



energy.application

THE SAFE FUTURE OF YOUR ENERGY

bachmann.

YOUR EXPERI- ENCED PARTNER IN ENERGY TECHNOLOGY

Automation: Safe, flexible
and modular

Bachmann electronic is a world leader in the automation sector. Besides future-proof technologies, high availability and quality from a single source, there's one thing we offer our customers above all: extensive experience and unique expertise in meeting challenging market and customer requirements worldwide with tailored solutions.



Automation solutions
for energy applications

06-37



Customer applications
in energy technology

38-63



Training seminars
at Bachmann

64-67





WIND ENERGY AND CONDITION MONITORING

- 100,000 wind turbines automated with Bachmann worldwide
- 9,000 Condition Monitoring Systems installed with Bachmann
- More than 250 automation partners trust Bachmann in the wind sector

Customers: Vestas, Nordex, eno energy, Sany, Abo Wind, BKW Wind Service ...

BATTERY STORAGE SYSTEMS AND HYBRID POWER STATIONS

- Support of open and standard interfaces/protocols
- Modular system in the hardware and software
- Integrated grid measurement and analysis

Customers: Younicos, Qinous, Gildemeister energy storage, Schäfer Elektronik ...

CHP

- Scalable controller system
- Grid synchronization integrated in the M1 controller
- Certified to VDE-AR-4105, BDEW FGW TR3 and TR8
- CHP Template – 80 % of the software is »ready-to-use«

Customers: 2G Energy AG, COMUNA-metall, enertec Kraftwerke, Bayern BHKW ...

HYDROPOWER

- Standard telecontrol protocols – Integration in virtual power stations in compliance with the 60870-5-101/103/104, MMS 61850-7-420
- Robust system – ensures high availability
- 48 hour »run-in test« of all modules
- Seamless web visualization of webMI pro via atvise® scada right through to atvise® portal

Customer: Rittmeyer

THE SAFE FUTURE OF YOUR ENERGY PLANTS

Everything under control with Bachmann
system solutions

The M1 controller system makes it possible to solve energy technology issues directly within the automation. Bachmann electronic's portfolio of PLC-integrated grid technology covers all application areas: From ultra-compact energy monitoring (EN 50001), grid quality measurement (power quality), monitoring and protection technology right through to synchronization and digital fault recorder. These applications are possible without the need for any additional interfaces on the CPU or communication via bus systems.



THE BACHMANN SYSTEM

The automation solution
for energy applications

We understand the big picture and are always thinking ahead for you. Our innovative solutions ensure efficient engineering of your plants. This is what the intelligent automation of state-of-the-art energy plants looks like.

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Top technology
without limits

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All-in-one engineering

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energy technology



TOP TECHNOLOGY WITHOUT LIMITS

Automation

Automate your energy plant with Bachmann, secure in the knowledge that every eventuality is covered. Our innovative automation systems stand out on account of their extraordinary robustness, high performance and open interfaces.

Openness in hardware and software

The M1 system operates as a real-time system. Different open-loop and closed-loop control programs are adapted in modules and run simultaneously in a preemptive multitasking environment. Like the hardware, the software system is also modular and can be structured and extended as required following our »no limits« principle. The controller offers additional reserves for expansions or plant-specific modifications.

Functionality means »ready-to-use«

The modular M1 system offers an extensive range of hardware, consisting of over 200 devices and modules. This system contains a large number of configurable blocks for all necessary machine functions, such as visualization, networking, closed-loop control and diagnostics, to provide you with all the basic functions from the start. Here we place tremendous importance in the fact that all tools have been developed according to international standards, and can also be integrated and parameterized flexibly.



Equipped for challenging climates

The ColdClimate modules of Bachmann are the solution for all applications in demanding climatic conditions, especially where maximum plant availability is critical. The ColdClimate modules are first choice, especially when demanding environmental conditions (e.g. temperature, air humidity, salt spray) are involved. For you this means: Safe operation, even with extreme transient temperatures from -40 to +70 °C, and reliable continuous operation guaranteed in the temperature range from -30 to +60 °C with condensation.



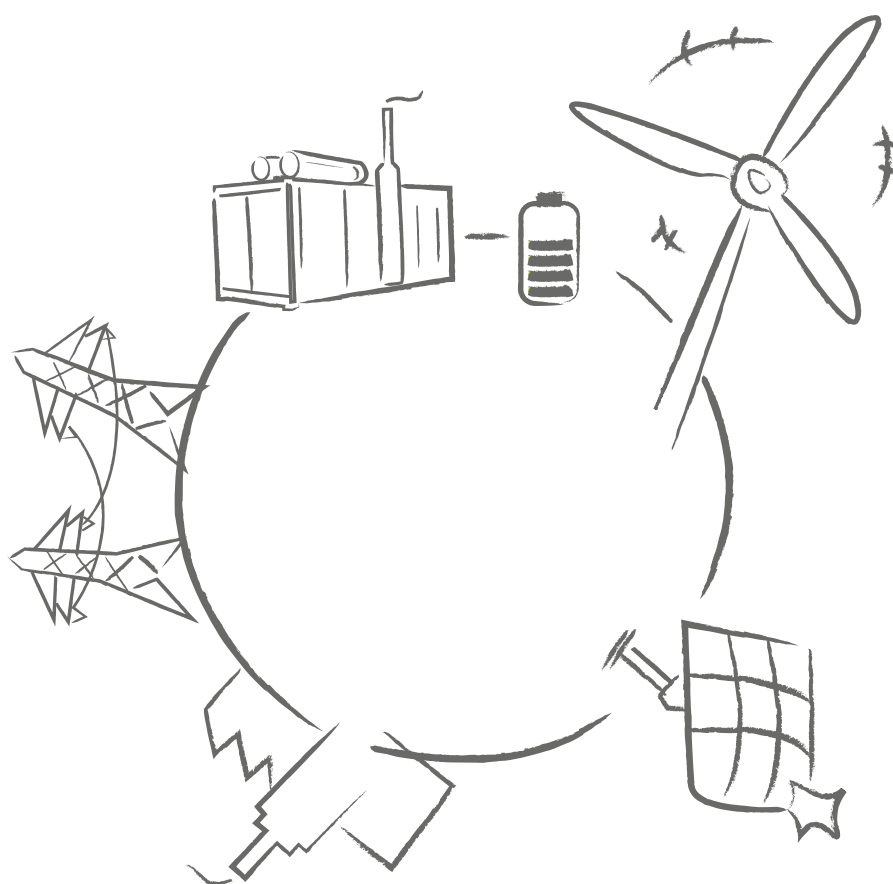
ColdClimate
-40 to 70 °C

System concept



Scalable and open

In order to minimize complexity and maximize ease of maintenance, all components of the M1 controller system are consistently developed as part of a modular system. In this way, optimum scalability is ensured for a wide range of requirements. The M1 system perfectly combines the openness of a PC-based controller with the reliability of industrial hardware platforms. A state-of-the-art system architecture designed for effective networking capability enables it to be integrated easily in the area of the controller and plant peripherals.



◀ The openness of the overall system makes it possible to integrate third party systems and components without any problem. A wide range of fieldbuses and telecontrol protocols are available for this. These can be selected as required without having to change the automation.

IEC standard benefits

IEC 61850 – A standard communication solution for easy access to relevant energy plant data.



Certified systems

Internationally accredited test institutes verify the conformity of our systems with the most important global standards and thus provide approval for the most demanding applications.



FGW TR3
BDEW

FGW TR8
IEEE Std. C37.90

VDE-AR-N 4105

A SYSTEM FOR EVERY REQUIREMENT

Digital input/output modules – DIO

The DIO248, DIO264 and DIO280 digital I/O modules are suitable for controlling digital consumers such as contactors, relays, pneumatic and hydraulic valves, as well as for reading the signals of digital sensors, probes or switches. The eight interrupt inputs provided enable a rapid response to any events. Alternatively up to four counters are available for tasks such as position detection or counting items. All outputs can be operated as PWM outputs for the energy saving operation of inductive loads. A stop time of 0 to 2 s can also be configured for PWM operation. Outputs can be switched in parallel if they are run in the same operating mode.

CPUs of the MX series

Maximum performance for demanding closed-loop control tasks, process control and signal processing, as well as a comprehensive range of communication protocols – all provided by the CPUs of the MC model series: state-of-the-art Intel processors, fast GBit networks, large CFA memory, battery-backed, non-volatile data storage (NVRAM), Ethernet, serial and USB interfaces.

GIO I/O module

The GIO212 can measure or output different types of signals. Each channel can be used as an analog or digital output or input. Different sensors and actuators can be connected with current (0/4 to 20 mA) and voltage ($\pm 10V$) standard signal types.

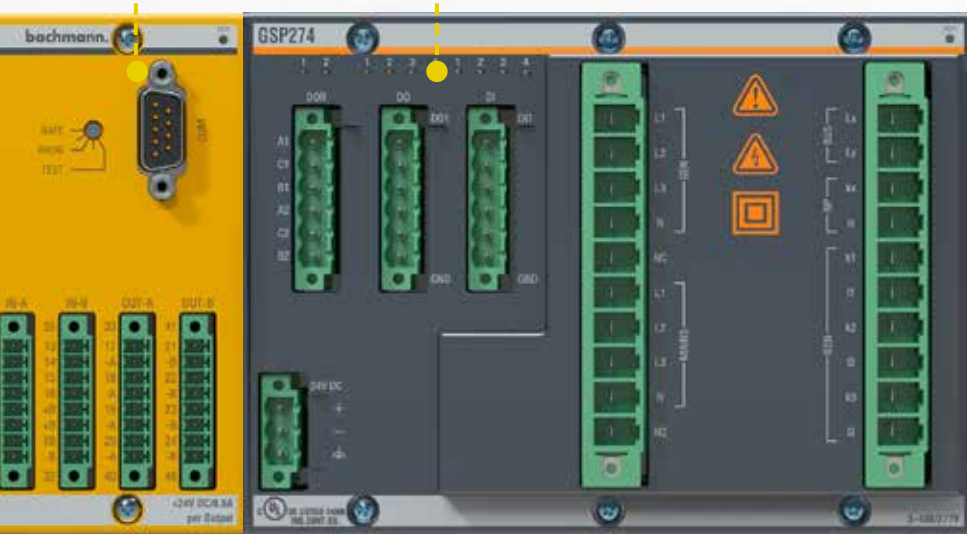


SLC safety processor module

The SLC284 – ideally integrated in the M1 controller – is a safe and modern safety controller. The SLC284 is approved in accordance with the latest IEC 61508 safety standard. No additional cabling is required for communication between SLC284 and the SDI208 and SDO204 safety input/output modules. The modules can be operated remotely – several hundred meters apart – distributed via the bus expansion or a FASTBUS.

Grid measurement, synchronization and protection – GSP274

The GSP274 enables the safe, reliable and automatic synchronization of generator units to the power supply grid. It also provides a number of monitoring functions for generator and grid protection. The circuit-breakers are tripped by the module directly via digital outputs and relays. Additional digital inputs enable the monitoring of the relevant switching state. The continuous monitoring of grid harmonics up to the 50th harmonic can be used for direct responses as well as for evaluating the power quality.



ColdClimate -40 to +70 °C



- Very large operating temperature range
- High moisture condensation resistance
- Use of modules at extreme temperatures from -40 °C to +70 °C
- 100 % »run-in test« for all modules with extreme temperature changes in climatic chambers



ALL-IN-ONE ENGINEERING

SolutionCenter

The Bachmann SolutionCenter represents a genuine milestone in the reduction of engineering costs. A single all-round software solution covers all areas of the engineering process – from configuration, programming, closed-loop control, motion, communication, safety, visualization, right through to testing and commissioning.

SolutionCenter – the all-in-one engineering tool

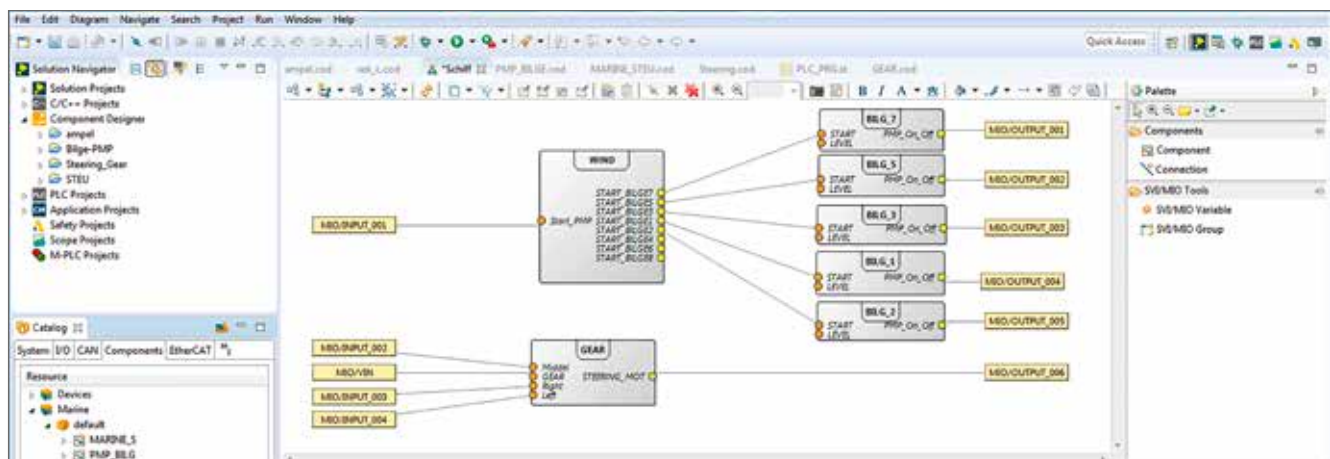
The SolutionCenter supports all aspects of the engineering for wind power applications and perfectly integrates to Bachmann devices and systems. It was designed in collaboration with experienced users and allows effective engineering in all phases. Through the plugin concept, the SolutionCenter enables necessary functions or user-specific requirements to be added at any time. This can be done either by selecting a third-party plugin from the extensive offering or with in-house developments.

