see

- Operating Manual ⇒ General ⇒ Safety regulations
 - Personnel - Qualifications and Duties

1.1.2 Validity

This manual is valid for switchgears with the TPEM system.

The manual is drafted in German. In other languages the documentation is a translation of the original manual.

1.1.3 Storage

This document is a component of the product. Keep the document in the immediate vicinity of the product. The document must be accessible at any time.

1.1.4 Switchgear operating manual

The switchgear operating manual consists of this general description of a switchgear and the operating manual of the switch cabinets in accordance with the scope of supply.



For further information on the switch cabinets, see

- Operating Manual ⇒ Installation note ⇒ Control
 - Operating manual of the respective switch cabinet
- Operating Manual ⇒ Operation ⇒ Control
 - Operating manual of the respective switch cabinet
- Operating Manual ⇒ Maintenance information ⇒ Control
 - Operating manual of the respective switch cabinet

1.1.5 Other applicable documents

The end customer documentation supplied includes a large number of documents. This document is a component of the end customer documentation and describes the product.

The end customer documentation includes the following documents:

- Power plants layout - Planning notes and installation notes
- Safety regulations
- Operating media regulations
- Reports, specifications, certificates
- Technical drawings
- Wiring diagrams and circuit diagrams

- P&I diagram
- Component documentation
 - Installation notes
 - Operating Manual
 - Maintenance information
 - Work instructions
- Spare parts catalog

1.1.6 Handling

The notes and descriptions given in the document enable safe and efficient handling of the product. Observe and comply with all warnings, safety notes and instructions for handling in order to work safely on the product.

In the document, illustrations assist in basic understanding and may deviate from the actual design.

1.1.7 Operator obligations

The operator must observe and ensure the following points so that the product functions without impairment:

- Have all activities on the product performed in accordance with the applicable standards and specifications
- Determine the responsibilities for operation, servicing and troubleshooting
- Inform the authorized specialist personnel of possible dangers that may arise from handling the product
- Ensure that the authorized specialist personnel have read and understood the operating manual

1.1.8 Symbols used

Symbols are used in this document so that the authorized specialist personnel can quickly recognize issues and clearly categorize them. Warnings are marked with symbols.



For further information on the symbols used, see

- Operating Manual ⇒ General ⇒ Safety regulations
 - Signs and symbols

1.2 Legal notes

1.2.1 Limitations of liability

In this document, all information and notes have been compiled taking the relevant standards and specifications for the product and the state of the art technology into account.

The manufacturer assumes no liability for damage resulting from the following causes:

- Non-observance of the operating manual
- Non-intended use
- Deployment of unauthorized specialist personnel
- Unauthorized conversions
- Technical alterations
- Use of unapproved spare parts or attachments
- Use of unapproved operating media

The actual scope of supply may differ under the following conditions:

- Special versions
- Utilization of additional order options
- Due to the latest technical modifications

The regulations apply in the following order:

1. Obligations agreed in the delivery agreement
2. Terms and conditions of the manufacturer for the sales and delivery of new engines, new plants and original parts in the current version
3. Legal provisions valid when the contract was concluded

The right for the manufacturer to undertake technical alterations to improve the performance characteristics and further development is reserved.

1.2.2 Copyright

The document is protected by copyright and exclusively designed for in-house purposes.

Unless for in-house purposes, the following measures are not permitted:

- Transferring the document to third parties
- Reproducing any parts in any form or by any means
- Utilization or disclosure of the contents

Contraventions necessitate compensation. Rights to other claims remain reserved.

2 Safety

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2.1 Safety regulations

Observe the applicable safety regulations for operation, maintenance and servicing. Observe and comply with all instructions for handling and safety notes given in this document. Otherwise, substantial hazards may arise.

The product is used in the commercial sector. The operator is subject to the legal obligations for health and safety at work.

The operator must comply with the following for the product's and overall plant's area of application:

- Safety notes in this document
- Safety regulations
- Accident prevention regulations
- Environmental protection specifications
- General rules on health and safety at work
- Risk assessment of the operator
- Directives and ordinances on operational safety

Directives, ordinances and regulations are available from trade associations or specialist dealers.



For necessary information on the safety regulations, see

- Operating Manual ⇒ General ⇒ Safety regulations
 - Safety regulations

2.2 Intended use

This switchgear controls and regulates components of an energy generation plant with a genset of the switchgear manufacturer. The switchgear must be integrated into the energy generation plant in accordance with regional regulations. The basic scope of supply of a genset always includes the TPEM system with the switch cabinet TPEM Control Cabinet (TPEM CC). Auxiliary drive cabinet (ADC), generator power field cabinet (GPF) and master plant control cabinet (MPCC) are optional.

The intended use of the components is:

- TPEM system with switch cabinet TPEM CC: Genset control system and system control
- Switch cabinet ADC: Auxiliary drives control and supply
- Switch cabinet GPF: Control of the generator circuit breaker (GCB)
- Switch cabinet MPCC: Control and monitoring of central plant components in plants with several modules, optional visualization of the plant and load share in island mode

Depending on local conditions and regional regulations, additional functions or changed settings are required. The commissioning engineer and the operator are responsible for adjusting the switchgear.

The technical data of the switchgear and the technical data of the individual components define the technological limits of the switchgear and are binding. In the case of components, the information specified by the manufacturer of the switchgear shall always apply since only they know the exact function of individual components in the switchgear.

The switchgear is only operated when it is in a fully functional and maintained condition.

Intended use covers the following points:

- Observe all the safety notes
- Observe Health and Safety at Work Regulations
- Perform all maintenance work in accordance with the maintenance information
- Adhere to the statutory accident prevention regulations and other generally recognized safety and occupational health-related regulations
- Observe the manufacturer's specifications
- Appropriate warning signs must be attached to the access points on the switchgear

2.2.1 Misuse

Note

Misuse automatically forfeits the operating license and any warranty claims against the manufacturer.

Reasonably foreseeable misuse results, among other things, from the following points:

- Non-intended use
- Use beyond the technical data
- Non-compliance with the maintenance work in accordance with the maintenance information
- Incorrectly and/or wrongly performed maintenance tasks

-
- Failure to perform measurements, analyses and tests for the early identification of damage
 - Failure to replace consumer components in accordance with the maintenance information
 - Defective or removed safety devices and security devices
 - Failure to observe safety notes and warning notes, or these have been removed
 - Defective or disconnected control system safety functions
 - Damaged insulation of live components
 - Failure to comply with the limit values according to the operating media regulations

2.3 Emissions

2.3.1 Electromagnetic compatibility (EMC)

The switchgear is built in accordance with EMC requirements:

- no negative influences on the switchgear through external interference (also not cable based)
- no impermissible interference emission

2.3.2 Persons with medical devices

Electromagnetic fields around conductors carrying current may interfere with the function of medical implants such as pacemakers, defibrillators, etc. This can lead to severe injuries or death of the affected persons.

Prohibitory signs with "No access for persons with pacemakers or implanted defibrillators" must be attached to all access points on the protective housing. Persons with medical implants or assistive devices with a function that can be interfered with by electromagnetic fields must not access the switchgear.

If restricted work areas are still to be accessed by persons with sensitive medical implants, then all necessary measurements must be made to determine the electromagnetic load in these areas. Only medical clearance for the defined work in the defined work areas shall allow affected persons to perform any work inside the protective housing. It must be ensured that the work and work areas always comply with the defined scope.

2.3.3 Noise

In the genset room, noise levels will exceed 85 dB(A) during operation. Over time, this will cause persons present in the genset room to suffer hearing damage if protective measures are not taken. Suitable ear protection must therefore be worn during operation in the genset room.



3 Technical data and rating plates

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3.1 General technical data



For information on the technical data, see

- Operating Manual ⇒ Installation note ⇒ Control
 - Switch cabinets

3.2 Rating plates

Rating plates identify components of the plant. Important components have a serial number.



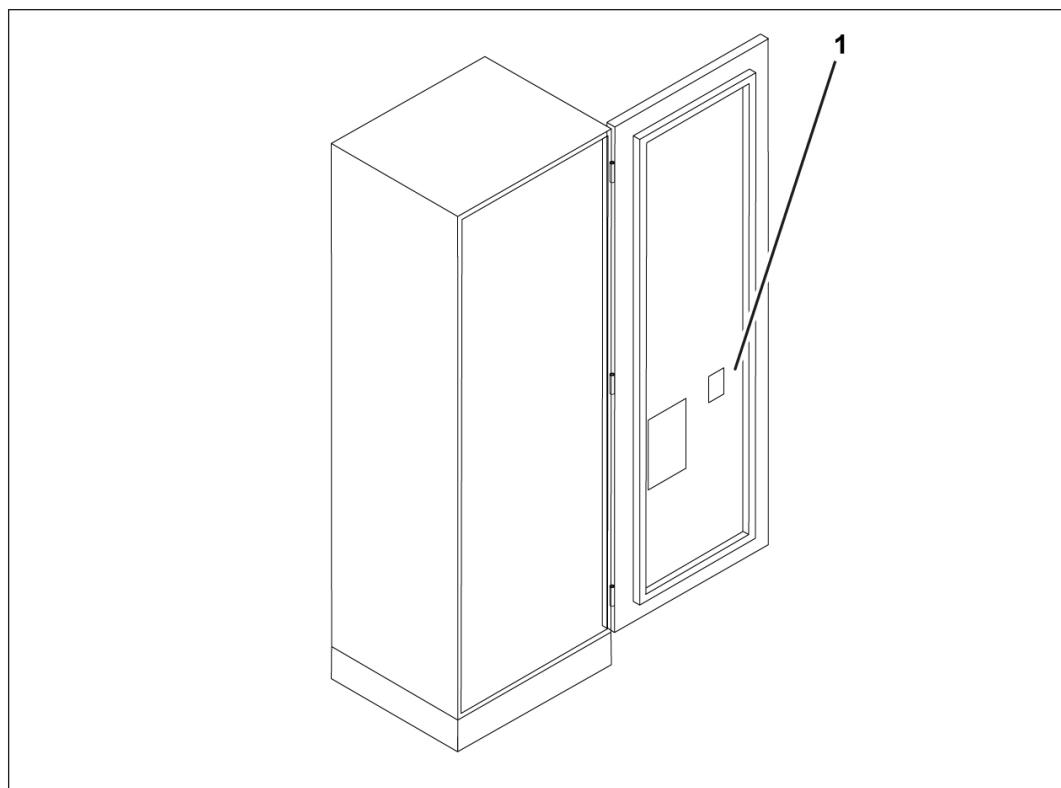
For important serial numbers, see

- Operating Manual ⇒ Operation ⇒ Control ⇒ TPEM Operating Manual
 - Section "Operation" ⇒ Function group "System" ⇒ Overview

3.2.1 Switch cabinet rating plate

The rating plate is fixed to the inside of the door on the switch cabinet.

The serial number clearly identifies the switch cabinet. Always specify the serial number.



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1 Rating plate with serial number (example on TPEM Control Cabinet)



4 Structure and function

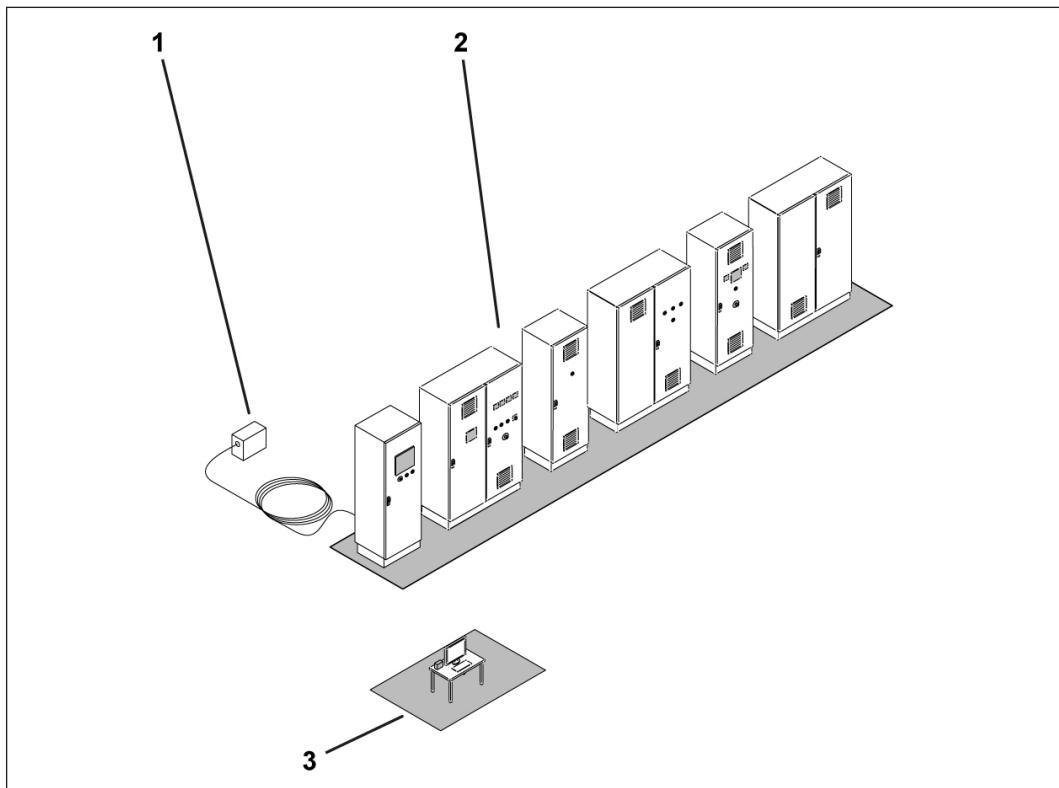
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4.1 Definition of switchgear

A switchgear is part of a generating plant for electrical current. A generating plant is a combined heat and power unit (CHP), for example. The switchgear primarily comprises switch cabinets for controlling and regulating power generation and power distribution.