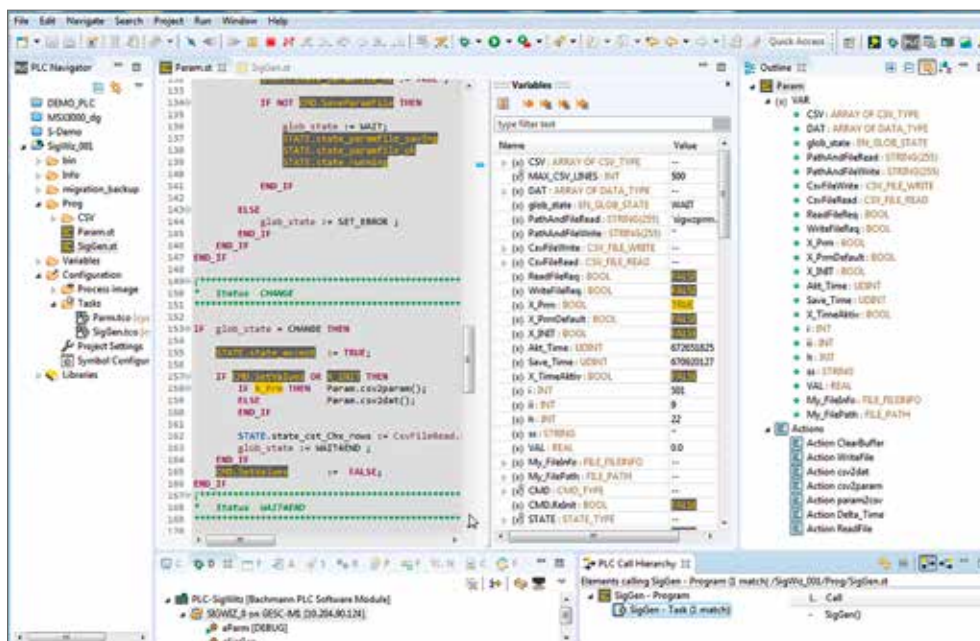
Component Manager

More than ever, modern plants consist of complex mechatronic systems, which can only be implemented through the close collaboration of all the engineering sciences required for the process. This complexity is handled by breaking down the plant into logical function units, also known as components. Bachmann's Component Manager is designed for this task. The tool allows you to form systems from different components, which are depicted as software modules in the system. These components can not only be created in

▼ Component Manager:

Clear application display in the SolutionCenter.



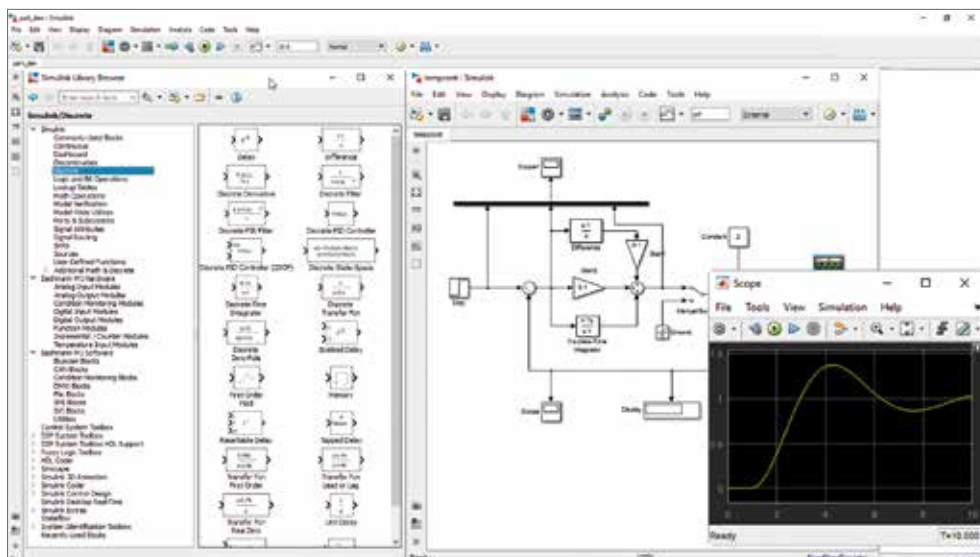


► **PLC Developer:** Modern editor for IEC 61131-ST fully integrated in the SolutionCenter.

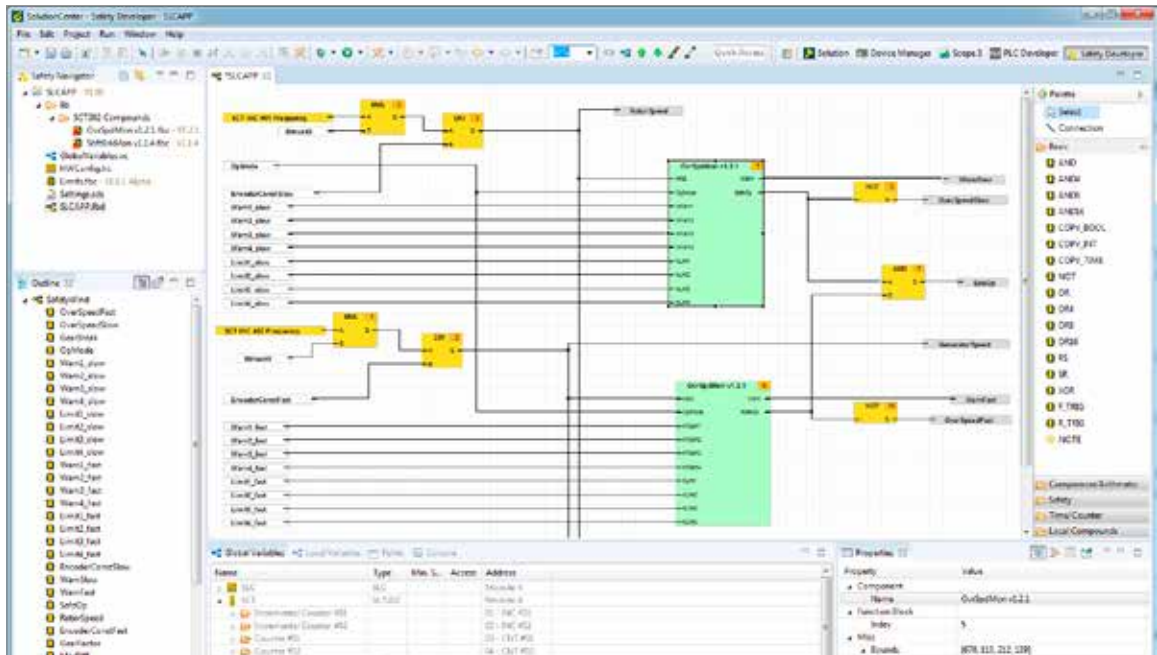
the optimum programming language for your task but can be also purchased and reused. This makes it possible to add new custom versions, product versions or new functions (different software module combinations, additional modules...) without modifying the existing software. This methodology makes use of modern tools to support the engineering process. Through the plugin concept, SolutionCenter makes it possible to use all common versioning systems (SVN, GIT etc.) and manage the entire history of the project with all its components.

Programming tools

The SolutionCenter provides modern programming environments for creating the software modules. Automation tasks and requirements can be addressed both with the new PLC Developer tool from Bachmann as well as with the proven M-PLC Tool in IEC 61131. Programming in C/C++ at the same time in the form of autonomous modules or as libraries for the PLC environment is also possible. Simulations and closed-loop control tasks can be modeled and simulated with MATLAB®/Simulink®. The M-Target Toolbox and interface developed by



► **MATLAB®/Simulink®:** Development of open and closed-loop control programs for the M1 using the M-Target Toolbox.



▲ **Seamless integration:** The complete integration in the SolutionCenter reduces the time required for the configuration and reduces downtimes, thanks to the simple remote diagnostics and onsite troubleshooting – safety integrated.

Bachmann ensures perfect integration in the M1 automation target system. Extensive libraries are available in any programming language for a variety of different tasks.

Test/quality/simulation

Quality assurance tests must be carried out during and after software development. The SolutionCenter supports the programmer while performing extensive software test procedures (unit test, static code analysis...) as well as when testing the application software. The component-oriented design of the application program enables targeted testing. Software can be tested as a complete application or as individual software modules. For these tasks, processes based on CSV tables, as well as extensive processes such as hardware-in-the-loop (HIL) are available.

Security/safety

Plants in the energy sector must comply with stringent security and safety standards. This involves both the area of unauthorized access to the controller as well as safety shutdowns in dangerous conditions. SolutionCenter allows the configuration of extensive security features and provides the Safety Editor as an easy to use tool with the CFC Editor for programming a software control program integrated in the M1

system. A wide range of libraries with compliant modules are available for the rapid implementation of the safety application. This includes the exchange of variables with the operational control program. The integration of the safety engineering in the turbine controller enables remote diagnostics and maintenance to be carried out easily.

Communication

Modern plants are no longer possible today without the implementation of a network. The M1 controller supports all commonly available networks, fieldbuses and protocols, such as Ethernet TCP/IP, PROFINET, EtherCAT, CAN bus or Modbus, IEC 61400-25, IEC 60870-5-104 or OPC UA. The configurators required are also included as well as diagnostic and testing tools.

Visualization

The increasing complexity and constantly rising level of automation in different plants require the use of HMI and SCADA systems. These systems support both very small applications, with only a few dozen data points, as well as large-scale plants with several 100,000 process variables. Visualizations are required to adapt quickly and effectively to the requirements of the application. SolutionCenter provides solutions for this based on standard technologies (OPC UA, HTML5 ...).

Highlights of all-in-one engineering

Simple

- Seamless and flexible operating concept

Efficient

- No redundant or unnecessary manual entries
- Reuse on all engineering levels
 - Program code
 - Configurations
 - Diagnostics

Universal

- One tool for all areas of engineering
 - Configuration
 - Programming
 - Diagnostics
 - Testing

Diagnostics

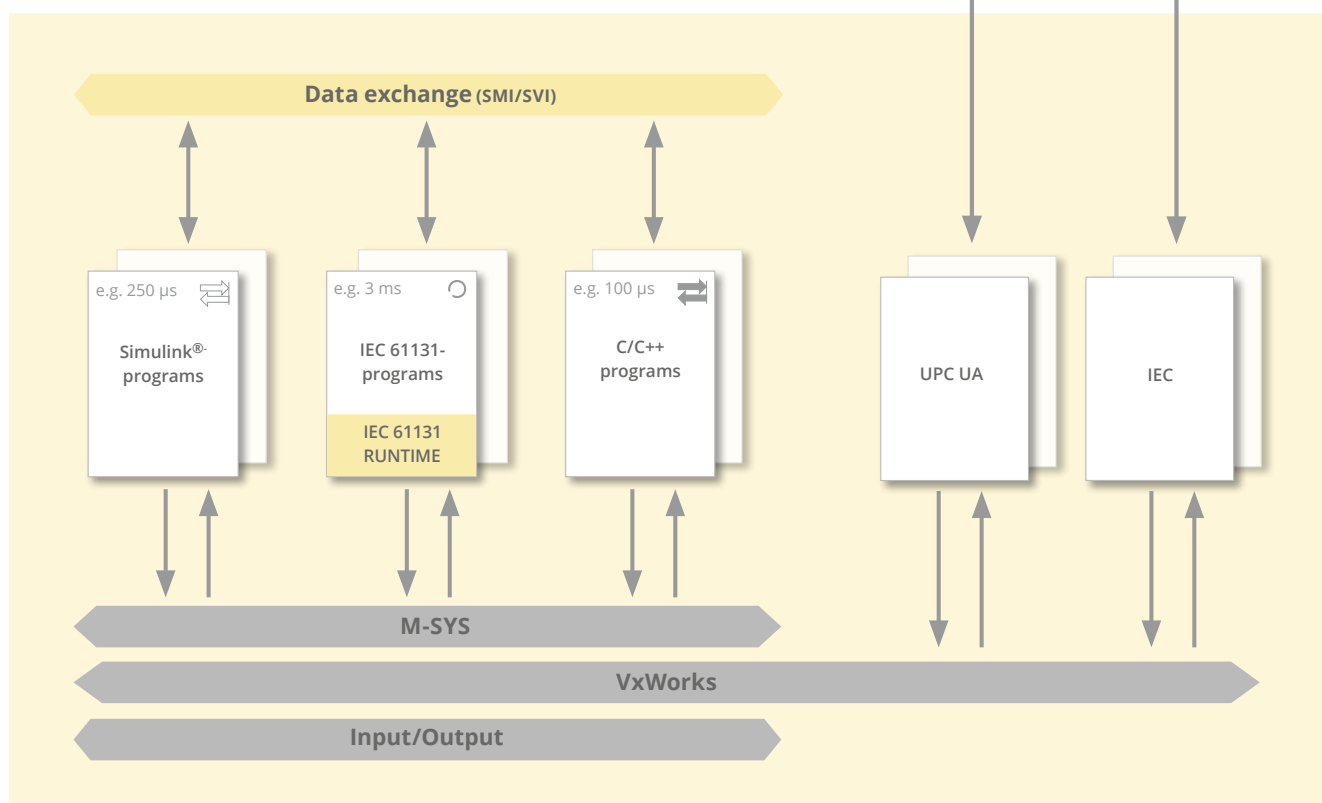
In all engineering phases, SolutionCenter offers an interface to all the information about the plant. With dynamic processes, the display of physical variables as numerical values is often not enough. The »Scope 3« Software Oscilloscope enables automatic long-term archiving (logging) as well as the automatic recording of sporadically occurring events in relation to other process variables. The acquired data can be archived in a database for subsequent processing. »Scope 3« is fully integrated in the Solution-

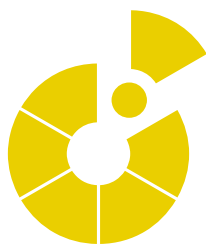
Center. This for example enables Scope recording configurations to be assigned to a project and managed in the integrated version manager.

Operational control

During the operating phase, SolutionCenter provides support with a clearly arranged display of all turbines and subsystems. The actual operating state as well as all necessary parameters are clearly displayed. SolutionCenter provides all the turbine data and information required for the operation of the plant.

▼ **Comprehensive engineering:** Basic structure of the Bachmann M1 system for open and flexible design using standardized software modules.





THE FAST WAY TO RELIABLE DIAGNOSTICS

Scope 3 data recorder and watch list

Regardless of whether during commissioning, troubleshooting or maintenance – the more modern and complex the automated plant, the more important the transparency of information on process states and sequences in the overall system becomes. The Bachmann SolutionCenter provides users of the M1 automation system with all the diagnostics tools needed in one software solution and keeps all the data reliably in view – in real time.

Scope 3: Data recording at high speed

With many dynamic processes, the display of a physical variable as a numerical value is not enough. The latest software oscilloscope generation from Bachmann, »Scope 3«, shows the values of processes over time and puts them in relation to other process variables. The core of Scope 3 is a powerful data logger: It offers an outstanding scan rate that can be selected in a range from 100 microseconds to 60 minutes. Thanks to the multi-tasking architecture of the M1 automation system, several data series can be logged in parallel and with different scan rates. Interfaces for several application programs increase the functionality of the product.

Database with selective access

The archiving and provision of data are central issues for an automatically operating data recorder. With Scope 3 a database archives all data in the background and offers selective access to it. Archive size and archiving intervals can be set to individual requirements. All data from the online buffer and also from the database is available at the same interface.