This chapter describes the function of a typical switchgear for a genset with a gas engine and generator as well as the most important interfaces. The proportion of the switchgear on site in the entire switchgear depends on project planning.



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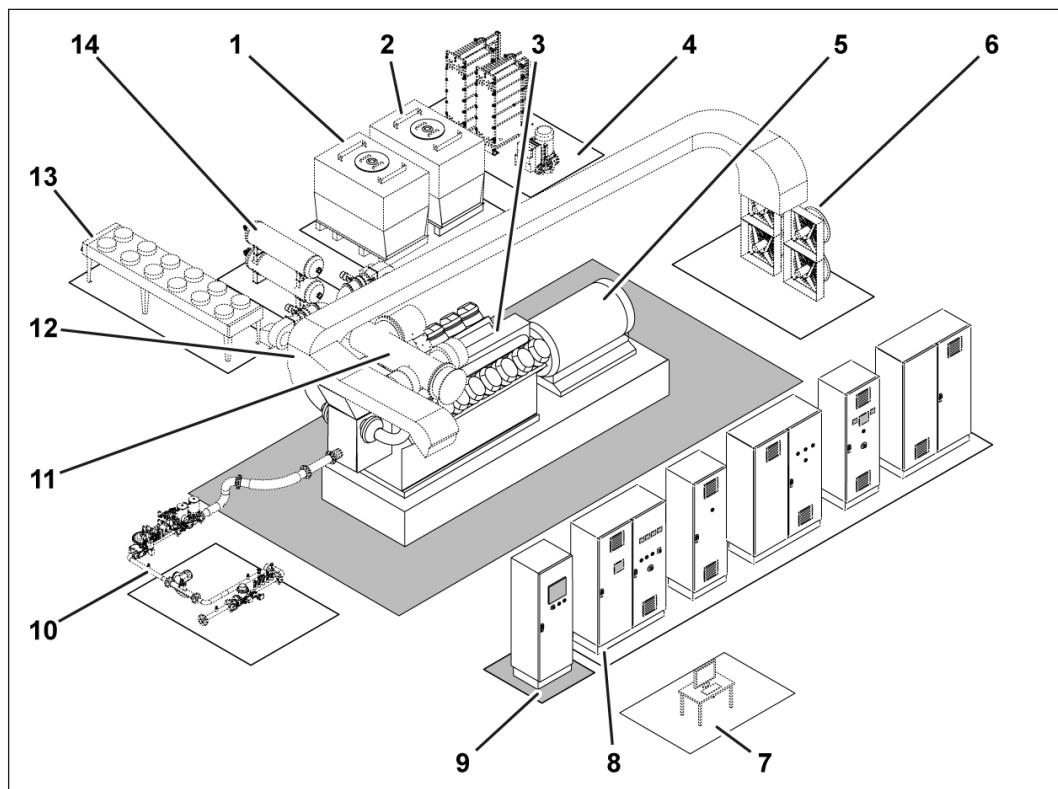
- 1 TPEM Connection Box (TPEM CB) as an interface between switchgear and gas engine
- 2 Switch cabinets with interfaces to the generator and electricity network
- 3 Control room

4.2 Switchgears for combined heat and power units

The switchgear described in this operating manual is designed for use in combined heat and power units.

4.2.1 Overview of combined heat and power unit

A combined heat and power unit generates electrical current and heat. The following figure provides a simplified overview of a combined heat and power unit with typical components.



63935-001

- 1 Fresh oil tank
- 2 Waste oil tank
- 3 Gas engine
- 4 Heat exchangers, pumps, fittings
- 5 Generator
- 6 Supply air fan
- 7 Control room
- 8 Switch cabinets
- 9 Switch cabinet TPEM Control Cabinet (TPEM CC)
- 10 Gas control line
- 11 Exhaust system
- 12 Combustion air duct
- 13 Recooler
- 14 Compressed air containers (only with compressed air starter)

Fresh oil tanks and waste oil tanks

A fresh oil tank holds fresh lube oil ready for replenishing or for the lube oil change. A waste oil tank receives the drained waste oil.

Gas engine

The gas engine converts the chemical energy contained in the combustion gas into mechanical and heat energy through combustion.

Heat exchangers, pumps, fittings

Heat exchangers cool or heat fluids such as lube oil. Pumps transport fresh oil or waste oil and keep coolants circulating in cooling circuits. Various fittings open, block or regulate the flow.

For heat recovery, heat exchangers extract heat from the heated coolant and feed it into the distribution network of the operator.

Generator

The gas engine drives the generator. The generator converts the kinetic energy into electrical energy.

Supply air fan

Fans and ventilation ducts dissipate surface heat, supply combustion air and ventilate the room.

Control room

Depending on the design of the plant there may be a separate control room.

Switch cabinets and user interface

The user interface for the genset is located on the switch cabinet TPEM Control Cabinet (TPEM CC). Communication with the genset is established via the operating software TPEM. However, operation is also possible from an optional control station via intranet or internet.

Further switch cabinets, for example for auxiliary drives, may be present depending on project planning. The auxiliary drives can also be operated with accessories from an optional control station.

Gas control line

The gas control line supplies the gas engine with combustion gas. The gas control line regulates the gas pressure using its own controller.

Exhaust system

The exhaust system with exhaust silencer and catalytic converter for cleaning the exhaust routes the genset's exhaust gases into the open air. Depending on project planning, an exhaust heat exchanger for heat recovery may be installed.

Combustion air duct

The combustion air duct guides the combustion air directly to the air filters.

Recooler

The coolant is cooled down in the cooling systems (for example in the engine cooling circuit) by coolers with ventilators. The TPEM system monitors the temperatures in the cooling systems and alters the speed of the ventilators accordingly.

Compressed air containers (only with compressed air starter)

In bigger engines a starter operated with compressed air drives the engine when the engine is started. Compressed air containers that load up a compressor or an operator's compressed air line hold compressed air ready for some start processes.

4.2.2 Energy conversion in the module

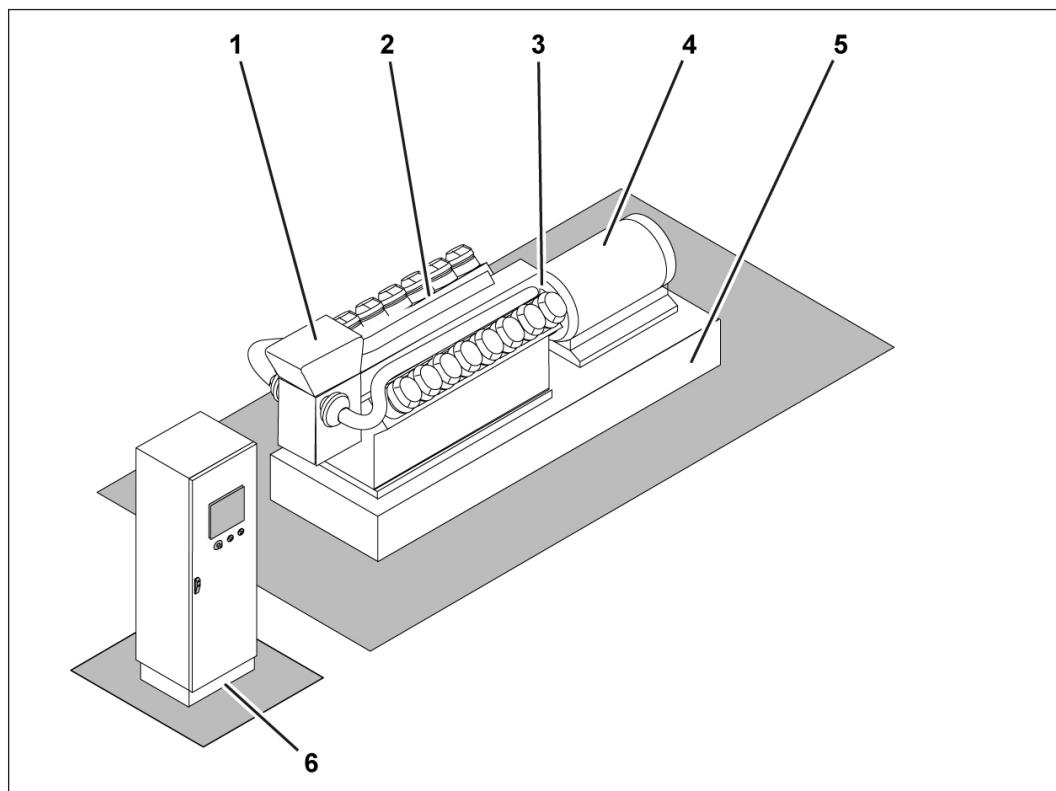
The module is the core of a combined heat and power unit. A module consists of:

- Genset: Gas engine, generator, coupling and base frame
- Switch cabinet TPEM Control Cabinet (TPEM CC)

The gas engine combusts an ignitable combustion gas / combustion air mixture under a high level of heat generation in its combustion chambers. During combustion the mixture expands and moves the pistons. A crankshaft drive transfers the movement and turns the generator via a coupling. The generator converts the turning motion into electricity.

The drive of the generator for the power input places special requirements on the gas engine:

- Continuous operation with rated power
- Low speed fluctuation during load change
- Quick startup if required



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- 1 Turbocharger assembly and air filter group
- 2 Gas engine
- 3 Coupling (concealed)
- 4 Generator

-
- 5 Base frame with elastic mounting
 6 Switch cabinet TPEM Control Cabinet (TPEM CC)

Depending on its use, special requirements apply for the genset's control accuracy and the switching on capability and switching off capability (load switching capability). In general, different load steps apply when generating power for combustion engines. The load steps describe the permissible operating performance of the combustion engine under load. The project planning defines a load step for the module.



For further information on the load steps, see

- Operating Manual ⇒ General ⇒ Installation directive
 - Load switching capability

4.2.3 Operating modes of a combined heat and power unit

A combined heat and power unit is designed for a specific operating mode:

- Electricity-led operation
- Heat-led operation
- Mixed use
- Temporary use of combustion gas

Electricity-led operation

Power generation with or without the use of heat energy being generated has priority. The lead factor here is the amount of electricity agreed with the mains operator or the electrical power demanded in island mode.

Heat-led operation

Heat generation with use of the electrical energy being generated has priority. The lead factor here is the current demand for heat. The switchgear must ensure that a sufficient amount of heat is generated during power generation or that external heat sources are requested.

Mixed use

Mixed use activates, for example, the combined heat and power unit on a time-dependent basis and offsets peak loads.

Temporary use of combustion gas

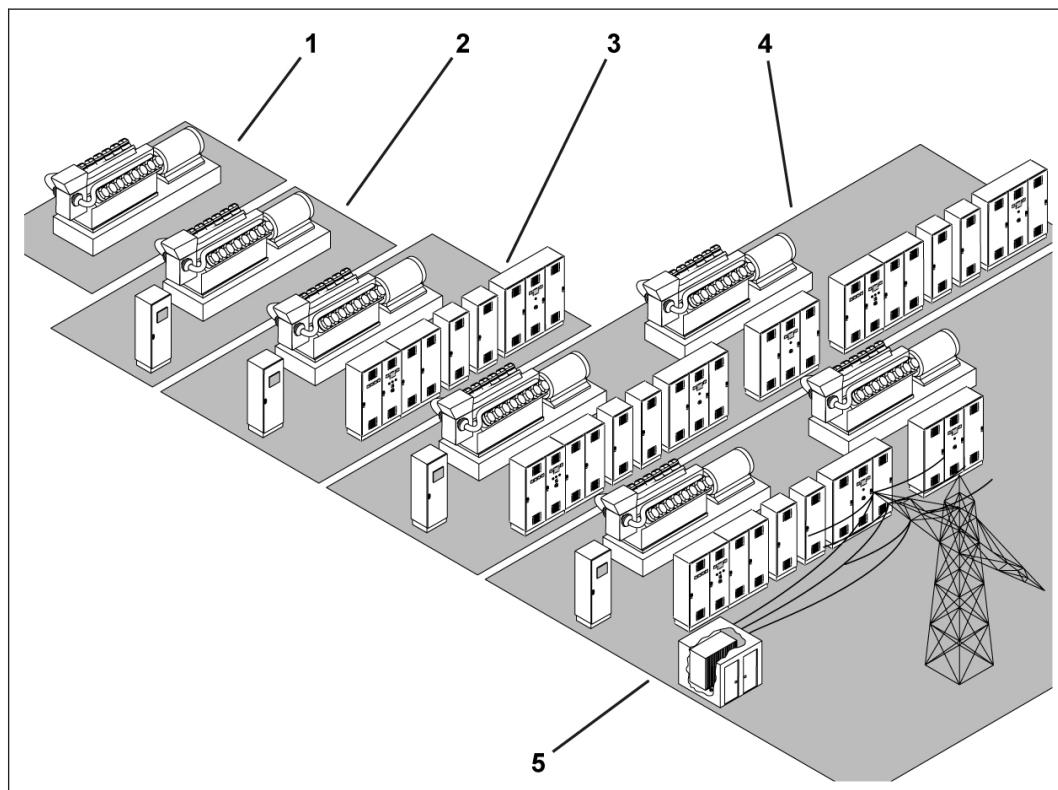
During temporary use of combustion gas, combustion gas is not constantly available. Alternatively there are also applications with two different combustion gas types available.

4.3 Structure of switchgears

4.3.1 Hierarchical structure

A complete switchgear consists of several parts that are hierarchically divided into:

- Genset with the interfaces for the connection to the switchgear
- Module: Genset, the auxiliaries required for its operation and the switch cabinet TPEM Control Cabinet (TPEM CC)
- Plant: Module and the electrical components (switch cabinets etc.) for operation and connection to a distribution network
- Multi-module plant: Several modules with the master plant control cabinet (MPCC) for controlling and communicating with the individual plants
- Generating plant: Plant or multi-module plant and other components of the operator's periphery, for example a transformer

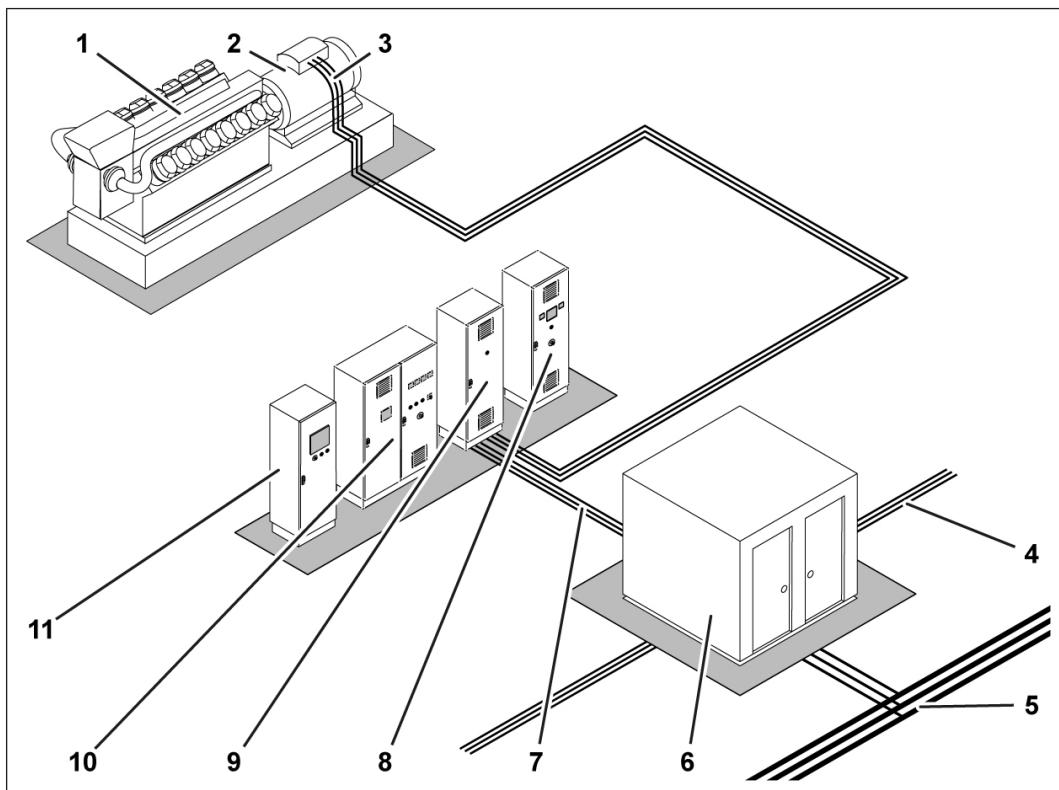


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- 1 Genset
- 2 Module
- 3 Plant
- 4 Multi-module plant
- 5 Generating plant

4.3.2 Components

The example plant depicted consists of several modules that are connected to a multi-module plant via switch cabinets and busbars.



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- 1 Gas engine
- 2 Generator
- 3 Power cables from the generator to the generator power field cabinet (GPF)
- 4 Busbar for a multi-module plant
- 5 Power supply to the distribution network with mains connection point (MCP)
- 6 Connection plant with mains circuit breaker (MCB), transformer etc.
- 7 Power cables from the generator circuit breaker (GCB) to the connection plant
- 8 Master plant control cabinet (MPCC)
- 9 Generator power field cabinet (GPF) with generator circuit breaker (GCB)
- 10 Auxiliary drive cabinet (ADC)
- 11 Switch cabinet TPEM Control Cabinet (TPEM CC)

The switchgear required for the operation of the module or a multi-module plant and the introduction of the generated electricity into the electricity network can be easily divided into:

- TPEM system with hardware, software and user interface for controlling and regulating the module
- Auxiliary components, such as pumps and fans with the auxiliary drive cabinet (ADC)
- Interfaces for the communication of the TPEM system in a multi-module plant or integration of a superior control in the master plant control cabinet (MPCC)

- Interfaces for switching on or switching off the electrical energy generated by the generator through the generator circuit breaker (GCB) in the generator power field cabinet (GPF)
- Interfaces for the power input to an internal distribution network, an external operator network or public power supply network or to a plant network in a multi-module plant

The design depends on the type of electricity network and the conditions on site.

Mains connection point (MCP) and mains operator

The mains operator is responsible, within the understanding of this operating manual, for the operation and maintenance of the distribution network which is fed electricity by the generating plant.

The mains connection point (MCP) is the interface at which the electricity network of the generating plant is coupled to the distribution network of a mains operator. Structuring and designing as well as operation is carried out in accordance with the regional guidelines and regulations as well as additional specifications from the mains operator. The guidelines and specifications also describe the location and design of the mains connection point (MCP).

Connection plant

The connection plant contains all the components that are required for connecting the generating unit to the distribution network. Structuring and designing as well as operation is carried out in accordance with the regional guidelines and regulations as well as additional specifications from the mains operator.

4.4 Total Plant and Energy Management (TPEM system)

The TPEM system controls, regulates and monitors the essential functions of the individual plant components (e.g. genset, cooling und heating circuits).

Some components of the TPEM system are installed in the switchgear. There are interfaces for non-installed components.



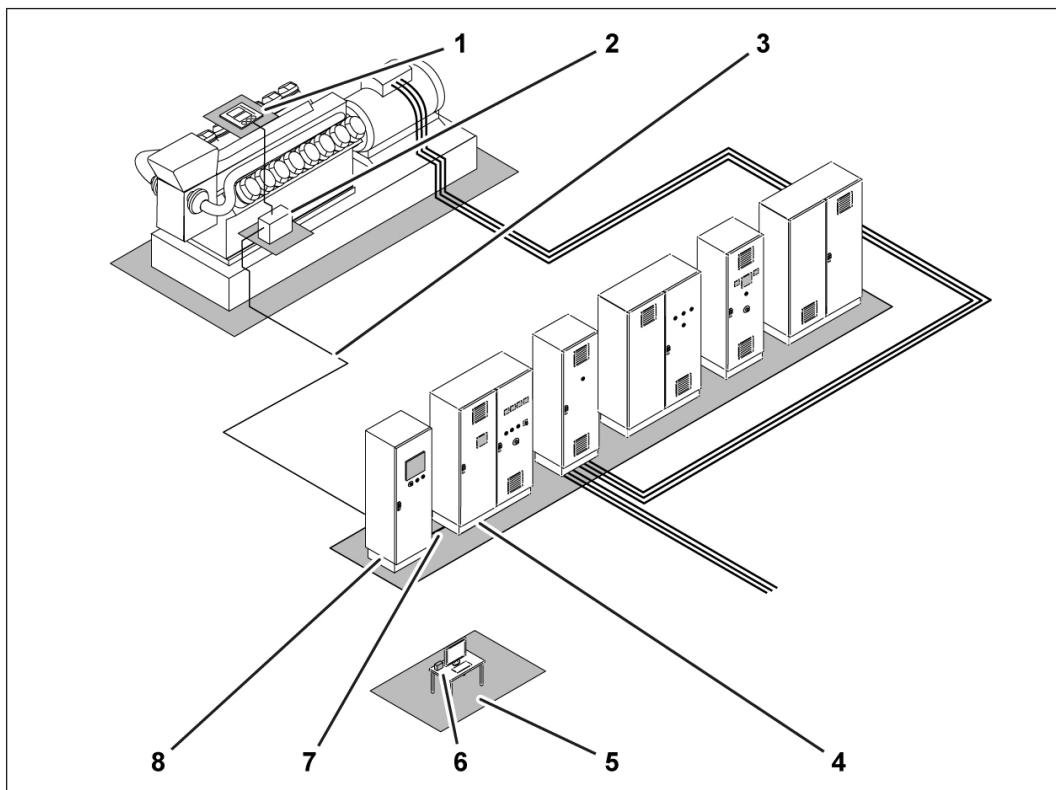
For further information on the TPEM system, see

- Operating Manual ⇒ Operation ⇒ Control
 - TPEM operating manual

4.4.1 Components

The TPEM system (Total Plant and Energy Management System) consists of the following components:

- TPEM Control Cabinet (TPEM CC): central control cabinet for the exchange of signals between the engine control units and the control of the generator and auxiliary drive
- TPEM Rendezvous Server (TPEM RS): enables access to the TPEM system with a TPEM Remote Client
- TPEM Remote Client (TPEM RC): software for visualization on a computer
 - For service: to perform remote diagnostics and remote maintenance of the plant
 - For the operator: remote operation and monitoring of the plant
- TPEM Control Unit (TPEM CU): assumes all tasks required for controlling and regulating the genset
- TPEM Connection Box (TPEM CB): interface between the TPEM Control Unit, the TPEM Control Cabinet and the gas valves
- TPEM I/O Controller (TPEM IO): interface between the TPEM system and the auxiliary drives



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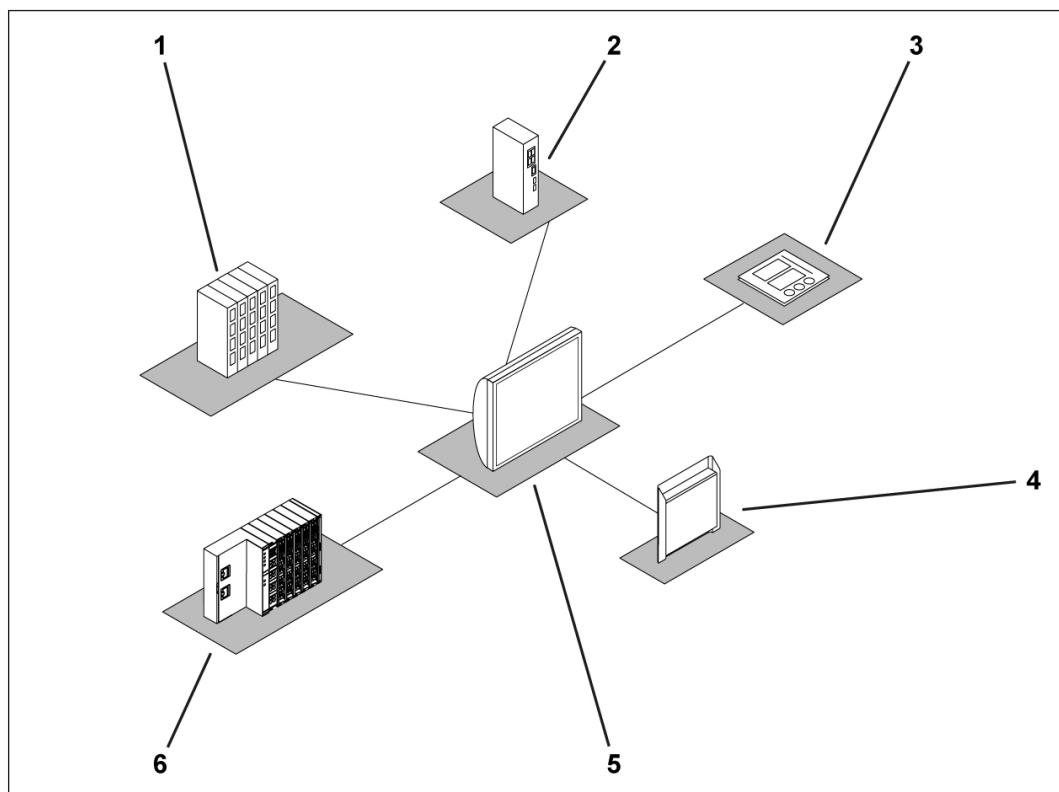
- 1 TPEM Control Unit (TPEM CU)
- 2 TPEM Connection Box (TPEM CB)
- 3 Connection cable TPEM CC and TPEM CU
- 4 ADC with TPEM IO
- 5 External computer with TPEM RC
- 6 Online connection to TPEM RS
- 7 Connection cable TPEM CC with ADC and more
- 8 TPEM CC with TPEM TP, TPEM RPG, TPEM SC, TPEM MFR

4.4.2 Control concept

The module is controlled and regulated via networked components in a real-time ethernet network.