Simple analysis of complex interrelationships

A simple click on the data recorder of an M1 controller enables data to be displayed immediately and makes it ready for analysis. The configurations can be managed in the work space and the logged data stored in a structured way. Besides frequently used graph functions, such as measuring cursor, zooming, color adaptations, Scope 3 now features important new functions such as curve recalculation, the graphical comparison of logged data or the fast Fourier transform function, directly available for the user. It is also possible for the user to implement his own calculation methods or export formats.

Simplified maintenance and service

In the event of a fault, a connection to the relevant machine or plant often had to be established in order to fetch the relevant data for analysis. In certain cases, work directly on site was then unavoidable. With Scope 3 this is no longer necessary. The occurrence of a fault automatically initiates the logging of the relevant data. Data generated around this time range can be incorporated easily with the pre-trigger and post-trigger func-

Benefits of »Diagnostic«

- Autonomous real-time data acquisition on the controller
- Long-term archiving by database configurable
- Number of recorded signals only limited by hardware resources
- High resolution (from 100 microseconds) and variable sampling priority
- Several trigger options as well as pre-trigger and post-trigger functions
- Data analysis with outstanding PC software
- Recalculation of logged data (standard algorithms, user-defined algorithms)
- Seamless integration in M1 web visualization

tions. After logging has been completed, a file with all the relevant data of the event is generated on the controller and automatically sent to the service technician by email.

The Bachmann watch list

When watching process variables, the user sees the controller as a black box: Defined signals are fed to the inputs and their trace observed at the outputs. If it is possible to read and write variables selectively, this enables conclusions to be drawn about the behavior of the automation system. For efficient work, however, a randomly sorted list of all controller inputs and outputs, as offered by most manufacturers, is not enough. That is why Bachmann offers a freely configurable variable list in the SolutionCenter – a so-called watch list.

The user defines the content

The variable list can be configured quickly by the user – by selecting the variables or channels with drag and drop or in the dialog window with an unlimited number of entered variables.

Different filter and sort functions are also provided that simplify the handling of extensive lists. The user can furthermore manually sort the variables and, for example, place the most important ones at the beginning of the list. Variables and channels of different controller systems can be managed in just a single list. In this way, overlapping processes in large machines and plants can be observed and followed.

Integrated setpoint definition

Setpoints for individual parameters can be defined very easily with the help of the watch list. These can be defined with multi-selection in a separate column and downloaded to the controller with just one command. Conversely, actual values from the controller can be entered directly as setpoints in the list. The Bachmann SolutionCenter also shows all the selected variables in a trend diagram. This makes it possible to trace signals over time without any extensive configurations required: for maximum efficiency with maximum certainty.



▲ **High precision:** The relationships of various process variables over time are analyzed and the exact values read out with the measuring cursor.



SIMULATION, PROCESS AND CONTROL

Model-Based Design

The growing size of energy plants and the use of new technologies are increasing the requirements placed on the automation used. Leading manufacturers are meeting the growing complexity of operational control and the control algorithms required for it with new development techniques. These enable technically mature and highly available plants to be brought out whilst saving development effort at the same time.

Highlights of M-Target for Simulink®

- Development of open-loop and closed-loop control algorithms with integration in the target hardware directly in MATLAB®/Simulink®
- Simulation modes for the I/O modules used in the application
- Automatic code generation and transfer to M1 controller without additional parameter setting
- Online communication between the Simulink® development environment and the PLC program for parameterization and diagnostics
- Integrated interface to automation programs created in conventional programming languages (IEC 61131-3, C/C++)
- Integrated interfaces to visualization systems and other PLC systems
- Support for hardware-in-the-loop systems with regression tests and environmental simulation

The design of comprehensive energy plants instead of individually isolated subsystems presents engineers with a new set of challenges. Simple analytical calculations provide insufficient information on the behavior of connected systems. One possible solution is an empirical approach, in which the information acquired is used in the solution process. What do you do, however, if a prototype is too expensive or its operation too dangerous?

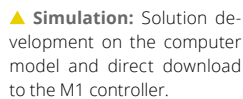
Simulation

Today's solution is: digital simulation. This enables the engineer to model the behavior of the entire energy plant in the simulation environment of choice. Irrespective of the software used, mathematical interrelationships are ultimately used to describe the response of the system. M-Target for Simulink® enables the simple use of computer-aided simulation, taking

the actual automation solution into account. The resulting virtual prototype is simulated as often as required, and both the parameters and environmental conditions derived from the user's design considerations. The viability and design risks of a new plant generation can thus already be drastically reduced during the development phase.

Quality and efficiency

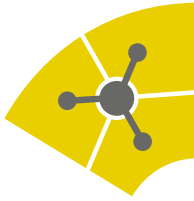
The engineer uses the simulation program not only for modeling plants, but also for designing the sequential and closed-loop control programs required for them. The use of new control concepts available increases the resulting product quality. Furthermore, the optimization algorithms used increase the yield of the energy plant concerned. Solutions that were developed with M-Target for Simulink® come into their own in this discipline. The MATLAB®/Simulink® tool



is fully automated and does not require any subsequent parameter setting on the controller. In this way, any subsequent compilation and configuration errors are excluded from the simulation from the start. The programmed controller is then available for use in a hardware in the loop (HIL) test setup, including regression tests, or can be operated directly in conjunction with the actual plant.

Cost optimized

The ability to also equip complex plants with advanced automation quickly offsets the inexpensive initial investment required. A transparent license model that does not require any quantity-based runtime licenses also simplifies the pricing of a completed wind turbine. M-Target for Simulink® thus makes an essential contribution to the aim of »bringing better goods to the market faster«.



COMMUNICATION IN ANY LANGUAGE

Efficient energy park networking

When different energy generators, such as from wind, PV, CHP and energy storage systems, as well as consumers are integrated in existing grids, the greatest challenge in implementing the project is the communication between systems. Communicative controller systems and standard protocols are first choice here.

Benefits at a glance

- Free choice of protocol without changing the automation
- Only one contact for automation and communication
- Always the required protocol available
- Ability to react flexibly and separate tasks
- Concentrating on the essentials: the core expertise
- No stock-keeping of additional devices
- Greater availability thanks to fewer devices used

Perfectly served with Bachmann

Bachmann's M1 controller system provides all the international telecontrol protocols required for energy technology as a software solution for straightforward and effortless installation. Additional hardware or modifications to the operational control program are unnecessary. This enables the requirements of the customer to be implemented quickly and inexpensively. The M1 is a genuine multi-talent here: It can control external devices as a master and at the same time be incorporated in a higher-level control system. Different protocols can also be operated on the same controller.

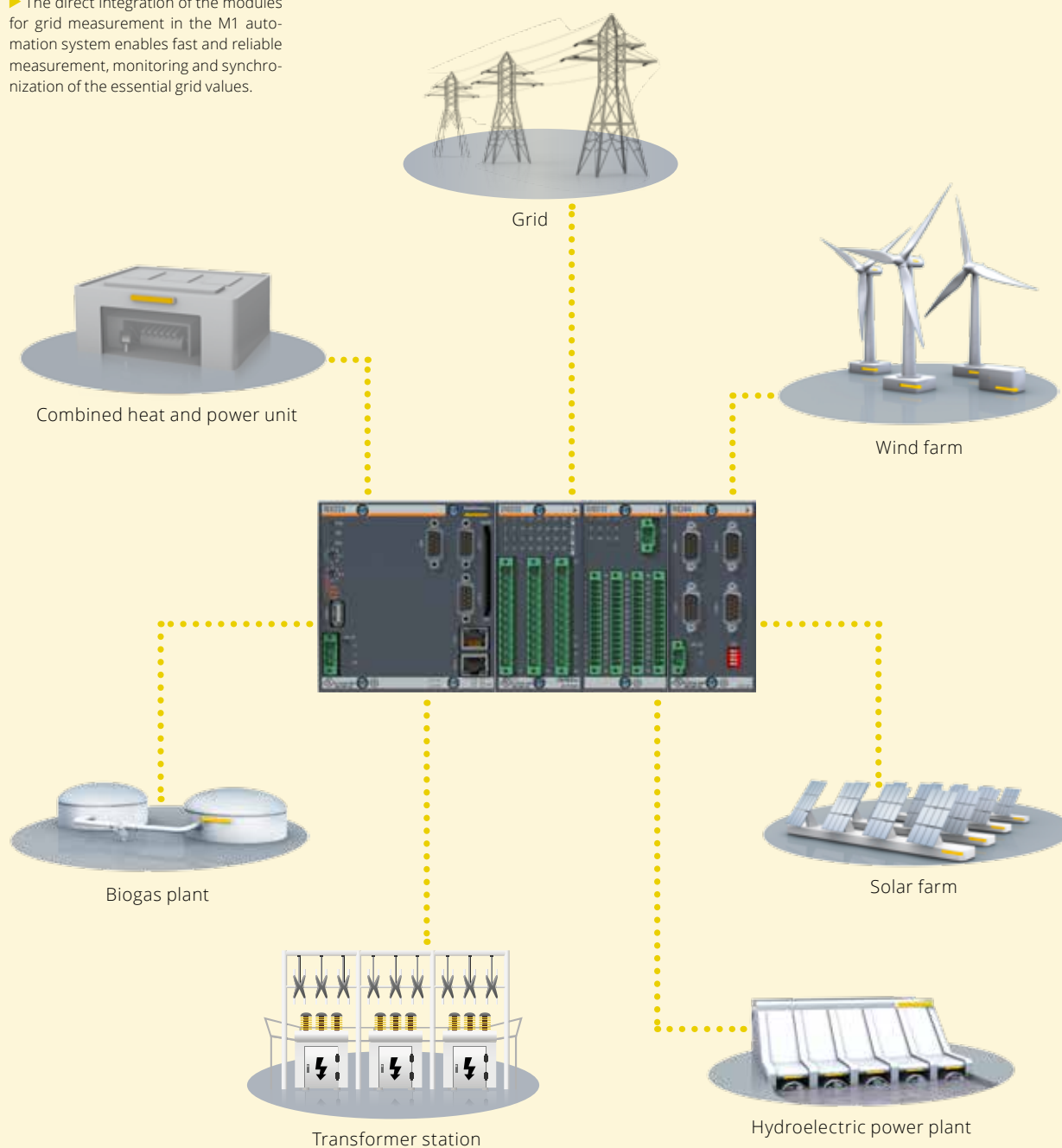
Preventing consequential damage

The constantly growing use of renewable energy sources in the grid is also increasing requirements with regard to communication: A continuous data exchange must be reliably guaranteed at all times – always in compliance with the relevant regulations and standards.

Application development in all languages

The SolutionCenter and M1 controller support a wide range of programming languages for example IEC 61131-3, C/C++ as well as MATLAB®/Simulink®.

► The direct integration of the modules for grid measurement in the M1 automation system enables fast and reliable measurement, monitoring and synchronization of the essential grid values.



Fieldbus communication

The openness of the overall system makes it possible to integrate third-party systems and components without any problems. The latest fieldbuses and telecontrol protocols are available for this.

PROFI[®]
NET

PROFI[®]
BUS

sercos
the automation bus

DeviceNet[®]

Modbus

FASTBUS

CANopen

EtherCAT[®]



DESIGNING STATE-OF-THE-ART VISUALIZATIONS EASILY

The world of visualization

The triumphant entry of smartphones and tablet PCs also in the industrial sector in recent years has led to considerably more requirements being placed on visualizations. This development has given manufacturers the opportunity to stand out from the competition with innovative operating concepts. Bachmann offers a complete product portfolio for a wide range of requirements in this area, from local machine visualizations, to SCADA systems for plants, right through to private cloud solutions.

The right solution for any application

The increasing networking of machines and plants arising from the onset of Industry 4.0 also opens up new possibilities in the field of visualization. More machine data can be extracted at several levels in order to maintain transparency and obtain new information. Bachmann's complete hardware and software solutions offer maximum flexibility and openness to ensure rapid implementation, easy maintenance and efficient expandability. The software solution is created from standard web technologies that are efficiently linked to data by drag and drop using a shared engineering tool. The hardware consists of a modular system made up of components that enable tailored solutions to be created quickly.

Machine visualizations

The server with M1 is directly integrated in the M1 controller for local machine operation. The visualizations are displayed on the dedicated web panels of the OT1200 product series.

Ready-to-use templates are available for other typical visualization tasks, such as alarming and the graphical display of trends or high-resolution Scope3 data. The visualization can also be activated for other terminal devices via http(s).

Plant visualization

atvise® scada enables the data of several controllers to be combined easily via the popular OPC UA standard. In this way, objects and types can be mapped to each other automatically. This architecture is suitable for the visualization of machines and plants, right through to entire control centers. The powerful panel PCs of the OT1300 series are used here both as an atvise® scada server and as a display device at the same time.

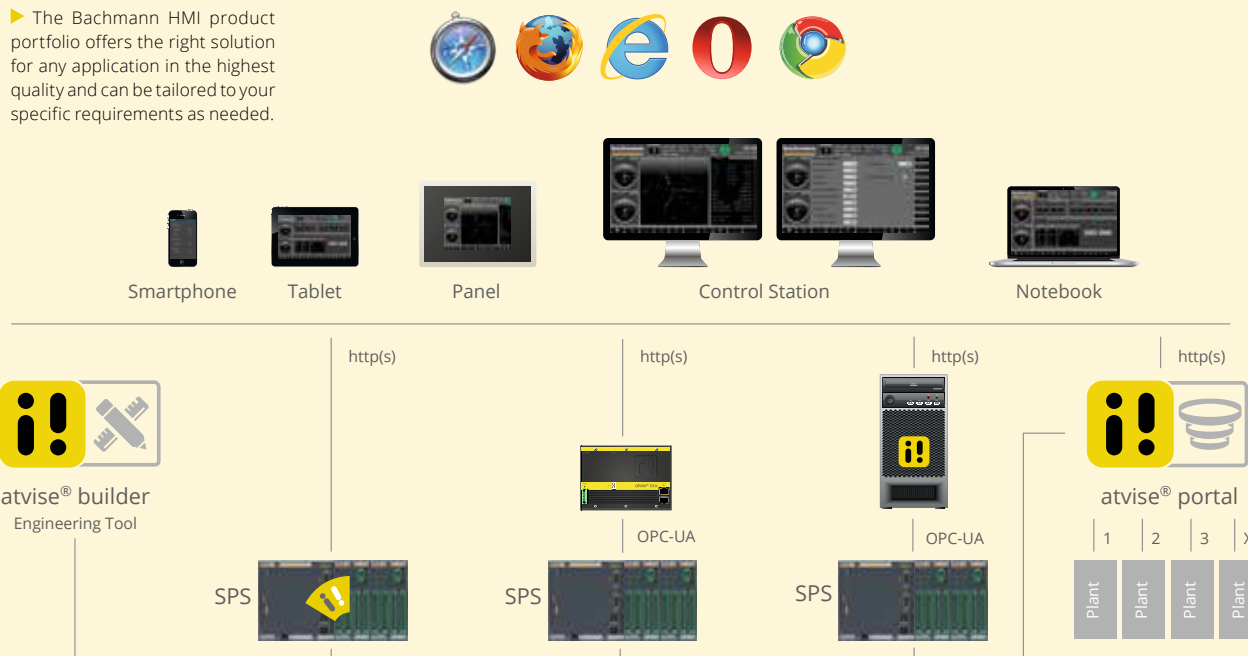
Visualization in the cloud

Information is one of our most valuable resources. Data has to be refined in order to optimize processes. The private cloud is the answer to sustainable data usage: The atvise® portal private cloud solution enables you to

Highlights of atvise® technologies

- The complete hardware and software solution considerably reduces the effort required for integration and testing
- Maximum flexibility and openness ensure rapid implementation, good maintainability and the possibility to expand the installation efficiently
- Complete user/group/rights concept incl. user-dependent language selection
- User interfaces in pure web technology

► The Bachmann HMI product portfolio offers the right solution for any application in the highest quality and can be tailored to your specific requirements as needed.



increase the efficiency of your remote monitoring applications – simply through the use of existing atvise® visualizations with just a single click. Important information is provided for the target groups specified, at the right time and place. A buffer mechanism guarantees the continuous transmission of real operating data, even if the network connections are unstable. Commands and alarm acknowledgements can also be sent back to machines in the field via an encrypted connection and the appropriate authorization.

Efficient engineering

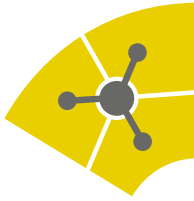
The engineering for all three levels, from the machine, to the plant, right through to the cloud, is carried out in the same development environment. Many typical tasks can be implemented quickly with ready-to-use components and templates. Additional options and variants for machines and plants can be created with dynamic configurations in a single visualization project. The use of standard web technologies also makes it possible

to seamlessly integrate the web services of third party providers.

The complete solution in view

The operator terminals have also been optimized for web visualizations, in line with the web-based software solution. The required browser, including an intelligent onscreen keypad, is already preinstalled and can be set up in a few steps to ensure rapid commissioning. The brilliant displays offer very good viewing angles, a bright image and strong colors to ensure the high quality presentation of the visualization. The trend toward widescreen diagonals and attractive multi-touch glass screens continues, and enables additional operating concepts that are already well established in the consumer sector.

For Bachmann, the world of visualization means having a perfectly matched portfolio for the visualization of web technologies from the machine right through to the cloud.



SAVING LOTS OF TIME AND EFFORT

CHP Template

The Bachmann SolutionCenter of the M1 automation system provides developers and manufacturers of combined heat and power units (CHP units) with a CHP Template specially tailored to their requirements. The template contains solutions for the most frequently required tasks for operating a CHP unit. This includes all the relevant functions for dynamic and static grid support according to the VDE-AR-N 4105 low-voltage directive and the BDEW medium-voltage directive.

Implementing new requirements quickly

Many manufacturers of CHP units want or have to implement new requirements on their plants. This includes for example the creation of virtual power stations or the implementation of the grid connection in accordance with the directives. These are tasks which require a far greater degree of freedom than the compact PLCs still frequently integrated in CHP units can actually offer. The CHP Template therefore provides support for this conversion work, which is sometimes considerable.

Directly usable – with certified Bachmann hardware

As well as the tasks needed for all aspects of grid connection, such as generator and grid monitoring, grid measurement and synchronization, typical close-loop control tasks can also be implemented. This includes, for example speed, power, phase frequency and voltage regulation as well as the regulation of the mixture or engine cooling circuit. The template, provided as a ready-to-use Codesys project in structured text, offers an extensive range of functions. The CHP Template provides these and other functions

as preprogrammed modules. The GSP274 hardware belonging to the library naturally meets the requirements of VDE-AR-N 4105, FGW TR3 and TR8 for generating plants on the low-voltage and medium voltage grid. This has been verified with the appropriate certificates.

Know-how protection included

All functions can also be modified or extended by the programmer as required. The development tools are kept with the manufacturer and are not needed for operation, whilst access to operating parameters and status displays can be controlled using an access rights system. The CHP Template therefore provides a highly effective basis for the engineering of a combined heat and power unit. However, it also provides sufficient room for implementing manufacturer-specific extensions, for which the know-how is protected all the time.

Web visualization

A web visualization is also provided for efficient testing and commissioning. The visualization of the CHP unit can also be adapted to customer requirements so that the CHP unit manufacturer can offer a unique product in terms of graphics and functions.



Components

- Motor control (starting, stopping monitoring etc.)
- Generator monitoring
- Grid monitoring acc. to VDE-AR-N 4105 and BDEW
- Grid measuring with integrated GSP functions
- Generator-grid synchronization
- Speed measuring, speed control
- Power control, phase-frequency control
- Voltage control, power factor control
- Mixture control/exhaust gas (lambda/pressure) with/without turbo charger
- Reverse power protection
- Derating
- Engine cooling circuit, heating circuit, charge air cooling circuit



Components

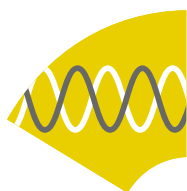
- Processing of anti-knock signals
- Emergency cooling circuit control
- Exhaust heat exchanger, room air cooling circuit control
- Control for throttle flap and gas air mixer (optionally also with stepper motors)
- Statistics recording such as operating hours, start counter, maintenance interval
- Alarm management/history, traffic light indication
- Saving machine parameters and loading in csv format
- Web visualization with user management



Separate program task for directive functions

- Static grid support
- Dynamic grid support
- CosPhi/P characteristic
- Q/U characteristic
- Startup ramp after mains supply failure
- Active power reduction with overfrequency (50.2 Hz characteristic)
- Adjusted power factor (CosPhi) control for LVRT
- Output setting through:
 - Binary inputs
 - Analog input
 - Setpoint
 - Telecontrol protocols can also be integrated
- Power factor control through:
 - Fixed CosPhi
 - Analog input
 - Fixed reactive power
 - Characteristics (CosPhi/P, Q/U)
 - Telecontrol protocols





SOLUTIONS FOR ENERGY SUPPLY

Power management

The widespread use of electricity in all aspects of work and life offers a multitude of benefits, greater convenience and an improved quality of life. In order to ensure energy-optimized solutions in production, in buildings and in infrastructures, there is a growing need for these to be based on suitable measuring systems. Bachmann offers both synergies through the direct integration in the PLC world as well as certified compliance with the latest regulations.

Modules for grid measurement

The energy efficiency of machines and plants has significantly increased in importance. This requires devices for operational measurement at individual machines just as much as the overall total measurement of consumption at an entire site (energy monitoring). At the same time, supply security must also be ensured at all network levels even when conditions are continually more difficult. So-called grid codes have been defined by grid operators because of the mutual interaction that occurs between energy generating units and the electrical supply grid. These grid codes stipulate the required behavior of generating units and also major consumers in the event of different grid situations or faults. Bachmann grid measuring modules accurately measure all relevant grid vari-

ables and provide the necessary monitoring/protection functions in order to adhere precisely and simply to the specified grid codes. The GSP274 module series also makes it possible to implement directly the actual synchronization of generating units with the supply grid.

Simple scaling and integration

Implemented as standard modules in the modular M1 automation system, they enable the simple scaling and integration of other measured variables via signal or fieldbus interfaces. Several telecontrol protocols, OPC, email and FTP are provided for routing the data to higher-level systems. The standard configuration and diagnostics in the SolutionCenter engineering tool supports commissioning and teleservice tasks.

| Application areas | GM260 | GMP232/x | GSP274 |
|--|-------|----------|--------|
| Operational measurement | ✓ | ✓ | ✓ |
| Energy monitoring | ✓ | ✓ | ✓ |
| Power quality | - | ✓ | ✓ |
| Monitoring/grid connection | - | ✓ | ✓ |
| Protection function | - | ✓ | ✓ |
| Online fault diagnostics | - | ✓ | ✓ |
| Generator connection (synchronization) | - | - | ✓ |

Grid and system protection

A range of 40 configurable monitoring functions enable the required combination of grid and plant protection to be set up easily. All the protection functions required by standard grid codes are provided. This ranges from multi-stage time independent voltage and frequency protection to Q(U), right through to phase shift monitoring. Time-dependent functions for LVRT and HVRT (low-/ high-voltage-ride-through) for dynamic grid support can also be configured easily via configuration points. The modules of the GMP232/x series have been extensively tested by TÜV Nord (German Technical Supervisory Association) and have valid component certificates (grid code compliant) in accordance with international standards: BDEW guideline, FGW TR 3 & TR 8, ENA ER G59/3, IEEE C37.90.

Fault diagnostics

The time sequence data can be recorded at a resolution of up to 100 μ s, either manually or when a protection function trips. The adjustable pre-trigger thus also enables the time leading up to the fault to be recorded. The fault recording can be saved in the SolutionCenter or directly by the application program in the established Comtrade format (IEEE Std. C37.111) or passed on. Each protection event is recorded in the internal event memory, together with all time stamps, which can be synchronized externally.



GM260: Grid Measurement Module

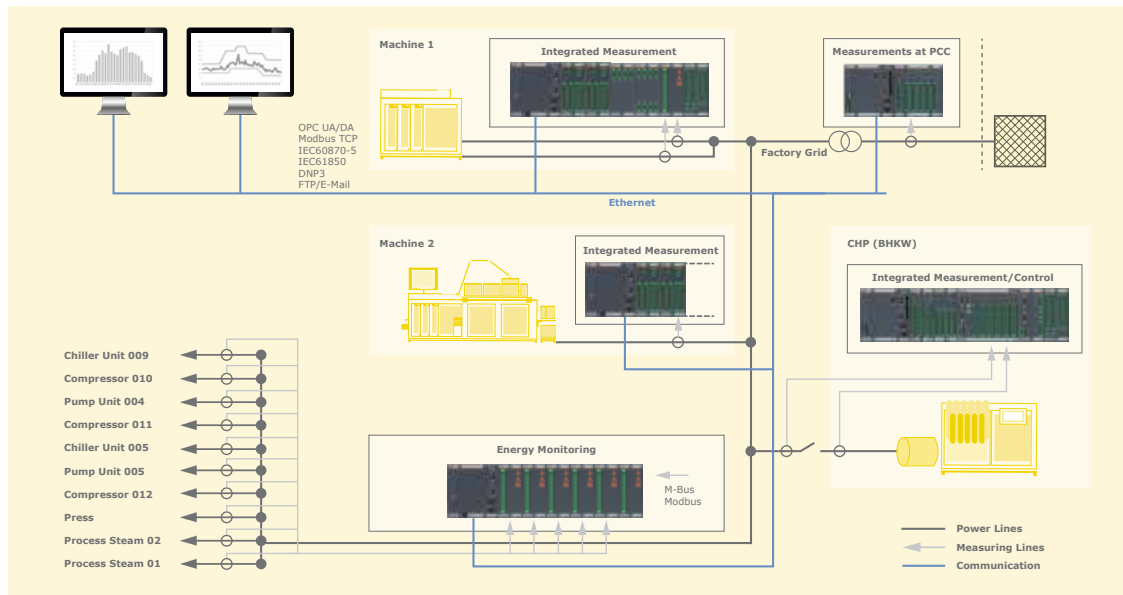
- Compact design for 2 three-phase branches
- Measurement of current, voltage, frequency, power, power factor, phase angle
- 2 independent 4Q energy counters (active and reactive power, drawn/supplied)
- Accuracy V: 0.2 %, I: 0.3 %, P,Q: 0.5 %
- TrueRMS calculation online
- Rated voltages up to 480 V directly connectable, 1A standard CT
- Cert.: CE, UL, DNV-GL, ABS, LR, BV

GMP232/x: Grid Measurement and Protection Module

- Highly accurate measurement of current, voltage, frequency, power, power factor, phase angle
- Separate 4Q energy counters for TRMS and fundamental
- Rated voltages up to 690 V directly connectable, 1A/5A CTs
- Accuracy V: 0.1 %, I: 0.1 %, P,Q: 0.2 %, f: 1 mHz
- Measurement of grid harmonics up to the 50th as individual amplitudes, THD, TDD (power quality)
- Monitoring functions for grid and generator protection including:
 - Overshoot/undershoot of V, f
 - Rate of change of frequency
 - Maximum power, reverse power
 - Asymmetry, vector jump
 - Fault Ride Through (LVRT/FRT)
 - Voltage dependent reactive power protection (Q(U))
- Direct relay outputs for circuit-breaker/trip circuits
- Integrated real-time data recorder
- Integrated event logging
- Automated data aggregation (MEAN, MIN, MAX)
- Measured value simulation
- Cert.: CE, UL, BDEW (TR3, TR8), ENA ER G59/3, IEEE C37.90,...

GSP274: Grid Synchronization and Protection Module

- Measurement of current, voltage, frequency, power, power factor, phase angle
- 4Q energy counter
- 7 voltage, 4 current inputs
- Synchronization monitoring
- Rated voltages up to 480 V directly connectable, 5A standard CTs
- Accuracy V: 0.1 %, I: 0.1 %
- Measurement of grid harmonics up to the 50th as individual amplitudes, THD, TDD (power quality)
- Monitoring functions for grid and generator protection including:
 - Overshoot/undershoot of V, I, f
 - Rate of change of frequency
 - Asymmetry, vector jump
 - Fault Ride Through (LVRT)
 - Voltage dependent reactive power protection (Q(U))
- 4 direct outputs for circuit-breakers/trip circuits and 2 relays for grid and system protection
- Integrated real-time data recorder
- Integrated event logging
- Measured value simulation
- Cert.: CE, UL, BDEW, VDE AR4105, G59/3, IEEE C37.90,...



Plant integration with synergy

The Bachmann energy modules guarantee the reliable and fast measuring of all essential grid variables for a wide range of applications. From operational measurement directly in the generating unit to the monitoring of entire distribution panels, right through to higher-level power quality monitoring, system protection or the synchronization of generator plants. The I/O interfaces of the M1 system offer an ideal addition to the measuring units, and communication protocols, such as IEC 61850, IEC 60870, DNP3, OPC or Modbus, are available for routing data to higher-level systems.