The hierarchical structure corresponds to the master and slave principle with the TPEM TP as the master. The Ethernet for Control Automation Technology (EtherCAT) is used as a protocol.

Individual slaves such as the TPEM IO are connected directly to the master. In other slaves, such as the TPEM CU with CAN bus, a module for communication is interconnected.



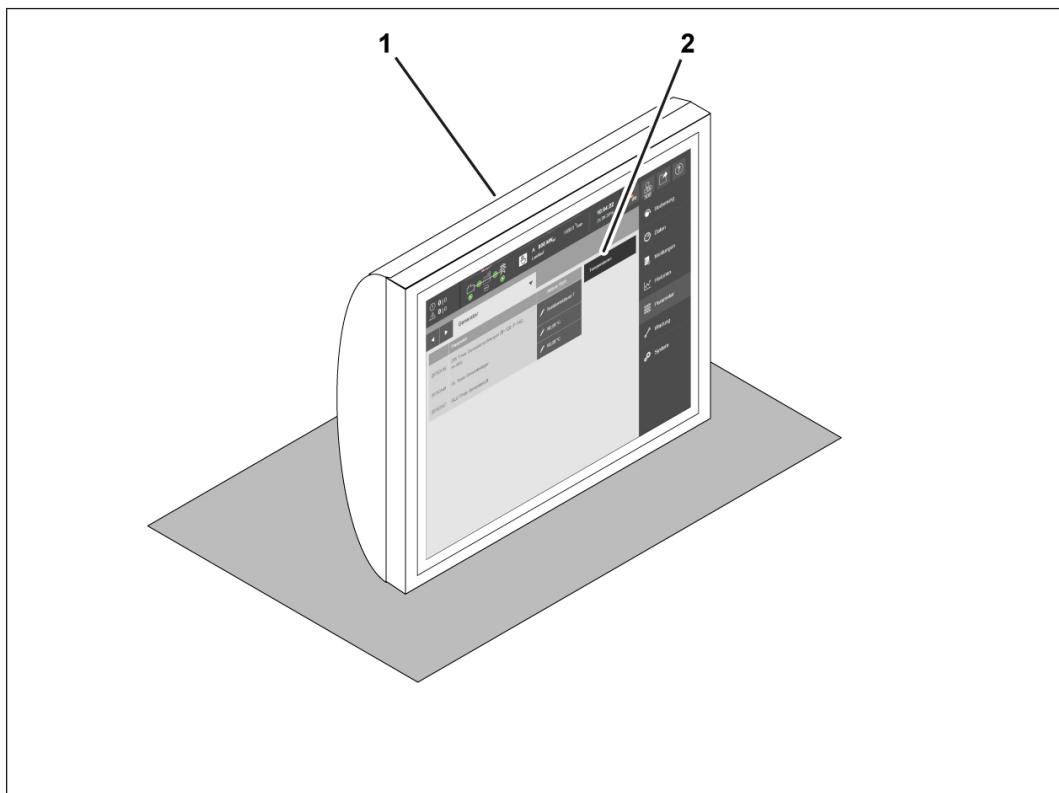
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- 1 Slave TPEM SC via EtherCAT
- 2 Slave TPEM RPG via EtherCAT
- 3 Slave TPEM CU via CAN-Bus
- 4 Slave TPEM MFR via CAN-Bus
- 5 Master TPEM TP
- 6 Slave TPEM IO via EtherCAT

4.4.3 TPEM Touch Panel (TPEM TP)

The TPEM TP with integrated operating computer is located in the TPEM CC. Many components communicate with each other and the operating personnel or service personnel via the operating computer.

When TPEM TP is started up, the TPEM user interface appears as an interface for operating the genset and parameterizing the components.



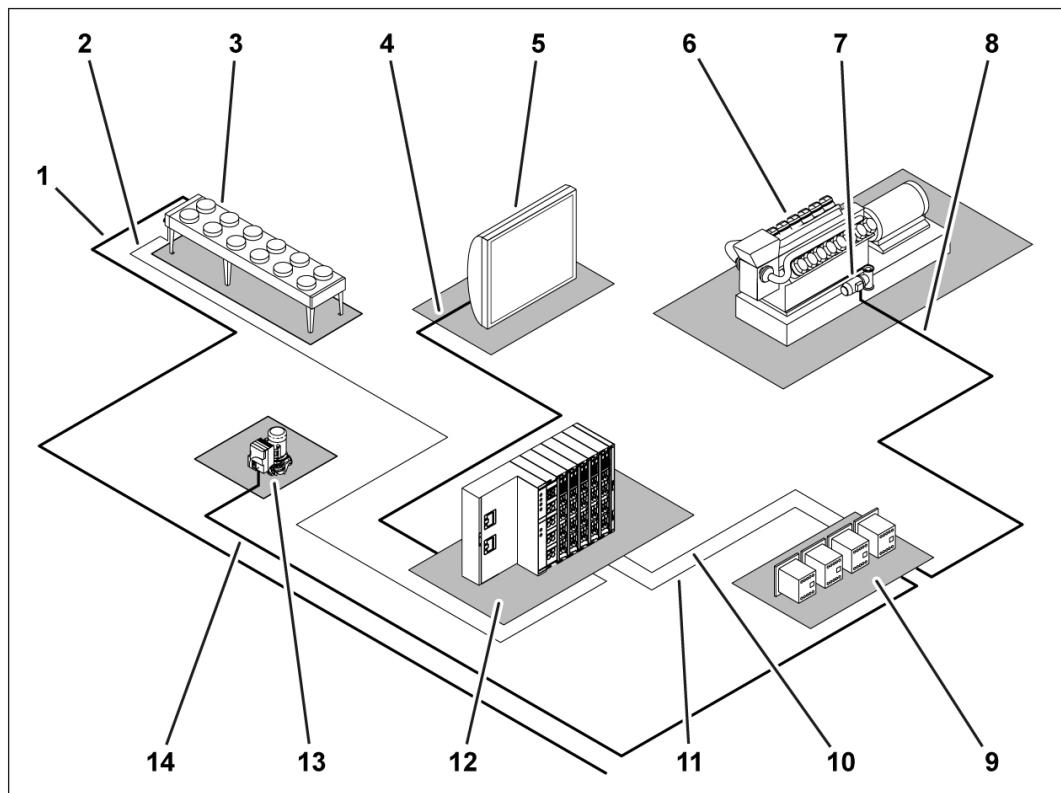
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- 1 TPEM TP
- 2 TPEM user interface

4.4.4 TPEM I/O Controller (TPEM IO)

TPEM I/O is the interface between the TPEM system and the auxiliary drives. Auxiliary drives, for example, are drive motors for pumps and fans but also the sensors for control and regulation. It is installed in the ADC.

The TPEM IO does not produce the power supply for the auxiliary drives, but rather provides inputs and outputs for activating and acquiring measuring data of the auxiliary drives.



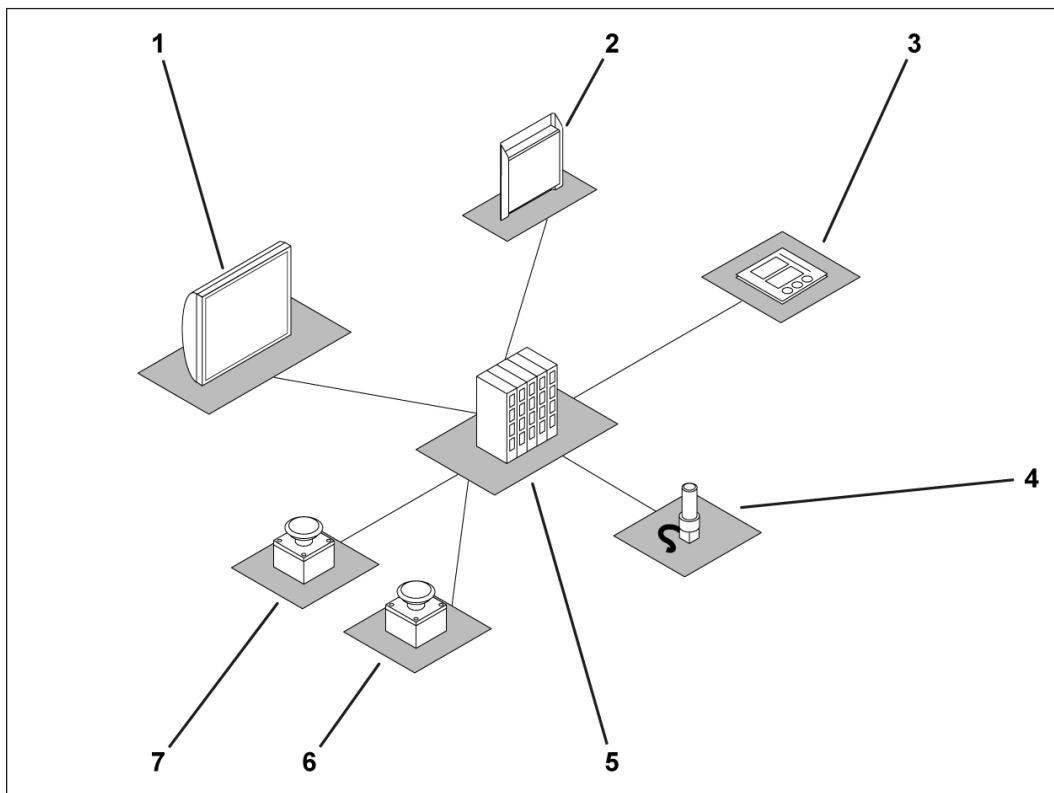
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- 1 Fan drive power connection
- 2 Control line to fan drive (as an example)
- 3 Recooler with electronically commutated fan drive
- 4 Bus line
- 5 TPEM TP
- 6 Gas engine
- 7 Prelubrication pump
- 8 Prelubrication pump power line
- 9 Terminal strip with circuit breakers
- 10 Prelubrication pump control line (as an example)
- 11 Cooling water pump control line (as an example)
- 12 TPEM IO
- 13 Cooling water pump (example)
- 14 Cooling water pump power line

4.4.5 TPEM Safety Chain (TPEM SC)

As a safety chain, the TPEM SC comprises all components that are required for recording, evaluating and switching off safety functions. Messages are not a component of the safety chain.

The central safety relay is an intelligent bus terminal system. This consists of a logic unit, digital inputs, digital outputs and a bus end terminal.



64060-001

- 1 TPEM TP
- 2 TPEM MFR
- 3 TPEM CU
- 4 Other safety-related sensors such as auxiliary drives
- 5 Safety relay
- 6 Emergency stop switch on the TPEM CC
- 7 Other emergency stop switches

4.4.6 TPEM Control Unit (TPEM CU)

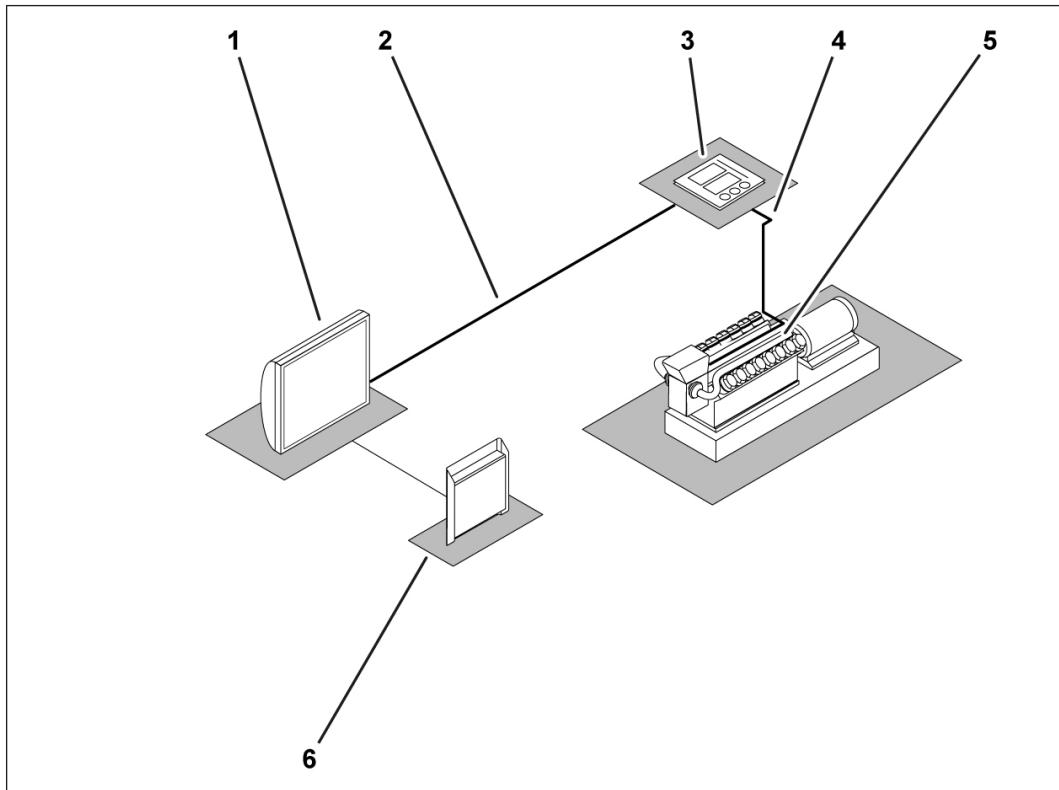
The TPEM CU comprises the components for controlling and regulating the gas engine. In order to perform the control and regulation as quickly as possible, it also comprises controllers.