PLC integration

Bachmann's grid measurement modules comply with the design of the signal modules of the M1 system. When mounted in main stations or substations of the modular PLC system, they supply the key characteristic values of the measured three-phase systems already as channel values. The configuration of communication elements or setting of fieldbus parameters becomes unnecessary. Values recorded from a highly dynamic process are provided in the user program without any delay caused by asynchronous bus cycles. Especially time-critical or safety-critical functions, such as protective tripping in the event of limit violations, are processed by the modules completely autonomously. The grid module can also be spatially separated from the PLC if it is mounted on an electrically isolated substation connected via fiber optic cables. Insights gained from measured values

or the status of the operational management can be incorporated into the energy tasks at any time, and vice versa. These correlations firstly allow the particularly low-stress operation of the plant, whilst also providing the basis for indirectly determining operating conditions and faults (for example, a change in power consumption in the particular operating state can indicate faults in heating circuits).

No separate signal lines or tools are required for monitoring and remote maintenance. By being integrated in the security concept and rights system, access to the grid modules and their data management are also controlled.

Configuration and display

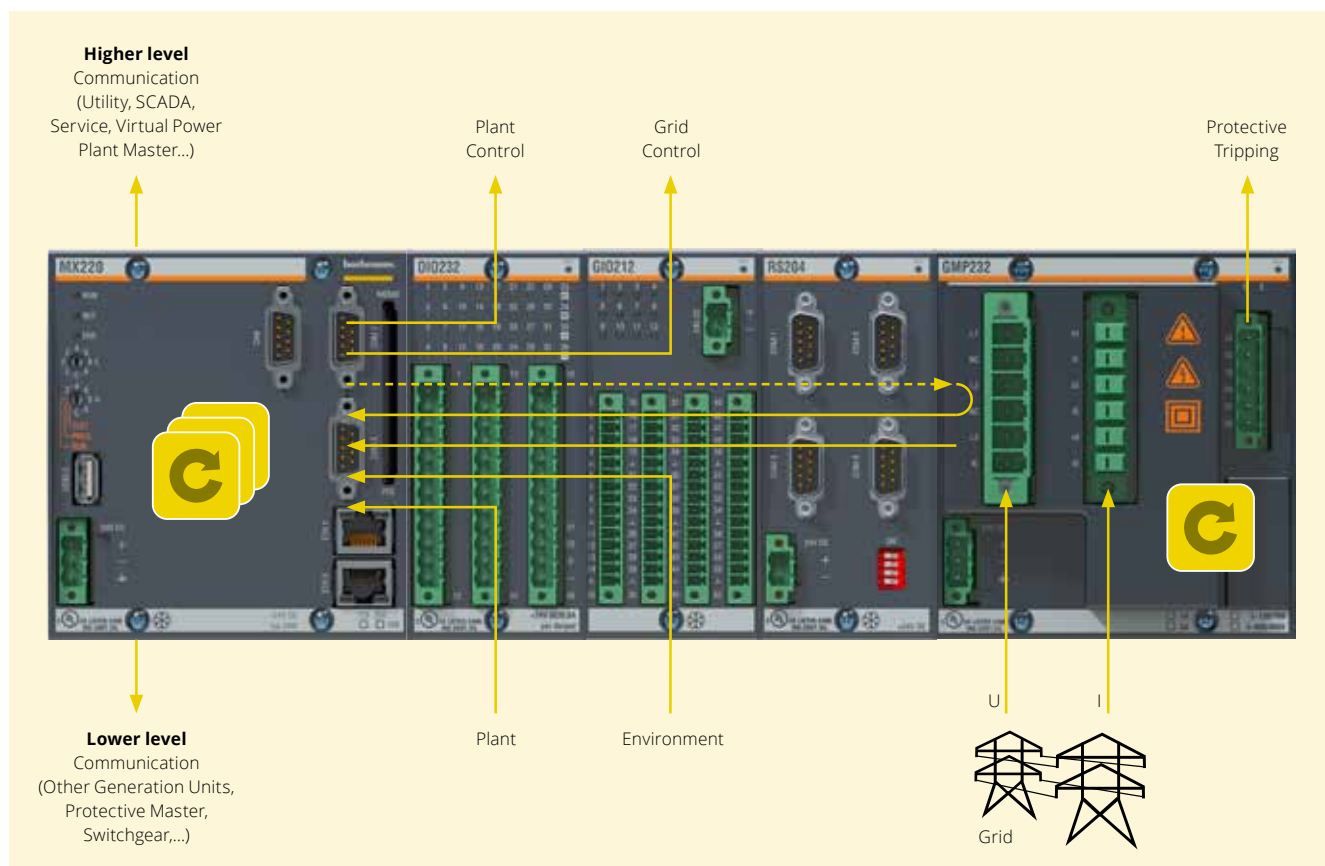
Grid modules from Bachmann are fully integrated into the SolutionCenter. Configurations can be created efficiently and saved for reuse at a later time. An automated comparison of limit values set online with saved configuration files makes it easier to locate changes. The user interface shows both the recorded channel values and the derived (calculated) variables. Development, commissioning and fault analysis are simplified with tabular, vector and time sequence displays. It is also possible to configure all measured and calculation values of the monitored three-phase grids as graphic displays in a dynamic web interface (webMI). The actual sequence of protection events (sequence of events) can be viewed in the event log of the protective devices. Thanks to globally synchronization time bases (SNTP,

The Highlights

- High-performance data connection via backplane bus
- Minimum delay/high dynamics
- Cyclic request or grid event-based updating (events)
- Correlation of various grid variables, correlation of different operating values
- Controller CPU permits additional calculations and combinatorics (based on provided calculation values or sampled data)
- Configuration management together with the M1 automation system
- Monitoring/data display via SolutionCenter, local visualizations (webMI) or SCADA via tele-control protocols and fieldbuses
- Security and remote maintenance via M1 automation system

IEEE 1588 PTP), the event sequence can also be reconstructed from remote stations. The modules of the GMP and GSP families offer a high-performance data recorder that can be directly integrated. If a protection event occurs (or if called in the PLC user program), high-resolution time series of selected grid values are also logged. The time leading up to the trigger-

ing event can also be logged using the pretrigger function. The data can be exported and transmitted in CSV or Comtrade format (IEEE Std. C37.111). Power quality values, such as harmonic spectrum or various distortion factors, can be displayed immediately in the Solution-Center without the need for any programming, or read via the application program.





SAFETY WITHOUT COMPROMISE

Safety Control

Modern safety solutions using a programmable safety controller make it possible to implement functions that go far beyond the conventional emergency-stop chain. Bachmann offers a complete safety package that is successfully used in a wide range of different applications under the toughest conditions.



In modern machine and plant building, the protection of personnel and systems is regulated by the new Machinery Directive. This directive and the associated safety standards stipulate the use of the latest methods and measures in the implementation of safety devices in order to ensure the optimum protection of people and goods. In addition to this, each safety component is developed and tested under the supervision of a certification body. Operators of energy plants not only benefit from the increased personal protection provided but also benefit financially. Critical signals can already be acquired and evaluated using several sensors.

An approved component such Bachmann's SLC284 safety processor module, combined with the integrated testing and monitoring functions, eliminates the need for multiple acquisition whilst keeping life cycle costs low at the same time.

Safety engineering under control

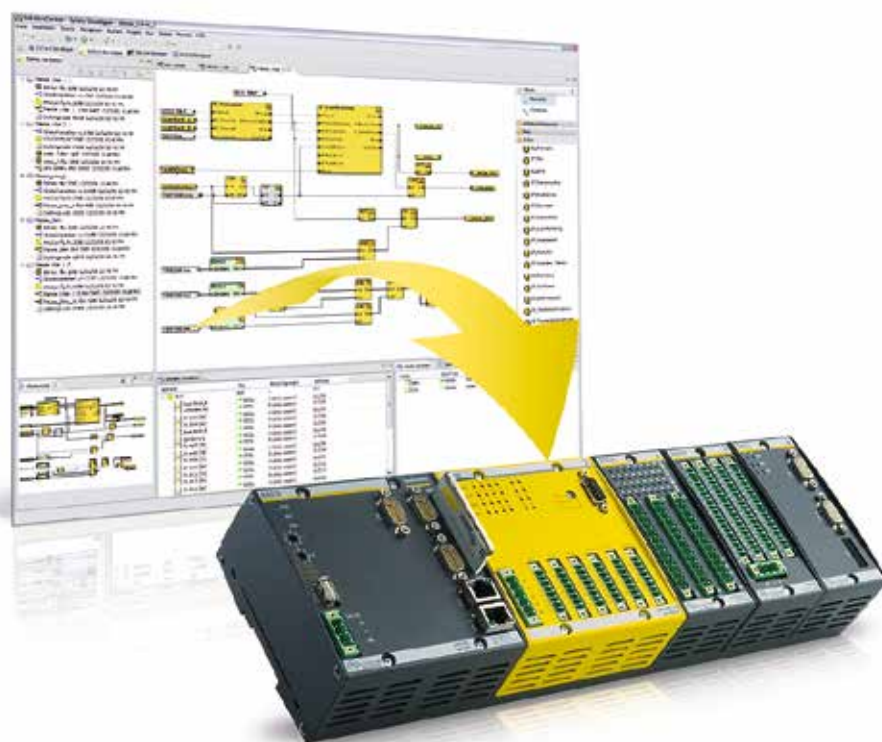
The safety components from Bachmann are ideally equipped for use in energy plants. Operational control, safety engineering and operating devices are perfectly matched and offer open communication. The fastest possible response times, intuitive opera-

tion and comprehensive diagnostic options guarantee the highest possible level of safety. All Bachmann safety modules are certified with the highest safety category SIL3 and PL3 for machines and systems. The safety modules can be arranged within the plant control system as required, thus enabling the implementation of individually tailored solutions. Safety channels that are not required can be used as standard digital I/Os without any restrictions. Safety relays can be replaced thanks to the 2A outputs of the remote SDO204 output module. This saves space, wiring effort and additional costs. With the integration of the Safety Developer in the SolutionCenter engineering tool, Bachmann makes safety programming easy for the user on the basis of established standards such as IEC 61131-3 and PLCopen Safety. All the safety modules of Bachmann, together with

the necessary programming tools and function blocks, have all been certified according to the relevant standards by the TÜV Süd certification body. UL508 approval also ensures safety when operating in North America. All modules are available as coldclimate versions. Safety is thus also guaranteed in extreme environmental conditions.

Benefits for manufacturer and operator

Programmable safety engineering makes practical implementation and daily use easy. It enables the secure monitoring of all the internal states of an installation during operation, including the safety circuits, also via teleservice functions. Bachmann offers you tailored solutions based on the experience gathered from thousands of successfully used control components in energy plants all over the world.



Safety standards and regulations

- IEC 60945
- IEC 61508
- ISO 13849
- IEC 62061
- EN 61511



KNOWING THAT PLANTS AND DATA ARE SECURE

Security

Modern business models for plant manufacturers require access to controller networks and control consoles via Intranet and via the Internet. Without the use of suitable mechanisms, the expanding network increases the possibility of plants being accessed without authorization. The unauthorized manipulation of processes here can result in serious damage. Furthermore, the complete logging of interventions is now even a statutory requirement in some sectors. Protection from unauthorized access and the targeted assignment of rights are therefore a top priority when networking plants.

The direct result of targeted malicious access to a machine controller or an unknown operating error are the same: downtime or even destruction of a machine or plant and therefore production outage, loss of reputation and money. Ensuring robust protection against faults is therefore an essential priority. Data and communication protection as well as the logging of accesses are preventative measures that make unauthorized access difficult and highlight any abnormalities.

Targeted access

Exposed machinery and plants do not have the same perimeter protection as enclosed manufacturing plants. Microgrids, energy storage systems, wind turbines or biogas plants are thus relatively easy to access, and the response times in the event of a detected security breach are high. The high risk to production plants mainly arises from the authorized personnel. The service personnel of external service providers or a dismissed employee who is intent on causing willful damage are two clas-

sical examples. At risk here are switches, routers and controllers with free ports. These can be used to cause faults unnoticed or for the targeted interception of communication. Bachmann controller components provide a range of measures to counter targeted access.

Security as standard

An effective security management system not only helps with unwanted and potentially destructive hacker attacks. Particularly in the protected environment of production plants, any accidental modification of machine parameters or configuration errors in the machine network are difficult to fully exclude. The effect of these, however, is often as serious as outside threats. Bachmann protects plants from production failure caused by unauthorized manipulation with a 5-level security concept. The entire Bachmann CPU product range comes with all security functions as standard. This therefore provides the user with an optimized ready-to-use security package.

The Bachmann Solution: Manipulation protection

- Integration of security functions into the basic functionality
- Protection from unauthorized manipulation with a 5-level concept
- Simple configuration and adaption
- Convenient user and password management
- Precise access logging, regression tests and environmental simulation



Level 1: Protected network

- Tap-proof data transmission through encrypted network connections
- Band width limitation to defend against overload attacks and for protection from faults in the network periphery



Level 2: Tap-proof communication

- Access control based on integrated user and password management
- Server and client authentication for the protection of automated teleservice accesses
- Secure end-to-end encryption to the latest state of the art (TLS 1.2)



Level 3: Authorized access control

- Rights are examined irrespective of the access path to the controller (visualization, SolutionCenter or with OPC UA)
- Restriction of system and execution rights for every user
- Role-based access control with groups (users inherit group rights)
- Individual configuration of access protection and visibility of files and process variables



Level 4: Hardened operating system

- The saving and running of additional applications can be prohibited
- Memory protection measures so that third-party processes cannot access the memory of the application
- Detailed logging of all user accesses with all user data and partition encryption



Level 5: Secure user applications

- Open interfaces to adapt and enhance all access control functions and for the use of cryptographic functions in applications
- Backup and recovery mechanisms
- Predefined security levels as templates for simple configuration



LONG-TERM AVAILABILITY IN ENERGY TECHNOLOGY

Saving resources

Energy plants are usually in operation for decades, so that the automation systems have to be available for a very long time as well. Long-term availability in this context refers firstly to the long service life of the components and secondly, the possibility to easily replace hardware modules or make system enhancements to hardware and software even after 15 or 20 years.

Ensuring the availability of machinery and plants is always the key objective here. For this the automation components must be able to run continuously in failsafe operation. This requires AAA quality and a proven high level of reliability. If a device replacement is nevertheless required, the controllers must be 100 % compatible both mechanically as well as functionally. Functional compatibility is important so that no software adaptations are required when a module is replaced. The controller must be mechanically compatible so that the new device can be replaced and connected 1:1 in the existing system.