The following components are the most important components of the TPEM CU:

- Engine sensors that record the current operating state of the genset
- Engine actuators that operate control units for controlling and regulating of the gas engine, e.g. the throttle valve
- Engine control units for regulation and control
- Wiring harness systems that connect engine actuators and engine sensors with the engine control units

The engine control units receive the signals of the engine sensors, evaluate them in processors and send corresponding signals to the engine actuators.

The TPEM TP is the interface for parameterization and for data exchange between TPEM CU and TPEM MFR.



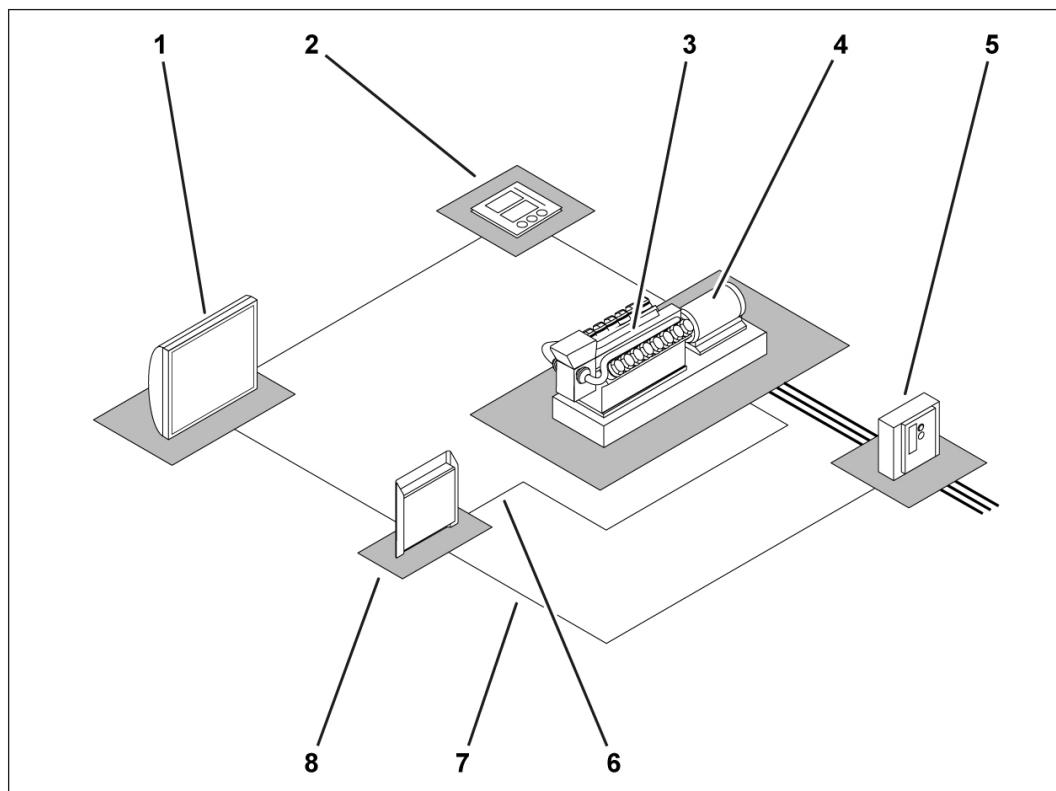
64030-001

- 1 TPEM TP
- 2 Bus line
- 3 Engine control unit (mounted on the gas engine)
- 4 Wiring harness
- 5 Actuators and sensors of the gas engine
- 6 TPEM MFR

4.4.7 TPEM Multi Function Relay (TPEM MFR)

The TPEM MFR records the current operating data of the electricity generated by the generator. The TPEM MFR determines the control deviation and generates the necessary control signal for the correction of the engine control units (TPEM CU). The TPEM MFR controls the synchronization of the generator in mains parallel mode.

The TPEM TP is the interface for parameterization and visualizes operating states.



64064-001

- 1 TPEM TP
- 2 Engine control unit (mounted on the gas engine)
- 3 Gas engine
- 4 Generator with generator controller
- 5 Generator circuit breaker (GCB)
- 6 Signal line TPEM MFR and generator controller
- 7 Signal line TPEM MFR and GCB
- 8 TPEM MFR

4.4.8 Online access (optional)

Online access to the TPEM system via another computer can be established in various ways:

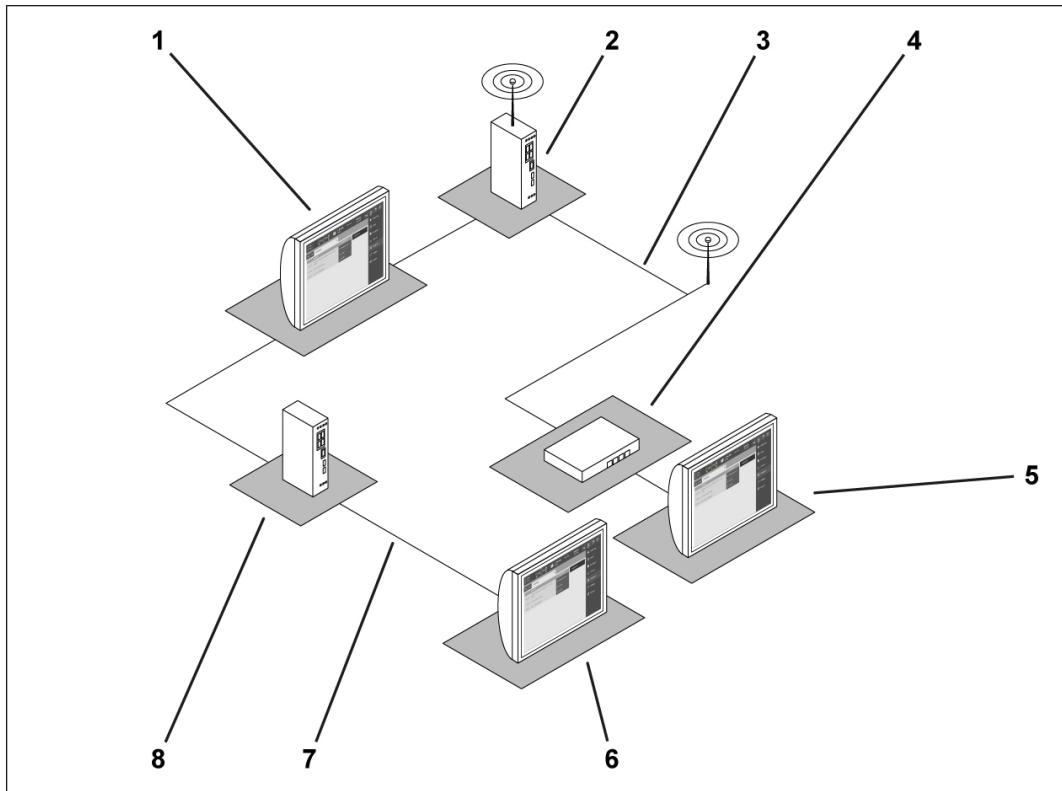
- Internally via the operator's network (Ethernet)
- Externally via an internet connection

Internal access, for example from a control room to the TPEM system, is established via the TPEM Remote Plant Gateway in the switch cabinet TPEM CC.

External access is possible via mobile communications or a wired connection. Data is transferred between the TPEM Remote Plant Gateway and the TPEM Rendezvous Server. The TPEM Rendezvous Server is located at the site of the switchgear manufacturer.

The software TPEM RC is required in order to visualize the TPEM user interface on a computer.

For internet access, a TPEM USB token with the appropriate authorization is required. For an ethernet connection, the user interface is also visible without the TPEM USB token (watch mode). However a TPEM USB token is required for accessing the TPEM system.

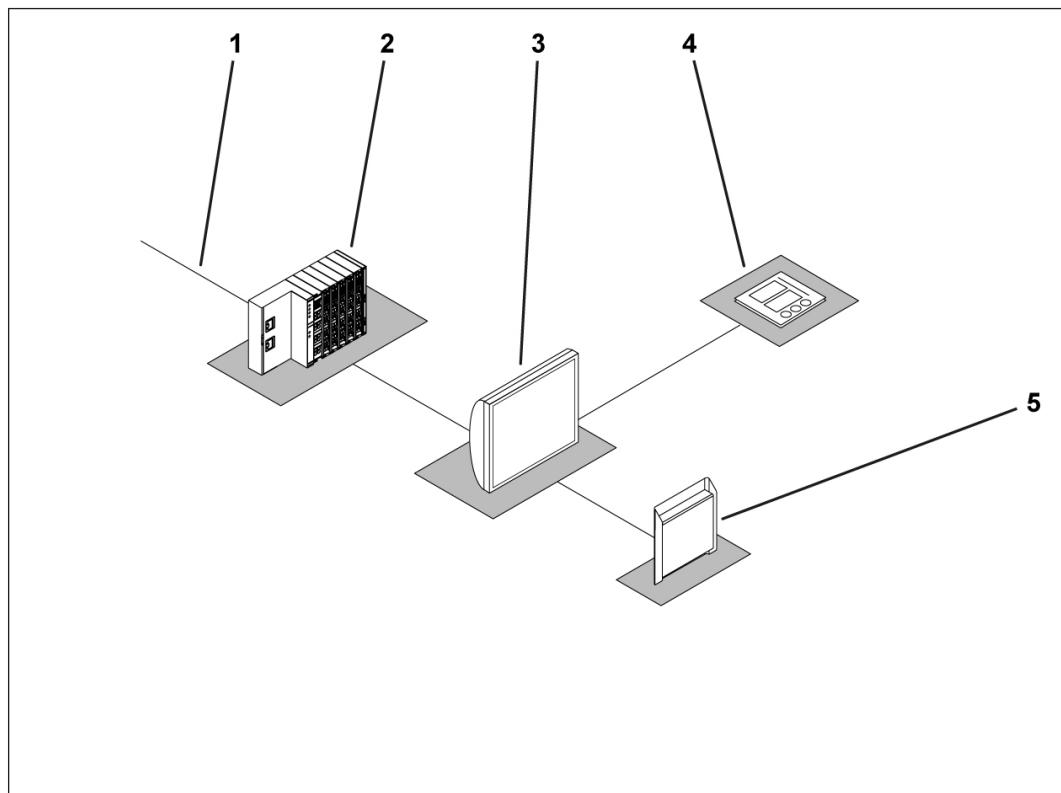


64049-001

- 1 TPEM TP
- 2 TPEM Remote Plant Gateway and internet access
- 3 Mobile or wired internet connection
- 4 TPEM Rendezvous Server
- 5 External computer with TPEM RC and TPEM USB-Token
- 6 Internal computer with TPEM RC with or without TPEM USB token in a control room
- 7 Ethernet
- 8 TPEM Remote Plant Gateway and ethernet access

4.4.9 Mains operator interface (optional)

Communication with a mains operator (power supply company) is established via the TPEM IO and the TPEM TP. It forwards the preset values to the TPEM MFR. The TPEM MFR determines the corresponding preset values for controlling the genset and forwards the preset values to the TPEM CU via the TPEM TP.



64055-002

- 1 Communication line to the mains operator
- 2 TPEM IO
- 3 TPEM TP with integrated operating computer
- 4 TPEM CU
- 5 TPEM MFR

4.5 Overview of power generation

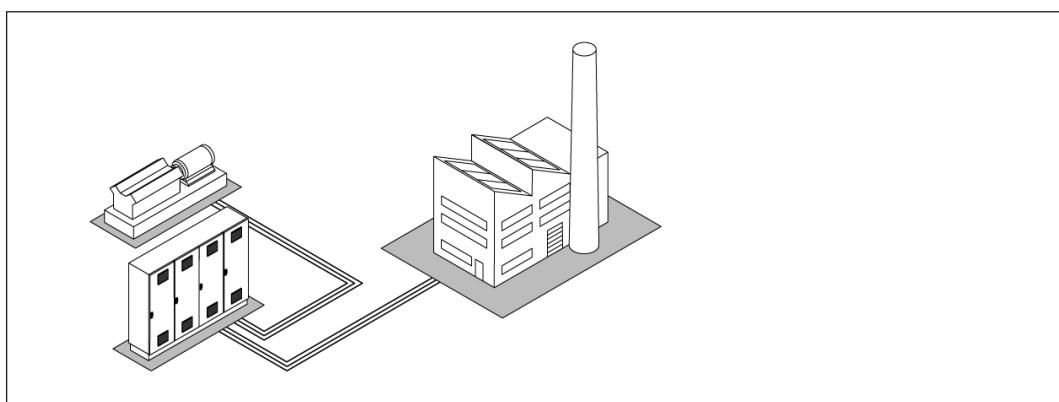
4.5.1 Switchgear and electricity network

Depending on the type of mains that is connected, the switchgear regulates the genset generating the power in different ways. A differentiation is made between:

- Island mode
- Mains parallel mode

Genset and mains must be adjusted to each other. This is particularly important when operating in island mode. It is essential to consult the manufacturer of the genset before altering the operating conditions.

Island mode



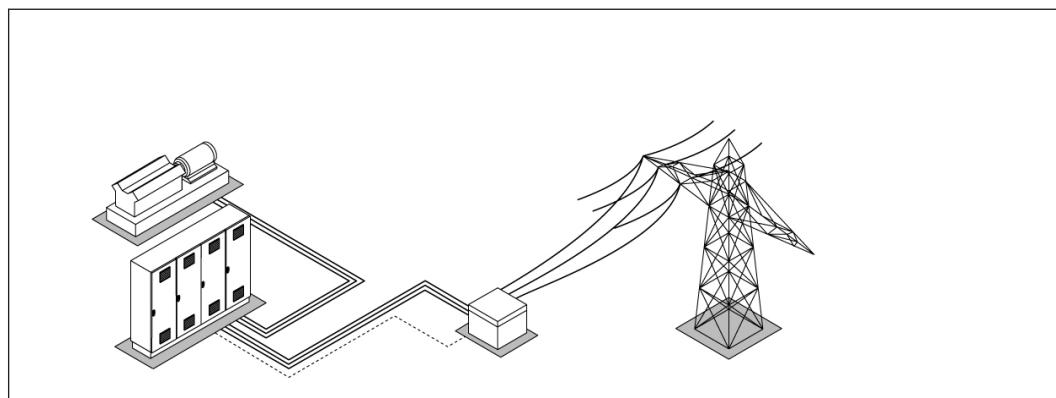
63940-002

When operating in island mode, only the genset meets the power requirement of the consumers in the island electricity network. For the regulation of the module this means:

- The generator determines voltage, phase position and frequency in the island electricity network
- The TPEM system regulates the frequency in the island electricity network through the speed of the gas engine
- The TPEM system regulates the voltage generated in the island electricity network through the generator controller

Depending on the number and power requirement of the consumers, the load in island mode fluctuates relatively quickly and to a significant degree. The gas engine therefore requires sufficient reserve capacity to be able to react immediately.

Mains parallel mode and synchronization



63942-002

When operating in mains parallel mode, the generator feeds current into an electricity network that is made up by many consumers and current sources. The generator is electrically connected in parallel to the electricity network.

During operation, the connected mains generates a braking magnetic field in the generator. It rotates at the mains frequency. The generator also generates a rotating magnetic field during operation. It rotates at the speed of the generator. Between these exists a strong magnetic coupling. As a result of this interaction, a synchronous generator may not be arbitrarily connected to the mains. In order to ensure that too high a torque does not act on the rotor and that no current flows between the generator and mains during coupling, the three-phase alternating voltage generated by the generator must be synchronous with the three-phase alternating voltage in the mains.

For the regulation of the module this means:

- The electricity network affects the voltage, phase position and frequency of the generator
- The TPEM system synchronizes the frequency, phase position and generator voltage with the mains upstream of the coupling
- In the mains, the TPEM system switches from speed control to power control and slowly increases the power of the gas engine to the desired value

Fluctuations in the electricity network are usually slower in mains parallel mode than in island mode. The gas engine therefore requires less reserve capacity and runs with the highest possible power. It reaches its highest level of efficiency.

4.5.2 Control and regulation

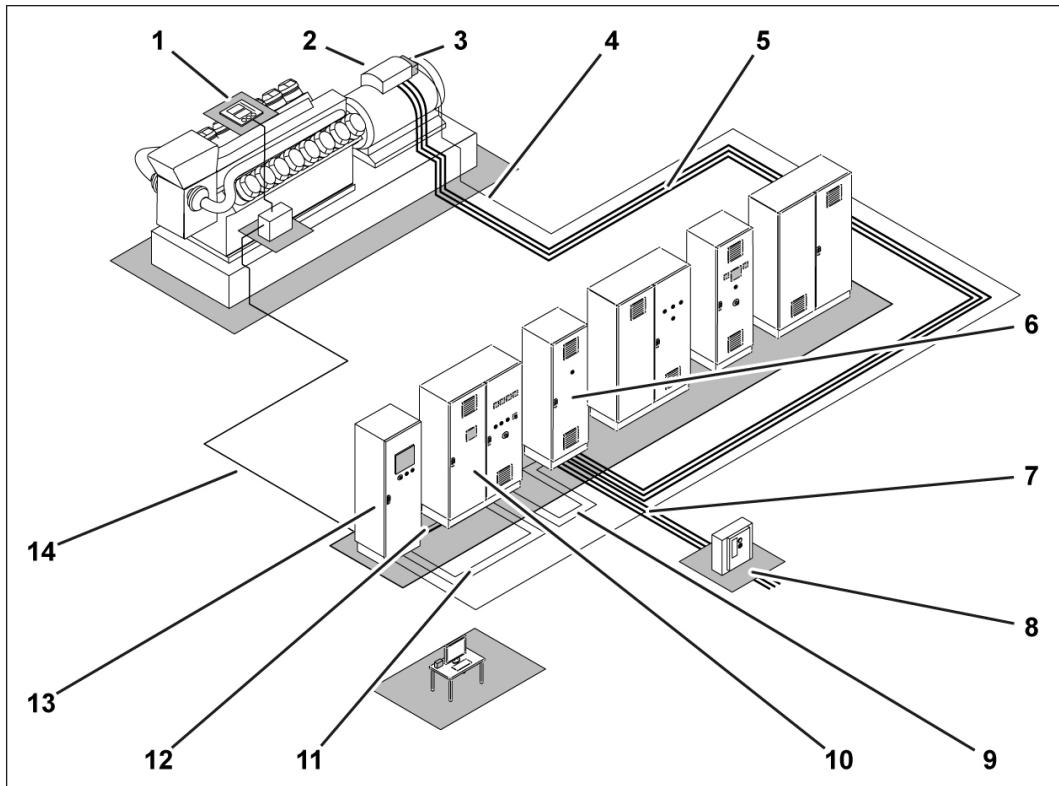
The electrical energy generated by the generator is regulated by connecting several control circuits.

As a main control device, the TPEM Multi Function Relay (TPEM MFR) measures the voltage that is currently being generated in terms of magnitude, frequency and phase position at the generator circuit breaker (GCB). The necessary specific values are available together with the current strength. The TPEM MFR determines the necessary control variables by comparing them with the set values and forwards these to the engine control TPEM Control Unit (TPEM CU). This takes into consideration these control variables and adjusts the gas engine accordingly.

The most important control circuits for power generation are:

- Speed regulation for island mode and synchronization before mains parallel mode
- Power control for the mains parallel mode

The following figure provides a simplified overview of a possible setup.



63946-002

- 1 TPEM Control Unit (TPEM CU)
- 2 Generator main terminal box
- 3 Auxiliary terminal box with integrated generator controller (example)
- 4 Signal line generator controller and TPEM MFR
- 5 Power cables to the generator power field (GPF)
- 6 Generator power field cabinet (GPF) with integrated generator circuit breaker (GCB)
- 7 Power cables to mains circuit breaker (MCB)
- 8 Power cables to the mains connection point
- 9 Signal lines / measuring lines for auxiliary drive cabinet (ADC) and generator power field cabinet (GPF)
- 10 Auxiliary drive cabinet (ADC)
- 11 Signal lines / measuring lines for TPEM MFR and auxiliary drive cabinet (ADC)
- 12 Connection cable TPEM Control Cabinet (TPEM CC) and auxiliary drive cabinet (ADC) and more
- 13 Switch cabinet TPEM Control Cabinet (TPEM CC)
- 14 Connection cable TPEM Control Cabinet (TPEM CC) and engine control

4.5.3 Connecting the generator to an electricity network (mains parallel mode)

Before connection

Before synchronizing, the generator runs without load through the mains.

- The gas engine runs with no-load and only compensates for the power losses, e.g. friction losses
- The generator produces a three-phase alternating voltage

For synchronizing the generator with the electricity network, the generator voltage as well as the mains or busbar voltage are measured in the generator power field cabinet (GPF) and forwarded to the TPEM MFR. The TPEM MFR then automatically synchronizes the generator with the electricity network.

Synchronization

The synchronization is speed-controlled:

- The TPEM MFR and the TPEM CU regulate the speed of the gas engine to the mains frequency
- The TPEM MFR and the generator controller regulate the voltage of the generator to the mains voltage
- The TPEM MFR and the TPEM CU adjust the phase position to the mains voltage by briefly changing the speed of the gas engine
- The TPEM MFR closes the generator circuit breaker (GCB). The genset is connected to the mains

Generator on the mains

When the circuit breaker is closed, the mains frequency, mains voltage and the reactive power in the mains determine the operation of the generator.

- The TPEM system switches from speed control to power control
- The TPEM MFR and the TPEM CU slowly regulate the power of the gas engine to the desired output power
- The generator produces power, which is fed into the electricity network

Control of reactive power

If the generator is connected to the mains it is capable of providing active power as well as consuming and providing reactive power. The PF controller regulates the power factor of the generator depending on the mains operator's demands.

4.6 Important switch cabinets

This subsection describes the switch cabinets that are required for understanding the relationships in plant electrics. The design of the switch cabinets may vary depending on project planning.

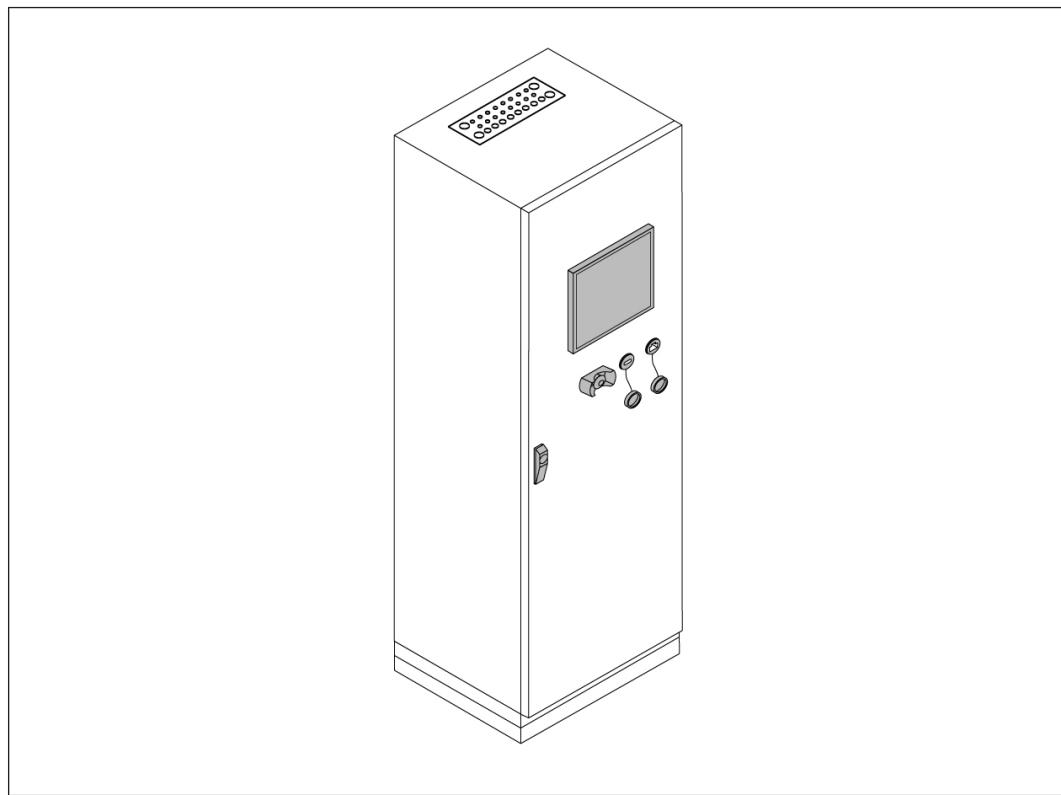
4.6.1 Switch cabinet TPEM Control Cabinet (TPEM CC)

While the scope of the genset cabinet may vary depending on project planning, each genset has one switch cabinet TPEM CC.

The switch cabinet TPEM CC is the central control cabinet for the exchange of signals between the engine control units and the control of the generator and auxiliary drives.