Quality standards

Highest quality standards in product development and manufacturing are the foundation of long lasting automation components. At Bachmann, a quality assurance system to ISO 9001 has already been in place since 1996. The development standard based on the V model, in which each development phase has a corresponding test phase, has already been in place at the company for 15 years. The detailed and complete documentation of all processes in development and production gives Bachmann still today easy access to articles over 20 years old, so that they can be produced as repair spares according to

the same standards and processes as for the latest products. Bachmann designs and manufactures its test equipment itself. The in-house development of test equipment ensures that testing and measurement processes meet the latest technological and normative standards. It also makes it possible, when necessary, to test older equipment required as replacements for repairs.

Intelligent component management

A module is only as good as the components it consists of. That's why Bachmann only relies on high quality components from reputable suppliers. All incoming components also have to meet a host of other criteria as well as providing the basic function. In an extensive process, a team of experts examine components in terms of supply security, quality, failure probability, price, identification, packaging, approvals and naturally correct operation. Their processing by the manufacturing department is inspected and the development department carries out function tests up to the limit of the load tolerance. Incoming goods tests are then defined and audits are carried out with manufacturers and suppliers if required. Only when the result reports do not show any objection to the use of the components does the automation specialist release them in

the article master data for the defined applications. Through intelligent supplier management, Bachmann ensures the long-term availability of each individual component by using only reliable manufacturers and robust technologies as well as running a second source strategy. All components are also monitored in a database in relation to their life cycle, which can lead to warnings like »do not use for new developments« right through to the active replacement through redesign. Bachmann thus ensures that all required components, even after 15 or 20 years, are available to make replacement equipment.

Climatic test

In the development phase, a wide range of different internal specification tests are performed in accordance with the standards and requirements of certification bodies. These include climatic tests according to the European standard EN/IEC 61131-2, which lays down the equipment requirements and tests for programmable controllers. All automation components at Bachmann also undergo temperature change tests according to EN/IEC 60068-2-14 (test Nb). The highly accelerated life test (HALT) climatic and stress test subjects the test objects to conditions that are more severe than in an Arctic climate. The HALT test exposes an electronic mod-

ule for release to a climatic change test under full load and in excess of the normal operating temperature limits (from -60 to +90°C).

The functional limits in the temperature range are tested first of all, i.e. the temperature range is continually extended at full load beyond the upper and lower limits in cycles until the device ceases to function. In the second test, the controller is subjected to vibration in all six directions across a broad frequency range and at increasing intensity every cycle until it fails. The shocks range up to 25 times the gravitational acceleration. In the third step, an identical module is exposed to the combined temperature and vibration limits at which the modules previously still functioned, until failures also occur in this combination. In these extreme conditions the test objects are effectively aged and damaged in order to determine any electrical and mechanical weaknesses early on. In this way Bachmann tests the electrical function of the device and its reserves, the component dimensioning as well as the electromechanical design, such as solder points and connectors. Only in this way is it possible to detect and rectify damage already in the development phase that would otherwise only appear during operation 15 to 20 years later.



▼ Iced up controller during a HALT test.





▲ MC test laboratory

Interference immunity thanks to in-house EMC laboratory

Automation products in the EU are required to observe the guidelines for electromagnetic compatibility. However, the measurement of electromagnetic compatibility (EMC) presents a particular challenge since the results cannot be predicted or simulated in every case. Bachmann has therefore set up its own EMC test laboratory, in which all the standard tests for interference immunity, such as electrostatic discharge (ESD), burst (interference from high frequency switch operations) and surge (high energy pulses caused by switching large currents) can be carried out. The standard here is set by Bachmann's own stringent EMC guidelines, which provide a large safety margin over and above the requirements of the general standard. The Bachmann EMC test bay can test emitted interference in a frequency range from 30 MHz to 3 GHz. Thanks to its advanced multiple shielding through shield plates, ferrite tiles and specially coated polystyrene pyramids, the chamber is designed for a frequency range from 1 MHz to 18 GHz. This makes it easy for Bachmann to test improvements to devices directly in terms of their EMC and implement them quickly.

Before production release

The following function tests include component tests, in which all modules are tested for features such as functionality, accuracy, response to faults, diagnostics, robust design, maintenance ability, usability and efficiency. System tests then test the specifications of the devices in the networked automation system. Only in this way is it possi-

ble to test the interaction with other modules or the effects of particular constellations. Individual acceptance tests are also carried out by the appropriate customer advisor for complex applications involving custom developments and new developments. The production release for a new automation component is only issued when all the tests described have been successfully completed.

Quality in series

Quality assurance in series production starts with a visual inspection. This is an automatic optical inspection (AOI) based on an ideal picture. In this way, any mechanical deviations, such as short circuits, positioning errors, breaks or incorrect components mounted on the printed circuit boards can already be identified. Bachmann either removes any affected boards or reworks them. The detected faults are then reported back to the preceding process in each manufacturing and test step so that systematic problems can be rectified immediately. The subsequent InCircuit test (IC) applies power to the controller boards and is the first electrical test in the production process. This can detect fault patterns such as the following: short circuits, missing components, incorrect component orientation, tolerance problems, incorrect component values or unsoldered components.

Bachmann's high standard of quality assurance is particularly demonstrated by the so-called run-in test, a climatic and function test, which every module has to undergo before shipment. For this continuous testing of the finished product the mod-

ules are placed in climatic chambers, in which they are switched on and off continuously at a particular rhythm for 48 hours and also through extreme temperature changes. This process creates the artificial aging of devices and thus induces the failure of any defective components. The probability of failure of electronic components is normally at its highest during the first few months of use and then not until the end of its service life. The expedited artificial aging provided by the run-in tests enables the more susceptible initial phase of a device's life cycle to be avoided. This means that if faults are to occur at all, then this happens in the test laboratory and not in operation. The 48 h run-in test thus makes a significant contribution to increasing the reliability and lifespan of Bachmann modules.

Intelligent design

A design with maximum longevity is of key importance. Thanks to its considerable design reserves, the Bachmann modules have a particularly long service life. They are specified for ambient temperatures up to 60 °C, whilst only 50 °C is required as the market standard. This means that the modules have up to twice as high a lifespan during operation at ambient temperatures of below 50 °C. Thanks to the metal housing and high quality screw connections, the modules have a high degree of robustness. The high quality standards in product development and manufacturing have enabled Bachmann to implement automation architectures with a proven availability of 99.97 %. The calculated values for the mean time between failure (MTBF) also verify the high degree of reliability of the modules: This is 200 years for CPUs, up to 400 years for digital I/O modules and 200 years for analog I/O modules.

Compatibility

Besides the quality of the hardware and software, their compatibility for secure long-term availability is critical. Bachmann has therefore drawn up internal guidelines with clear rules for compatibility and which apply in parallel with the development guidelines. With this concept, Bachmann aims to enable the user to replace a CPU with a more powerful or newer one, to simply insert the memory card of the »old« CPU in the new one, and to restart the new one without any software adaption necessary, fully in line with the »plug and play« principle. Software design is playing an increasingly more important role with regard to compatibility. The architecture of the system software, such as the many possibilities of the engineering software for the M1 automation

system, ensures that the user program is compatible over different controller generations. Bachmann's entire automation architecture is generally designed to be modular and open, with the ability to be expanded flexibly. This not only simplifies the use of the automation systems, but also increases long-term availability through the principle of backward or downward compatibility.

The hardware modules can also be configured flexibly. The latest generation of Bachmann's I/O or function modules offers the same functionality on delivery as the module to be replaced. The special feature is that new functions, which for example were not yet possible years ago with the first delivery, can also be added by simply configuring in Bachmann SolutionCenter. This multi-function capability leads in many cases to the possibility for several older modules to be replaced with just one new one.

▼ All Bachmann modules undergo a 48 hour run-in test in the climatic chamber.



OUR CUSTOMERS

Applications in energy technology

Many of the leading global manufacturers and operators of energy plants rely on us. Together with them, we are setting new benchmarks and achieving new success.



**A FURTHER MILESTONE
IN ENERGY EFFICIENCY**

2G Energy AG

40



**EFFICIENT, RESOURCE-
FRIENDLY AND SAFE**

Bayern BHKW GmbH

42



GREEN ELECTRICITY, GREEN HEAT

enertec Kraftwerke GmbH

44



SIMULATING REALITY

Fraunhofer IWES

46



IMPRESSIVE INTEGRATION

GVH mbH

48



**ELECTRICITY FROM
THE ZILLERTAL ALPS**

Rittmeyer AG

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**COMPENSATING GRID
FLUCTUATIONS AT HIGH SPEED**

Schäfer Elektronik GmbH

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**ENERGY SUPPLY – SUSTAINABLE,
ALWAYS AND EVERYWHERE**

Qinous GmbH

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**INTELLIGENTLY CONTROLLED
ENERGY STORAGE SYSTEMS**

Younicos

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ANOTHER MILESTONE IN ENERGY EFFICIENCY

Bachmann automates the latest generation of CHP units

With the launch of its »avus 500 plus« combined heat and power plant, 2G has set a new milestone in energy efficiency – and with an electrical output of 550 kW and an efficiency of 42.6 % has impressively emphasized its technological leadership. The avus series is once more controlled by the Bachmann M1 automation system.



With 470 employees worldwide, 2G Energy AG is headquartered in Heek, Germany, and is one of the leading international suppliers of combined heat and power plants. The company offers integrated solutions in the growing market for highly efficient combined heat and power generation.

www.2-g.com

Over the course of the energy transition, combined heat and power units (CHP units) are increasingly gaining in importance in smart grid energy systems due to their plannable availability. 2G Energy AG is a company headquartered in Heek, North-Rhine Westphalia, Germany, that has consistently focused on the development and the construction of highly efficient CHP units for natural gas and biogas in the electrical output range between 20 and 2,000 kW. The units of the »avus« series available in the electrical output range from 500 kW to 2,000 kW achieve overall efficiencies of 85 % and more through the combined heat and power generation process. This enables CHP units to take on a noticeably more significant role in the energy mix and make a considerably greater contribution to the power supply. Frank Grewe, CEO at 2G Drives GmbH is convinced: »Combined heat and power generation provides an ideal supplement or even soon the efficient replacement of the large power stations that have dominated the energy supply to date.«

Compact high tech

The engines developed by the subsidiary company 2G Drives make an essential contribution to the total energy balance of CHP units. The »avus 500 plus« uses a water-cooled, turbocharged

12-cylinder gas engine designed for natural gas and biogas applications, but can also be run with synthetic gas containing hydrogen. Moreover all pumps, heat exchangers and other peripheral units are integrated in such a way that the reduced dimensions make it increasingly easier to install the CHP unit in an existing building infrastructure. »There is an increasing demand in the market for highly compact designs, particularly with high output units,« Frank Grewe explains.

Greater convenience

The integral optimization approach of 2G is not only applied to the engine and the mechanical design but also to the control technology and the software: »Our aim is to design the control of the unit to be as simple and as efficient as possible. This means: More convenience and manageability, intuitive operation and timely diagnostic options.« The operation and visualization of the »avus 500 plus« is implemented with the 10.4" monitor of the Bachmann OT1310 operator terminal. The new OT1300 series combines the latest technology, performance and durability with an attractive and slim-line design. The consistent use of industry standard components moreover guarantees long-term availability and thus investment protection.



◀ **Compact performance:**
»avus 500 plus« with an electrical output of 550 kW and an overall efficiency of over 85 %.

Perfect modularity

The ability to execute rapid responses and interventions is critical, particularly with the complex processes involved in generating and using biogas. »A service-friendly plant design and the full utilization of all possibilities to reduce stock-keeping are key requirements,« Frank Grewe describes one of the challenges and continues, »the modularity of the Bachmann M1 system used matches our requirements perfectly: We can make efficient use of the periphery, and this solution enables the same hardware platform to be used for all engine classes.«

Communication capability counts

The control and regulation of the 2G combined heat and power plants can be operated according to both the heating demand and the power demand. »As the M1 system comes with the communication modules needed, the connection to a virtual power station can also be implemented directly,« the development manager describes an important detail for the future. The simple and fast networking capability of entire plants via Ethernet and the associated access options are very important during operation. This was not least one of the important factors in the decision to also use the M1 automation system for the new avus

500 plus modules: »For profitable operation, the ability to continuously monitor the process and to access the plant remotely are after all essential for the operators,« Frank Grewe says.

Maximum efficiency and optimum benefit

In line with the corporate philosophy, optimum customer benefit was the prime objective in the development of the latest innovation. As Frank Grewe explains, the »avus 500 plus« modules represent a milestone and are an ideal solution to the long-term reduction of energy costs.« The Bachmann M1 controller is making its contribution here.



» The support from
Bachmann is excellent. «

Frank Grewe, CEO
at 2G Drives

EFFICIENT, RESOURCE-FRIENDLY AND SAFE

Control and monitoring of combined heat and power plants

of Bayern BHKW GmbH

The economical use of valuable raw materials and the considerably reduced environmental impact through the reduced production of toxic substances are key reasons for the use of combined heat and power units (CHP units). Bayern BHKW GmbH, based in Dorfen, Germany, produces compact combined heat and power modules and has an extensive knowledge base in this field. The company has relied on the M1 automation system from Bachmann electronic for controlling and monitoring its systems.



The beginnings of Bayern BHKW go back to 1921 when Sebastian Niedermeier used a water turbine to produce electricity for his own power supply network. In the sixties, the company produced the first power generating system with diesel and gas gensets. In 1984 the first landfill gas generator plant followed, and in the nineties Bayern BHKW started building high-end combined heat and power plants. The family run business based in Dorfen, Germany, now specializes in the construction of CHP units, and offers a range of services, including repairs and maintenance for CHP units through to servicing.

www.bayernbhw.de

Bayern BHKW has already been active in the field of power generation, cogeneration and CHP units for 50 years. Their modern systems are suitable for use with conventional energy carriers such as natural gas as well as for use with biogas. The efficiency of combined heat and power units is impressive: »The financial benefit is achieved by the high overall efficiency of up to 90 %«, says Michael Niedermeier, CEO of Bayern BHKW GmbH. »Electricity and heating costs are considerably reduced through the use of combined heat and power units; electricity is either fed into the public grid and remunerated or is consumed and used on site.« Compared to conventional energy generation, combined heat and power units in particular offer an impressive performance. »The carbon dioxide emissions have been reduced by up to 60 % and the nitric oxide emission by up to 25 %. Through the use of modern lean engines and catalyzers the emissions are also below all legal emission limits«, Michael Niedermeier explains the benefits of combined heat and power units.