The switch cabinet contains:

- TPEM Touch Panel (TPEM TP): for operating the module and for data storage. The Touch Panel is the interface between the operator and the TPEM control
- TPEM Safety Chain (TPEM SC): safety equipment of the TPEM system
- TPEM Remote Plant Gateway: interface between the TPEM system, the Rendezvous Server and the local network
- TPEM Multi Function Relay (TPEM MFR): serves for automatic synchronization and provides generator protection functions and mains protection functions



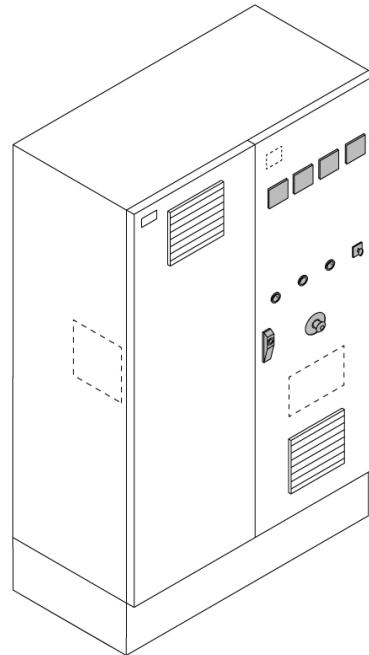
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4.6.2 Auxiliary drive cabinet (ADC)

The switch cabinet ADC serves as an interface to the auxiliary drives. Auxiliary drives control and regulate, for example, fans, flaps, pumps, valves using actuators and sensors. A typical plant contains one auxiliary drive cabinet per genset.

The power supply for the current control circuit and the auxiliary batteries with their battery charging devices are also located in the switch cabinet. The auxiliary batteries buffer the mains power supply for the time that is required to shut down the genset properly in the event of a power failure.



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The switch cabinet also usually contains the TPEM I/O Controller (TPEM IO) as an interface between the TPEM system and the auxiliary drives. The maximum distance to the TPEM CC must be ensured for secure data transfer.

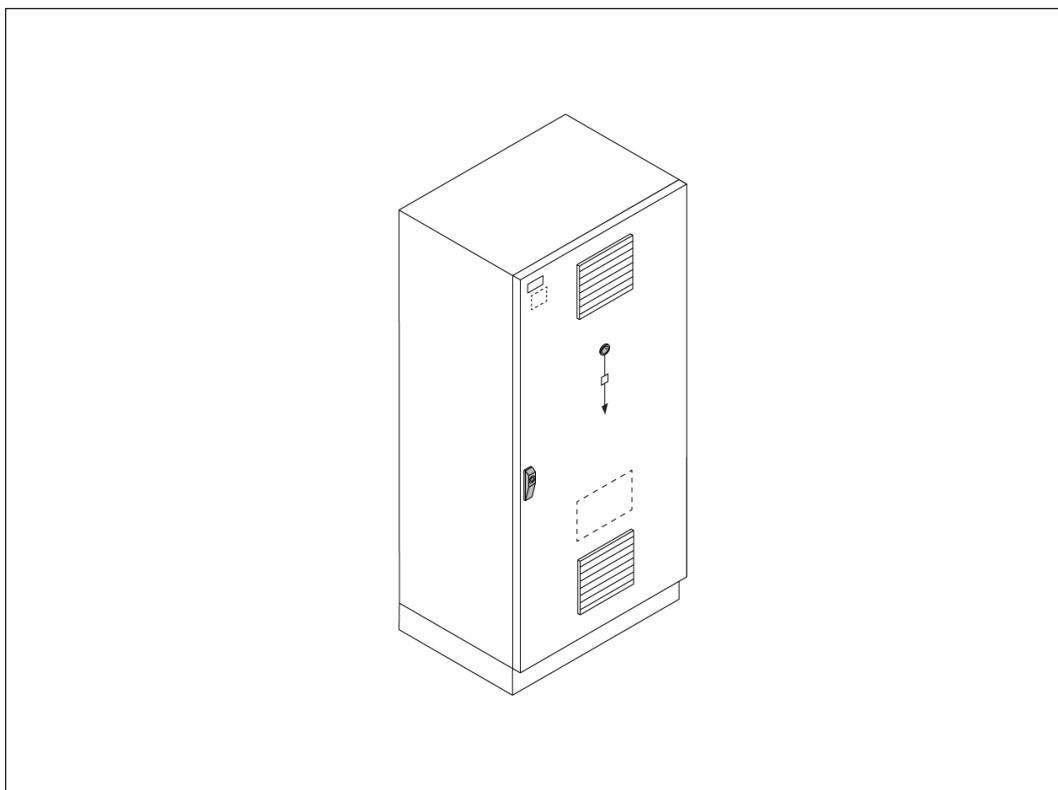


For further information on the length of the connecting line of the TPEM IO, see

- Operating Manual ⇒ Installation ⇒ Control
 - Switch cabinet TPEM Control Cabinet (TPEM CC) ⇒ Technical data

4.6.3 Generator power field cabinet (GPF)

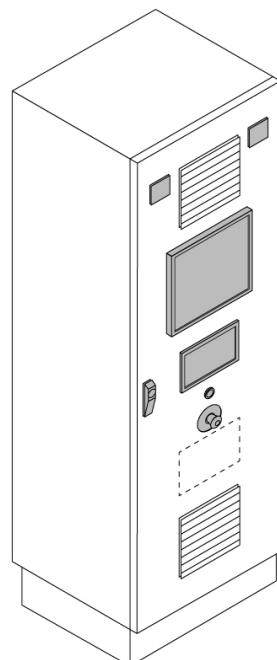
The switch cabinet GPF contains the generator circuit breaker (GCB) as a switching point between generator and customer system. In the event of a fault (e.g. a short-circuit), the generator circuit breaker disconnects the generator from the mains or connected consumers. The position indicator indicates the switching state (open/closed). Actuation is carried out by the TPEM Multi Function Relay (TPEM MFR).



63951-001

4.6.4 Master plant control cabinet (MPCC)

The master plant control cabinet (MPCC) undertakes superior applications in a plant with several modules. This may be central lube oil management, for example.



63953-001

4.7 Protection in case of critical operating states on the mains

When operating the genset on the mains, critical operational states may occur that can damage the generator and/or gas engine and the electricity network. The TPEM system detects many critical operational states using its sensors and responds accordingly.

Reverse power

If the genset does not provide any power or only low power when in mains parallel mode and the circuit breaker on generator power field cabinet (GPF) remains closed, then the electricity network drives the generator just like an electric motor (reverse power). The TPEM system therefore controls the generator circuit breaker (GCB) and opens it automatically if necessary.



For further information on reverse power, see

- Operating Manual ⇒ Operation ⇒ Genset
 - Genset operating manual

Mains power

If the electricity network fails or becomes too weak, then the gas engine has no load. This would cause its speed to soar. For this case, the TPEM system monitors the generator power and speed of the gas engine.

Reduced power

The gas engine is designed for a high power output. If the generator places only a small load on the gas engine, the TPEM system shuts down the gas engine after a specified time.

Winding temperature

Currents that are too high in the generator windings may cause the generator windings to overheat. The TPEM system monitors the winding temperature and shuts down the genset once a specified limit value is reached.

Additional protective functions in accordance with ANSI

Additional critical operating states such as overload, unbalanced load, voltage and frequency fluctuations that are too high, and a short-circuit can cause damage. The TPEM system already has protective functions. In order to protect the genset and the electricity network, additional monitoring devices as per ISO 8528 must be used according to the conditions on site and the configuration of the plant.

4.8 Requirements for the feed-in to the mains

The mains operator's specifications must be followed for the feed-in to their mains. Depending on the region, these involve specifications on the acceptance and certification of the generating plant, operation and maintenance, as well as accessing parts of the generating plant.

Quite often the genset must also engage in the voltage stability in the distribution network during the feed-in to the mains. Depending on the mains operator, these may involve the following requirements for example:

- Power demand controlled remotely by the mains operator or power supply company
- External power demand
- Active power reduction in the event of overfrequency
- Provision of reactive power
- Dynamic mains support

For further information on feed-in to the mains, see

- Documentation of the electricity network operator ⇒ Mains connection conditions
-





5 Corrosion protection, packaging, transport, storage

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5.1 Safety notes



WARNING!

Risk of injury from swinging, slipping or falling loads

This can lead to severe injuries and even death.

- Do not stand underneath suspended loads.
- Secure the swivel range of the suspended load.
- Raise or lower load slowly and evenly.
- Only use tested load suspension devices and lifting equipment which are of a suitable size for the relevant weight.



For necessary information on corrosion protection, packaging, transport, and storage, see

- Operating Manual ⇒ General ⇒ Operating media regulations
 - Technical Bulletin (TR) 2169 Specification for corrosion protection, packaging, transport and storage

5.2 Symbols on the packaging

	Attach here Position fastening material for lifting the package - as shown.
	Center of gravity Shows the center of gravity of the respective package.
	Top Shows the correct upright position of the package. Only transport and store the packages in an upright position.
	Protect from moisture Protect packages from moisture and store in a dry place.
	Fragile Indicates packages with fragile or damageable contents. Treat packages with care, do not throw and be careful not to knock or bump them.

5.3 Removing from transport

Immediately check the delivery for completeness and transport damage upon receipt.

In the event of visible transport damage on the outside, proceed as follows:

1. Do not accept the delivery or only accept under reserve
2. Note the extent of the damage on the transport documents or on the hauler's delivery note
3. Lodge complaint

Note

Make a claim for each fault as soon as it is detected. Claims for damage may only be made within the legal and contractually agreed claim deadlines.

5.4 Transporting packages and pallets

All notes in this section refer to transporting individual packages or pallets.



For further information on transport, see

- Operating Manual ⇒ General ⇒ Operating media regulations
 - Technical Bulletin (TR) 2169 Specification for corrosion protection, packaging, transport and storage

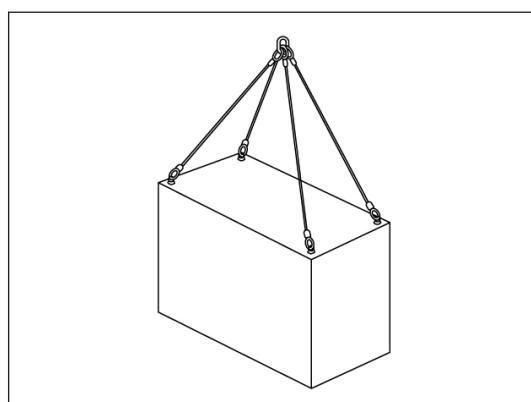
Transporting packages by crane

Prerequisites

- The packages are fitted with attachment points.
- Cranes and hoists are designed for the weight of the package.
- The personnel are authorized to operate a crane.

Proceed as follows:

1. Attach lifting gear at the application points



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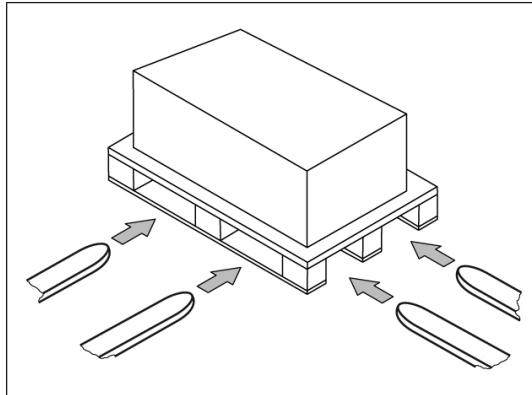
2. Ensure that the package hangs straight
 - Pay attention to the off-center center of gravity when attaching gear.
3. Lift package slowly and begin with the transport

Transporting pallets with the forklift

Prerequisites

- The packages are fixed to pallets, which can be transported with a forklift.
- The forklift is designed to take the weight of the transport unit.
- The personnel are authorized to operate a forklift.

Proceed as follows:



61135-002

1. Drive the forklift with the forks between the blocks of the pallet
→ Drive the forks into the pallet as far as possible.
2. Ensure that the pallet cannot tip over
→ Pay attention to the off-center center of gravity when attaching gear.
3. Lift pallet slowly and begin with the transport

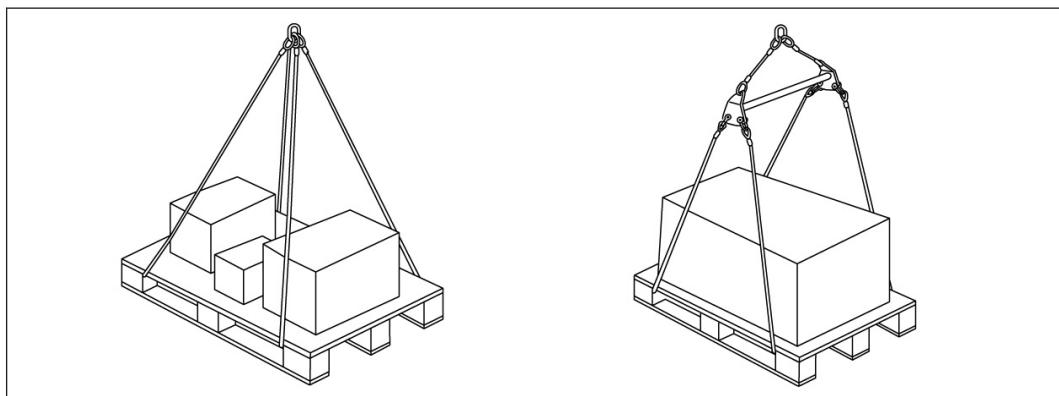
Transporting pallets by crane

Prerequisites

- The packages are fixed to pallets, which can be lifted and transported with a crane.
- Crane and hoists are designed to take the weight of the transport unit.
- The personnel are authorized to operate a crane.

Proceed as follows:

1. Attach lifting gear



61136-003

2. Ensure that the packages are not damaged by the fastening materials
→ If necessary, use other fastening materials.

-
3. Ensure that the pallet hangs straight
→ Pay attention to the off-center center of gravity when attaching gear.
 4. Lift pallet slowly and begin with the transport

5.5 Information on packaging

The individual packages are packed according to the expected transport conditions.

Note

For required information on packaging, see

- Operating Manual ⇒ General ⇒ Operating media regulations
 - Technical Bulletin (TR) 2169 Specification for corrosion protection, packaging, transport and storage
-

The packaging should protect the individual components up to assembly. Therefore, do not destroy the packaging and only remove it directly before assembly.

Handling packaging materials



Danger to the environment

Incorrect disposal of packaging materials may cause environmental damage.

- Dispose of packaging material according to the respectively applicable legal regulations and local specifications.
 - Pass recyclable packaging material on to be recycled
 - Commission a specialist company if necessary
-

5.6 Notes on storage

All notes in this section refer to the storage of individual packages or pallets.



For further information on the storage, see

- Operating Manual ⇒ General ⇒ Operating media regulations
 - Technical Bulletin (TR) 2169 Specification for corrosion protection, packaging, transport and storage

Store packages under the following conditions:

- Do not store outside
- Store in a dry, dust-free place
- Protect from sunlight
- Avoid mechanical vibrations
- Storage temperature: free of frost to 45 °C
- Relative air humidity: max. 60 %
- If storing for more than three months:
 - Regularly check the condition of all packages and their packaging
 - Replace damaged packaging if necessary
 - Refresh or replace corrosion protection if necessary

Note

Under certain conditions, there are notes about storage on the packages which go beyond the requirements stated.

Observe and comply with these notes.

5.7 Notes on corrosion protection

All notes in this section refer to the corrosion protection of individual packages or pallets.



For further information on corrosion protection of the genset, see

- Operating Manual ⇒ General ⇒ Operating media regulations
 - Technical Bulletin (TR) 2169 Specification for corrosion protection, packaging, transport and storage

Packages, pallets and spare parts are protected from corrosion before being dispatched.

The period of corrosion protection should extend to at least twelve months. The actual length of protection also depends on:

- Method of corrosion protection
- Packaging
- Storage conditions

Note

In some circumstances, there are additional notes in relation to corrosion protection on the packages, pallets and spare parts, as well as in the supply documents of the spare parts.

Observe and comply with these notes.

Check the corrosion protection of all packages, pallets and spare parts regularly and replace or refresh where necessary.

6 Installation

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6.1 Safety notes



WARNING!

Electric shock if live components are touched

This can lead to severe injuries and even death.

- Only authorized specialist personnel may work on the electrical system.
- Turn off electrical power supply and secure against restarting:
 - Disconnect electrical system.
 - Secure against restarting.
 - Check that equipment is voltage-free.
 - Ground and short-circuit the electrical system.
 - Cover or cordon off adjacent components which are electrically live.



WARNING!

Injury due to improper installation

This can lead to severe injuries and even death.

- Ensure sufficient installation space.
- Handle sharp-edged components carefully.
- Ensure tidiness and cleanliness in the workplace.
 - Do not leave tools lying around.
 - Components left lying around and on top of one another are causes of accidents.
- Assemble components properly.
 - Observe specified tightening torques.
- Secure components from being knocked over or falling down.



WARNING!

Improper installation

This can lead to severe injuries and even death.

- Only authorized specialist personnel may work on the electrical system.
- Only authorized specialist personnel may work on the combustion gas system.

6.2 Requirements

Tightening specifications



For necessary information on the tightening specifications, see

- Chapter Maintenance, Tightening specifications section

Personnel

- Only qualified specialist personnel may carry out assembly work on the product
- Only authorized specialist personnel may work on the electrical system
- Only authorized specialist personnel may work on the fuel gas system

Personal protective equipment

Wear the following personal protective equipment during all assembly work:

- Protective work wear
- Safety helmet
- Safety shoes
- Safety gloves
- Goggles

Required preliminary work

- The foundation is capable of bearing loads, is resistant to frost, dry, incombustible and horizontal
- The supply connections for the operating media are wired
- Sufficient ventilation to the outside is available
- The fresh air is free of chemical additives (e.g. fluorine, chlorine, sulfur)
- The installation location is equipped with a sealing, self-closing, fire-proof door
- There is a suitable chimney connection available at the installation location
- A free space of at least one meter around the genset exists at the installation location



For further information on the requirements of the installation location, see

- Operating Manual ⇒ General ⇒ Installation directive
- Operating Manual ⇒ Installation note ⇒ Genset installation

7 Commissioning

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7.1 Safety notes



WARNING!

Injury due to improper commissioning

This can lead to severe injuries and even death.

- Only authorized specialist personnel may operate the product

7.2 Commissioning

7.2.1 Initial commissioning

The initial commissioning is carried out in consultation between the operator and the commissioner.

Have the work for the initial commissioning carried out according to the commissioning specification. Only have the work carried out by employees of the manufacturer or people authorized by the manufacturer.

The parameterization is done via TPEM Touch Panel (TPEM TP). The corresponding access rights are required.



8 Operation

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8.1 Safety notes



WARNING!

Electric shock if live components are touched

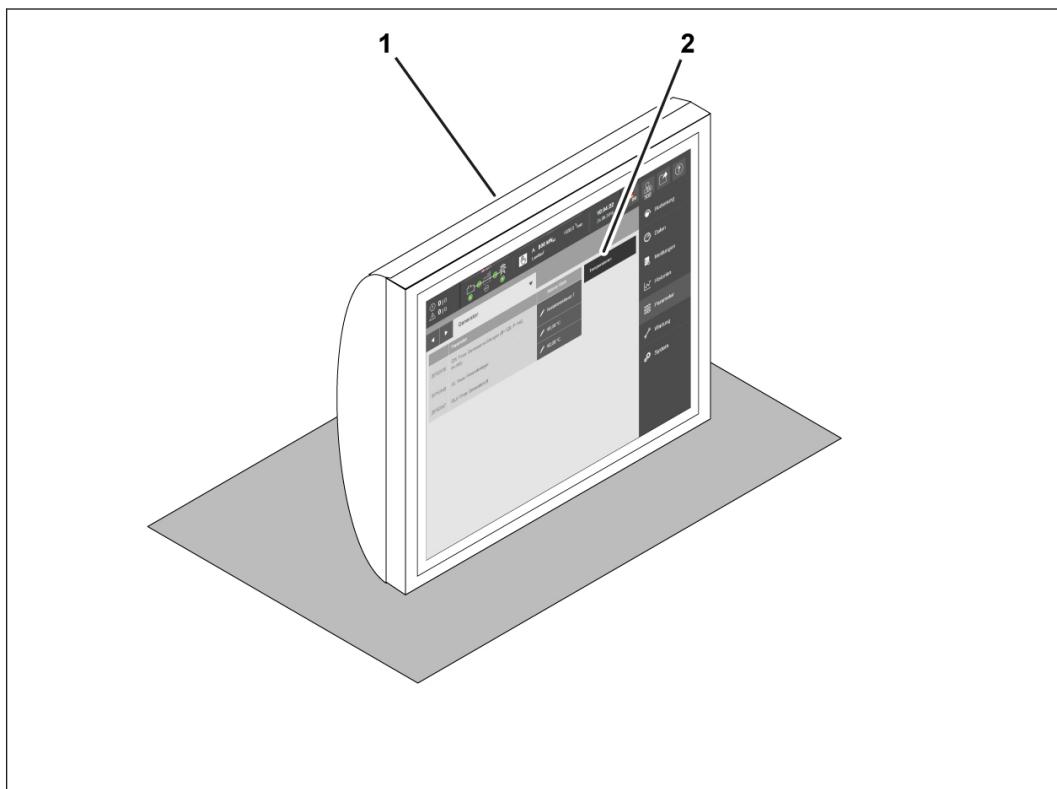
This can lead to severe injuries and even death.

- Only authorized specialist personnel may work on the electrical system.
- Turn off electrical power supply and secure against restarting:
 - Disconnect electrical system.
 - Secure against restarting.
 - Check that equipment is voltage-free.
 - Ground and short-circuit the electrical system.
 - Cover or cordon off adjacent components which are electrically live.

8.2 Displays and operating elements

8.2.1 Module operation

Each module has a switch cabinet TPEM Control Cabinet (TPEM CC) with the TPEM Touch Panel (TPEM TP). The functions for the operation of the module are operated by the TPEM TP. Once the power supply of the switch cabinet TPEM CC has been established, the TPEM TP starts up and a user interface of the TPEM system appears.



64063-001

- 1 TPEM TP
- 2 TPEM user interface



For further information on the operation of the module, see

- Operating Manual ⇒ Operation ⇒ Control
 - TPEM operating manual

8.2.2 Additional switch cabinets

The number of switch cabinets and their functionality depends on the scope of supply of the switchgear.



For further information on the operating elements and displays on the switch cabinets, see

- Operating Manual ⇒ Operation ⇒ Control
 - Operating manual for the respective switch cabinet



9 Troubleshooting

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9.1 Safety notes

Unless otherwise indicated, the operator may carry out the work described for troubleshooting.

Only qualified specialist personnel may carry out certain work. Particular reference is made to this work in the description of the individual faults.

Only qualified electricians may carry out work on the electrical system.

Only qualified gas technicians may carry out work on the gas line.

Conduct in the event of faults

1. In the event of faults that pose an immediate danger to people or property, press the emergency stop switch immediately
2. Inform those responsible at the place of use of the fault
3. In case of troubleshooting in the danger zone, shut down the genset normally and secure it against restarting ⇒ Job card B 0-0-10
4. Depending on the type of fault, have it rectified by authorized specialist personnel or fix it yourself ⇒ Section Rectify fault
→ If necessary commission the contact person: Caterpillar dealer.

9.2 Fault displays

The TPEM Touch Panel displays all alarms and warnings as a text message.

There may be other acoustic or visual fault displays in the immediate vicinity of the genset, if applicable. The operator is responsible for integrating the genset into the signal chain of the entire plant.

The status bar displays information regarding pending faults on every page of the screen.



For further information on the fault displays, see

- Operating Manual ⇒ Operation ⇒ Control
 - TPEM operating manual

9.3 Rectifying faults



For troubleshooting, see

- Separate document ⇒ Error diagnosis (currently not available)

10 Appendix

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10.1 List of abbreviations

Abbreviation	Explanation
DES	Demand for external starting preparations
JC	Job card
AKC	Anti-knock control
DMT	Inverse time maximum current monitoring
ANSI	American National Standards Institute
ETC	Exhaust turbocharger
IAP	Intake air preheating
EHE	Exhaust heat exchanger
BDEW	Bundesverband der Energie- und Wasserwirtschaft (German Association of Energy and Water Industries)
oh	Operating hours
CHP	Combined heat and power plant
BY	Exhaust bypass
CH4	CH ₄ compensation
PF	Active power factor
TV	Throttle valve
M steps	Maintenance steps
f	Frequency
FC	Frequency converter
FCC	Frequency converter cabinet
GGB	Generator gang switch
MC	Mixture cooler
MCC	Mixture cooling circuit
MCC Rec	Mixture cooling circuit recooler
GPF	Generator power field cabinet
GAM	Gas-air mixer
GCB	Generator circuit breaker
GCL	Gas control line
AD test	Auxiliary drive test
ADC	Auxiliary drive cabinet
HP	High pressure
HC	Heating circuit

Abbreviation	Explanation
HC EHE ECC	Heating circuit with exhaust heat exchanger in engine cooling circuit
HT	High temperature
I/O	Input/Output
CAT	Catalytic converter
CPH	Coolant preheating
CWHE	Cooling water heat exchanger
CL	Competence level
CiB	Circuit breaker
ECC	Engine cooling circuit
Grid code	Grid code
EmCC	Emergency cooling circuit
EmCC Rec	Emergency cooling circuit recycler
MCB	Mains circuit breaker
LT	Low temperature
P	Pressure
P diff.	Differential pressure
UDC	Upper dead center
PTFE	Polytetrafluoroethylene
PHE	Plate heat exchanger
P&I diagram	Pipe and instrument diagram
CV	Cabin ventilation
RP	Reduced power
S	Speed
busB	Busbar
SSOV	Safety shut-off valve
SC	Shutdown controlled
Act	Actuator
SCC	Sandwich cooler control
LHE	Lube oil heat exchanger
T	Temperature
TPEM	Total Plant and Energy Management
TPEM CB	TPEM Connection Box
TPEM CC	TPEM Control Cabinet
TPEM CU	TPEM Control Unit

Abbreviation	Explanation
TPEM IO	TPEM I/O Controller
TPEM MFR	TPEM Multi Function Relay
TPEM RC	TPEM Remote Client
TPEM RC DT	TPEM Remote Client Desktop
TPEM RC TP	TPEM Remote Client Touch Panel
TPEM RPG	TPEM Remote Plant Gateway
TPEM RVS	TPEM Rendezvous Server
TPEM SaC	TPEM Safety Chain
TPEM TP	TPEM Touch Panel
TR	Technical Bulletin
UPF	Underpressure filter
LDC	Lower dead center
PLP	Prelubrication pump
WG	Wastegate
WO	without auxiliary drives
IG	Ignition general
SP	Spark plug