Efficient engineering

The company has broken new ground with the Bachmann M1 automation system. The ingenious engineering software was a real benefit here. »The CHP unit template in the Bachmann SolutionCenter provided us with all the necessary functions already preprogrammed«, the CEO highlights a benefit of this solution. »We only had to make the necessary configuration and parameter settings and could thus considerably reduce the engineering effort required.« The function library covers all the tasks needed for grid connection as well as typical closed-loop control tasks. All functions can also be modified or extended by the programmer if required. Bayern BHKW values this flexibility and openness in the system. »This allows us to offer our customers a product that is maintenance-friendly and reliable«, Michael Niedermeier emphasizes. »Any requirements in the electricity market can be met automatically and without any major effort involved for the customer.«



Grid synchronization ensured

Besides the control functions, the monitoring of all operating parameters could be implemented with Bachmann technology. The GSP274 grid synchronization and protection module ensures a problem-free power feed into the grid and meets all the requirements of the medium-voltage directive. »All electricity generation plants on the medium-voltage grid must be certified to ensure supply quality,« Michael Niedermeier explains. »They must be self-regulating and stabilizing during the feed-in so that voltage stability is maintained.« The GSP274 combines measured data acquisition, fault tolerant grid and plant protection as well as the monitoring of grid synchronization in a single device. Thanks to the complete integration in the automation system, high-precision measured value data is provided for further processing: Any deviations in phase angle, frequency, voltage differences and many other parameters are recorded in real time. The protection functions of the module were tested by external certification bodies and the GSP274 was certified accordingly. »The complete package of the M1 automation system and the GSP274 enabled us to implement the medium-voltage directive without any major interventions and changes to the hardware,« Michael Niedermeier explained.

Visualization with web technology

The automation implemented was rounded off with M1 visualization. This makes it possible to easily combine the specified function blocks into an attractive user interface. The M1 auto-

mation system provides a web server and the visualization can be displayed on any terminal device. »Modern usability concepts here enable very easy operation for a wide range of user groups,« Michael Niedermeier explains. »With small plants in particular, M1 enables us to achieve cost savings since any permanently installed operator terminals become unnecessary. The possibility for mobile access also provides greater operator convenience.«

Impressive solution

At Bayern BHKW they are really impressed with the solutions from Bachmann. »We have achieved greater flexibility in programming, improved the performance offered by the controller and can guarantee a higher level of reliability,« says a delighted Michael Niedermeier. »The compact design is another benefit.« The CEO adds: »In our view, Bachmann offers the best product, and its service provision is also just what we want.«



» We are certain that we have chosen the right partner in Bachmann. «

Michael Niedermeier, CEO
of Bayern BHKW

GREEN ELECTRICITY, GREEN HEAT

CO₂-neutral and highly efficient small power plants

The expansion of renewable energy as an alternative to nuclear energy is one of the pillars of the energy transition. This requires the energy share in electricity generation from sun, wind etc. to be 40 to 45 % by 2025 and 55 to 60 % by 2035. Renewable energies are already number 2 in the energy mix with over 33 %. The energy supply is thus becoming environmentally friendly. The second pillar of the energy transition is energy efficiency. The use of decentralized energy production, such as from combined heat and power systems, plays an important role here. enertec Kraftwerke GmbH is a specialist in these particularly energy-efficient systems.



enertec Kraftwerke GmbH is a company that develops, produces and sells combined heat and power units with ratings from 20 to 400 kW of electrical or 40 to 560 kW of thermal output as ready-to-connect standard products.

www.enertec-kraftwerke.de

Combined heat and power plants convert natural gas or regenerative energy sources, such as biogas or sewage gas, into electric power using modern combustion engines. They meet the energy needs of the installation site and can possibly feed excess electricity into the power network. The thermal energy released is used simultaneously to provide connected consumers with heat. As a result, combined heat and power plants are very efficient and can be used wherever electricity and heat are needed. This can be in companies, hospitals, residential buildings or municipal facilities. Small, compact combined heat and power plants are also designed for use by private customers in private homes or apartment buildings.

Combined heat and power generation is gaining importance

The combination of generation and use of heat and electricity represents one of the most important technologies for energy savings and reduction of CO₂ emissions. This is called »combined heat and power generation« (CHP). This has a markedly higher total efficiency than conventional energy generation systems, where the electrical energy is generated centrally in large-scale power plants and thermal energy in a local heating system. Modern block heating power systems convert fuel into electricity and heat at around 90 % efficiency. The losses are thus only 10 %. This essentially double energy use massively reduces CO₂

emissions compared to a conventional power plant for pure electrical energy generation: There, significantly more than half the fuel's energy is emitted into the environment as unused heat. If the enertec block heating power systems use CO₂-neutral biogas or sewage gas, no additional CO₂ is produced at all.

System availability determines cost-efficiency

The cost-efficiency of block heating power systems depends on the number of operating hours per year. And so for manufacturers and their final customers, it is very important to use a robust, reliable system to control and regulate the block heating power systems. The unmatched high availability of the Bachmann M1 automation system convinced enertec Kraftwerke. In addition, enertec Kraftwerke values the openness and scalability of the M1 system: »The hardware and software concept developed together with Bachmann makes our systems 100 % modular,« says Matthias Lehmann, Director of Automation at enertec Kraftwerke, and is pleased that in this way many functions and characteristics can be used in all block heating power systems simultaneously.

Convenient project planning with the SolutionCenter

The large interface variety of the M1 system, from PROFIBUS to PROFINET, ETHERCAT, Modbus and CANopen, makes it easier for the enertec Project Planning Department to integrate it into the overall block heating power system. »The Bachmann SolutionCenter is also extraor-



»The unmatched high availability of the Bachmann M1 automation system impressed us.«

Matthias Lehmann,
Automation manager
at enertec Kraftwerke

dinarily helpful for our work,« Matthias Lehmann mentions. The programs for the machine process and process control, visualization and, last but not least, communication with the outside world are created quickly and conveniently here in a uniform environment without obstructive interfaces. »That enormously accelerates the engineering process up to startup and service,« the Director of Automation of enertec Kraftwerke confirms.

Demand is rising

To achieve greater independence from fossil fuels, demand for renewable energy and its efficient use will continue to grow considerably in the next few years. With its block heating power systems, which can be individually adapted to meet the respective needs, enertec Kraftwerke delivers customized solutions with high ecological and economic benefit for the most varied of buildings and application fields. Here, the Bachmann M1 system is an important element of the overall concept.

▼ **Highly efficient and environmentally protective:**
Block heating power plants from enertec Kraftwerke.



SIMULATING REALITY

GMP232 grid measurement module

in operation at the Fraunhofer IWES

The energy transition has put the spotlight on renewable energies as key sources of energy supply. In this process, the redesign of the power supply grid is of critical importance: After all, a wide range of different energy producers have to be integrated. The fact that the energy from the sun, wind and other sources cannot be supplied at a constant rate poses a major challenge. The PNI testing laboratory for grid integration at the Fraunhofer Institute for Wind Energy and Energy System Technology (IWES) in Kassel, Germany, provides the facilities for testing the necessary innovations on grid components and for testing grid operation in practice. It is here that Bachmann's GMP232 grid measurement module is making an important contribution.



The research activities of the Fraunhofer Institute for Wind Energy and Energy System Technology (IWES) founded in 2009 cover all aspects of wind energy and the integration of renewable energies into energy supply structures. The IWES in Kassel currently employs around 240 scientists, staff and students.

www.iwes.fraunhofer.de

At the PNI laboratory, grid components and equipment can be developed and tested in realistic conditions in terms of new system functions. The main focus of the laboratory is the investigation and testing of the grid interface of storage facilities, generators and combined heat and power generation plants. The PNI also focuses on adjustable load appliances, electric vehicles and transformers. Tests in the low-voltage grid up to 1.25 MVA and in the medium-voltage range up to 6 MVA are carried out here.

Technical infrastructure

The test facility and the test sequence is controlled from a central control room. All relevant electrical data, in particular power quality parameters, can be acquired, recorded and analyzed here: This is where the GMP232 grid measurement and protection module from Bachmann is used. »The GMP is integrated in the central controller and provides a wide range of functions that

are very important for the flexibility of our measurements,« explains Dipl.-Ing. Dominik Geibel, head of the specialist group for grid control and grid dynamics in the Systems Engineering and Grid Integration Division. The module can measure up to 690 volts. »We haven't been able to find this anywhere else,« Geibel sums up. »As we don't have to incorporate any external module, it offers us a considerable degree of freedom.«

Adaptable and easy to integrate

The GMP232 enables a grid point to be monitored completely. In all, 17 of these modules are installed in the PNI. »The GMP can be adapted to our requirements and that is exactly what we need here,« Dominik Geibel explains. Applications developed in Matlab® and simulated in Simulink® can be loaded directly onto the controller without any intermediate steps. This is important for future projects: Online simulations can be carried out without any training in special

programs required. »The GMP was one of the key factors in our decision to work with Bachmann,« the expert explains. What's more, compliance with IEC 61850 was also a persuasive argument. This protocol is used in the PNI to activate the switch panels and the decentralized generators in the grid. We also received very good support from Bachmann for the initial training. All entry obstacles have been as good as overcome. »We were greatly impressed by Bachmann's overall concept,« Dominik Geibel sums up.



» The GMP can be adapted to our requirements and that is exactly what we need here. «

Dipl.-Ing. Dominik Geibel,
Head of the specialist group for
grid regulation and dynamics
at the Fraunhofer Institute

Visualization with enhanced monitors

The controller is configured via the visualization of the Bachmann SolutionCenter – both for the web terminal displays in the laboratory itself as well as for the computers in the control room. »Here we use enhanced monitors for the GMP,« the engineer explains, »the Scope function and the grid diagram in particular are very helpful for our work.« Measurement information, such as the actual grid status or the power flows are clearly displayed. The data is synchronized using the Precision Time Protocol (PTP). The static and dynamic behavior of all kinds of decentralized generators can be tested on the grid interface in the PNI. Simulators for emulating PV installations are available for creating the all weather test conditions for PV power inverters. The benefits are obvious: For example, configurable dis-

tribution sections for low and medium voltage not only enable the testing of individual components, but also the testing of their behavior as part of a system. Mobile test apparatus also enables onsite testing, such as in large wind farms and solar farms. The IWES also offers these services to companies. However, the key interest of the PNI is the development of reliable new system components for the supply of power from renewable energies. Bachmann is actively engaged in the renewable energy field: The company is helping with its products to use these energies efficiently, safely and reliably. With the implementation of the GMP232 in the laboratory of one of Europe's leading research organizations, the company is helping to further advance this development.

▼ The activities of the research and testing laboratory for grid integration (PNI) include the testing of grid components and equipment.





**START
STOP
ENGINE**

IMPRESSIVE INTEGRATION

**Configurable and modular test stand control
and monitoring system based on M1**

Test stands for combustion engines are apparatus with an extremely high level of technical complexity. They must ensure reproducible operating conditions irrespective of external factors and must protect persons and the engine at the same time. They must also be highly flexible since virtually any test object requires an individual test setup.

Based on the M1 automation system, GVH mbH, which is headquartered in Dortmund, Germany, has developed a configurable and modular test stand control and monitoring system – and considerably reduced development times by using M-Target for Simulink®. The Gesellschaft für Verbrennungsmotoren und Hybridantriebe mbH (GVH) offers development and testing support for internal combustion engines as well as the prototyping of electronic control systems. GVH specializes here in the direct injection of gaseous and liquid fuel as well as the associated exhaust gas after-treatment.

Flexibility is key

GVH operates in a field characterized by short innovation cycles, not least because new emission guidelines are constantly stipulating new and more demanding requirements for engines. Furthermore, the subsystems for combustion engines presented by different suppliers continually present the developers at GVH with new challenges: The systems have to be converted and test conditions adjusted.

»The development of highly efficient and low emission drives requires short development cycles, particularly with regard to the integrated electronic real-time systems,« explains Dr. Tobias Musiolik, technical manager at GVH. In the past, similar test environments were implemented with conventional PLCs. However, these did not offer the necessary flexibility, so that the changes required couldn't normally be implemented quickly enough to meet expectations. Therefore the constraints soon came quickly for GVH when a new test bay had to be built with three engine test stands for utility vehicles and industrial engines with a rated output of up to 700 kW: »We wanted to develop an individually configurable and modular test stand control and monitoring system that also handles additional test stand automation tasks,« Dr. Musiolik describes the most important parameters of the project. »At the same time we needed an environment in which we could develop and adapt the necessary control functions without any dependence on external service providers, in the shortest possible time, and flexibly to meet requirements.«



GVH mbH (Gesellschaft für Verbrennungsmotoren und Hybridantriebe mbH) is an independent service provider for engine and component manufacturers, headquartered in Dortmund, Germany. GVH develops and builds engine test stands such as for gas engines for CHP units, truck engines or ship engines. It also offers testing and development services.

www.gvh-online.de



» The integration of the M1 automation system in the MATLAB®/Simulink®/Stateflow® tool chain offers much more than all the other alternatives we examined. «

Dr.-Ing. Tobias Musiolik,
Technical manager Development of electronic systems
at GVH

M-Target for Simulink® made an impression

Different solutions available on the market were examined as a result. It was ultimately the Bachmann M1 system that made an impression at GVH: »The outstanding integration of the M1 automation system in the MATLAB®/Simulink®/Stateflow® tool chain was the key factor, since it offers much more than all the other alternatives we examined,« Tobias Musiolik confirms. Changes to test conditions often require the implementation of solutions at short notice, which can virtually only be performed by internal personnel. In future, any necessary adaptations are tested using physical models of the environment system on the development PC fully in line with the model-based development process in virtual prototyping. »Parts of them can now even be parameterized before they are implemented on the test stand. Not only the development times but also the non-productive downtimes

of the system are considerably kept to a minimum,« Dr. Musiolik continues.

Complex system – with enough power reserves

The test engine is run under load on a combustion engine test stand with a power brake. This enables the different applications to be examined and the key operating condition values measured. The operating conditions here have to be known and reproducible in order to minimize environmental factors on the measuring results. »Coolant, fuel and exhaust air, for example are regulated at a specific temperature and pressure before they are fed to the test engine,« Dr. Musiolik explains. On the one hand, the control loops have to balance out considerable disturbance factors, while test conditions have to be adapted flexibly on the other. This requires the integration of a wide range of sensors and actuators as well as monitoring functions. These last devices ensure that operating personnel on

▼ **Everything under control:** Technicians control and monitor test operation. The monitoring functions allow several test stands to be run automatically by only one person.



the test stand as well as the technical equipment and test engine are protected safely. The openness of the Bachmann M1 system therefore also plays an important role at GVH: »Our in-house measured data acquisition system, the development environment and the different subsystems of suppliers present a wide range of different communication requirements. CANopen, Profinet or OPC – all were established on the M1 in a short time,« says Markus Bock, project engineer for the development of electronic systems at GVH. The M1 system handles here both the described closed-loop control tasks for the conditioning of the ambient conditions in the test stands as well as the monitoring functions: »The MX213-CPU now allows us to run several test stands in three-shift operation with few personnel needed,« a delighted Markus Bock describes the successful implementation.

Mains power under control

The GMP232 grid measurement and protection module was also integrated in the automation system. »We use it on the one hand for consumption measuring and also for managing the dynamic distribution of mains power to power components, such as the frequency inverters,« Markus Bock describes the use. »This is particularly important if test objects are put under load using electrical machines. This may require more power on the one hand, but also the feedback of energy to the grid,« Markus Bock explains. The GMP232 module now enables the controller and the operator to respond according to the situation.

Reliable and future proof

Previously, the test stands were always set up with a distributed intelligence. This prevented the conversion or the failure of plant sections to result in downtime for all test stands. »Due



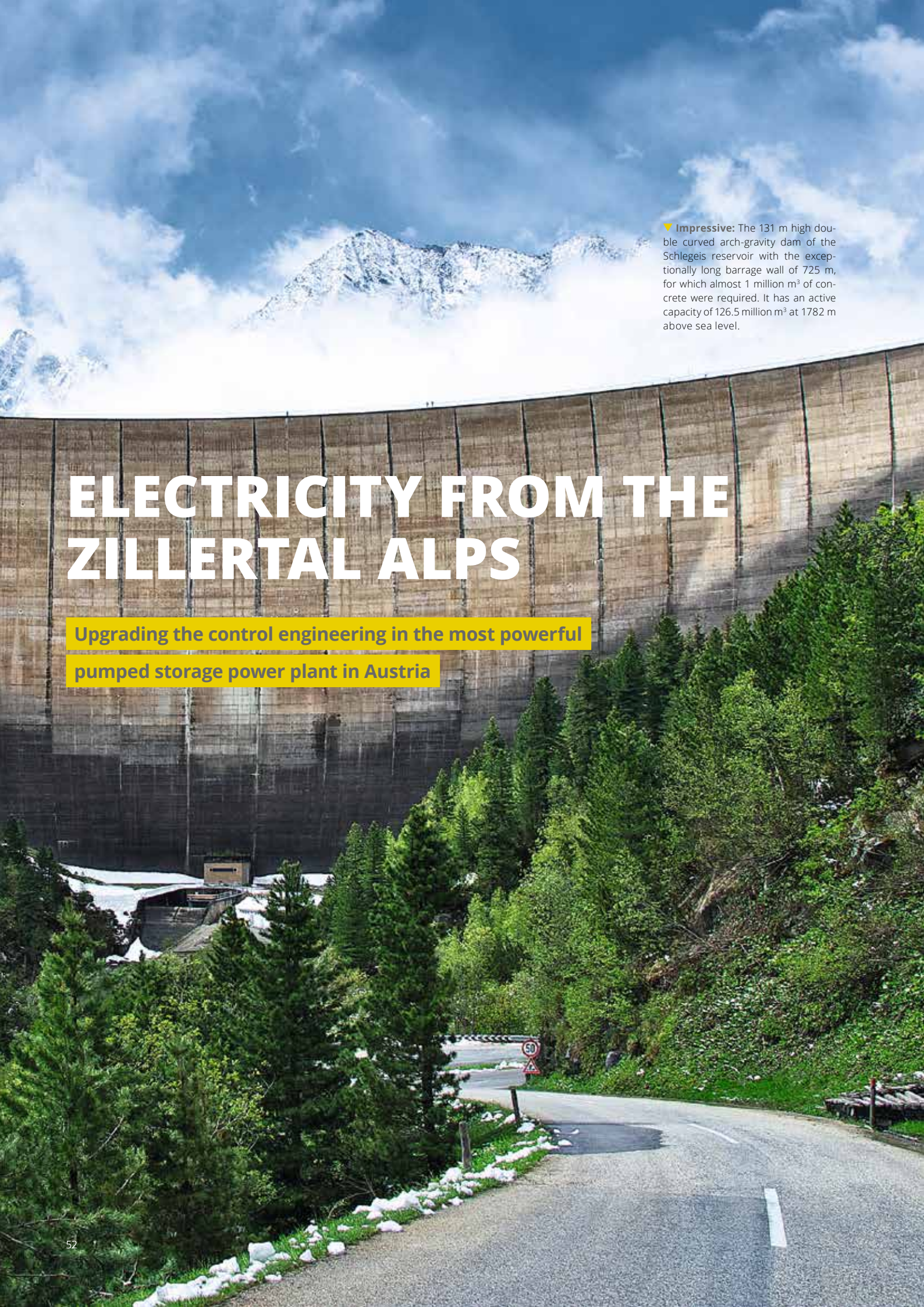
▲ **Impressive:** Test bay of GVH with three test stands and the power supply equipment (ventilation, cooling, exhaust gas extraction, fuel supply) on the roof.

to the high availability of the M1 system we can now use a single central processing unit instead of the previous distributed solution. This considerably reduces the requirements for communication and wiring,« a satisfied Dr. Musiolik explains. He adds: »With Bachmann we simply feel safe: The long availability of the hardware, the guaranteed upward compatibility and a technical support that is second to none in the sector, ensure the future proof capability of the new test stand.«



» The wide range of communication requirements were established on the M1 in a short time. «

M.Sc. Dipl.-Inform.(FH) Markus Bock,
Project engineer in development of electronic systems
at GVH



▼ **Impressive:** The 131 m high double curved arch-gravity dam of the Schlegeis reservoir with the exceptionally long barrage wall of 725 m, for which almost 1 million m³ of concrete were required. It has an active capacity of 126.5 million m³ at 1782 m above sea level.

ELECTRICITY FROM THE ZILLERTAL ALPS

Upgrading the control engineering in the most powerful pumped storage power plant in Austria

The main ridge of the Zillertal Alps in Austria at well over 2,000 meters above sea level is the source of several large streams that merge at 600 meters above sea level in the area near Mayrhofen in Austria. This water supply is used by the hydroelectric power plants of the Zillertal group. The upgrading of the entire control system in several stages between 2010 and 2014 has been the responsibility of Rittmeyer AG, a company based in Baar, Switzerland. For a long time, the company has relied on the M1 automation system from Bachmann electronic.

The Roßhag and Mayrhofen power stations were built between 1965 and 1971, and were extended in 1976. The Häusling power plant was built between 1974 and 1987. Together they form the most powerful group of storage power plants in Austria with a total output of almost one gigawatt.

Complete upgrade after thirty years

An upgrade of the entire control system was required in order to ensure the continued safe operation of these power plants. Rittmeyer AG was awarded the contract for this extensive modernization project, which was planned in several expansion stages over five years. This involved the replacing of the process control system for all twelve main machine units: Six double Pelton turbines in the Mayrhofen power plant, four Francis turbines with radial pumps in the Roßhag power plant and two in Häusling. The machine unit control system with a startup and shutdown sequence, control of auxiliary units, as well as mechanical and thermal protection was entirely based on the M1 automation system. The process stations for the general systems, such as cooling water, onsite consumption and switchboards, as well as the auxiliary and secondary systems, were also renewed.

Extensive end-to-end networking

»Over 50 networked M1 controllers and more than 30 remote substations connected via fiber optic cable were used,« Stephan Fabel, head of the hydropower division at Rittmeyer AG, describes the enormous magnitude of the installation in a single sentence. The process stations and the local operator panels are connected via a process bus in a ring topology. Inside the power plants this is implemented as a fiber optic Ethernet network with an IEC 60870-5-104 communication protocol.

Secure transmissions over large distances

»The integration of the high-speed FASTBUS in the M1 automation system is a major benefit for this solution as well as for most of our complete solutions,« Stephan Fabel highlights one detail. »This makes it easy to integrate remote input/output units in the control system over long distances via multimode fiber optic cables and without any loss in performance.«

This kind of requirement was needed, for example, at the Häusling power plant: It was built into the steep rock face with a maximum height of almost 64 m. The installation in the power house consists of two machine units, each made up of a generator, a Francis turbine as well a two-stage single-flow pump and a hydraulic converter – interconnected by means of a vertical shaft over a total height of 40 m. »Thanks to the FASTBUS, we were able to implement a completely reliable connection over these distances,« as Stephan Fabel confirmed. The control and monitoring of the 220 kV outdoor switching station at the Mayrhofen power plant are also integrated in the control system.



Rittmeyer AG was founded in 1904 and is a company belonging to the Brugg Group. Headquartered in Baar, Switzerland, Rittmeyer develops and supplies turnkey measuring and control solutions for hydroelectric power plants, water and energy supply systems and waste water treatment plants. With around 300 employees, the company achieved a turnover of 67 million CHF (approx. 56 million euros) in 2012.

www.rittmeier.com



» We really value the extraordinary robustness and quality of the M1 system. «

Stephan Fabel,
Vice president for hydropower
at Rittmeyer

COMPENSATING GRID FLUCTUATIONS AT HIGH SPEED

Modular battery storage system from Schäfer Elektronik

provides low-voltage-ride-through in real time

The worldwide supply of energy is in a state of transition due to the several international programs for reaching climate targets. Regenerative energy, such as wind power, photovoltaics and biogas, will play a decisive role in the energy supply mix of the future. Schäfer Elektronik GmbH is a company that has developed a modular battery storage system that also offers »low-voltage-ride-through« operation in real time.



Schäfer Elektronik GmbH, with headquarters in Achern, South Germany, has around 230 employees, and has been a technology leader in power supplies, converters, active harmonic filters and charging systems for almost 50 years. The solutions are used in application areas such as electric mobility, railway technology and energy technology.

www.schaeferpower.de

Klaus Riekötter, sales manager at Schäfer Elektronik, sees an expanding future market for battery storage systems: »For example, a stable grid infrastructure is a necessary requirement for electromobility. Although electricity comes out of the power outlet, the requirements for energy generation and distribution must be fulfilled. This is where Schäfer and its systems make a contribution.« The new battery storage system from Schäfer consists of at least two containers. The control container contains the power electronics from Schäfer and the control system from Bachmann. The battery container houses the battery systems for storing energy. A modular concept enables the Schäfer PCU (Power Conversion Unit), which is the basic system (1 MW), to be expanded with two additional containers in order to achieve a total capacity of 3 MW. Alexander Spengler, project manager at Schäfer Elektronik explains:

» For demanding developments, we take Bachmann into account from the beginning. «

Hansjürgen Schäfer, CEO
at Schäfer Elektronik

»As is known, batteries operate with DC voltage. To store the energy, we use an active charging circuit with compact rectifier systems. The energy output is regulated in the opposite direction via a power inverter.« As this storage system is designed for the compensation of sudden fluctuations in the grid, the energy flow in both directions has to be constantly regulated. The system can also be used for brake energy regeneration in the railway sector and for regulating peak loads in industrial plants. Whatever the case, the power feed-in has to be synchronized with the grid.

Multi-flexible for all grid variables

To implement the control application, Schäfer relies on the latest technologies of the Bachmann portfolio. The proven and robust decentralization via the fiber-optic based FASTBUS is thus used in the control area. This queries status information and temperatures in the battery container in real time. Different analog sensors and temperature sensors can be connected to each channel of the new and versatile AIO216 module. The GMP232 (grid measurement and protection module) provides all grid-relevant information. This ensures availability in the control program of all grid variables, such as voltage and current values, power data and frequency information. Besides measurement, grid protection is also ensured and the grid is stabilized (LVRT) in the event of



▲ **Clear visualization:** The status of the batteries and any errors are clearly shown.

a voltage drop in accordance with the relevant grid codes. The integrated data recorder helps to analyze the causes of faults if they occur. All functions are performed in real time in the MC210 CPU. These are programmed with the Bachmann programming systems, particularly the PLC Developer, which is a new tool that enables very efficient software development. Stefan Breitzkopf, responsible for the software at Schäfer, was able to master all facets of the system with very little training.

Precise interaction required

The cooperation between Schäfer and Bachmann started with the development of a 3 MW converter for the wind industry. As the engineering company, Schäfer developed the key parts of the design. »This was when we gathered our first experiences with the M1 automation system,« says Hansjürgen Schäfer, CEO of Schäfer Elektronik GmbH. This project involved very extreme reaction times and placed some very demanding requirements on the communication technology and visualization. »With the development of the battery storage system we drew on our experience and considered the Bachmann controller from the start,« he recalls. The power electronics ultimately required very precise interaction between the grid conditions and the connected battery systems. Another requirement was for the communication to the operator to be flexi-

ble and adaptable. In this specific case, Schäfer's customer stipulated the use of the DNP3 protocol. Bachmann offers this and also all standard communication protocols such as: IEC 61850, IEC 60870, IEC 61400 or MODBUS. The protocols can be adapted to customer requirements with little effort. The webMI pro web-based visualization is another benefit, as this enables the graphical operation and parameter setting of the system to be implemented. »We therefore had all the elements required for this demanding development together in one place,« says a delighted Hansjürgen Schäfer.

The face of the system

The ability to operate the system intuitively and to display operating data is very important. »A high-resolution graphical user interface basically acts as the face of the system. On the one hand, it has to impress the customer, on the other hand, it has to provide a full overview of plant status and clearly indicate any faults,« explains Alexander Spengler. Schäfer implements full graphics visualization with an industrial computer and a 15 inch display from the OT1200 series. The webMI pro visualization software enables Schäfer to implement an intuitive operator interface. As webMI pro is web-based, the information can also be transferred to mobile terminal devices. This naturally requires appropriate access rights and security mechanisms, which are in turn defined in different groups in the M1 controller.

ENERGY SUPPLY – SUSTAINABLE, ALWAYS AND EVERYWHERE

Bachmann M1 control energy storage systems of Qinous

There are many places in the world where a reliable energy supply can only be implemented by using diesel generators. This may be due to the absence of a supply grid, wars, armed conflicts and natural catastrophes, as well as the geographical factors such as islands. Photovoltaic installations and wind turbine plants provide alternative technologies for power generation. However, these are strongly dependent on the prevailing weather conditions. The Qinous »ESS« energy storage system combines diesel generators and power generators from renewable energy sources together in an island grid to ensure reliable operation – round the clock.



▲ Qinous energy storage system (ESS)



▲ Albert Schweitzer Hospital
in the Artibonite valley, Haiti

The Hôpital Albert Schweitzer is situated in the Artibonite valley around 60 kilometers north of the capital, Port-au-Prince, in Haiti and provides medical care for 350,000 people. In order to maintain the running of the hospital, up to four diesel generators (2x 410 kW and 2x 210 kW) have been required for this so far. Connecting to the power supply grid in this region is not possible. The unstable power supply and poor power quality in Haiti make the extension of the grid to the Artibonite valley just as unattractive.

Power cuts, voltage drops or overvoltages in the power supply grid occur frequently. The electricity price of 0.40 US dollars per kWh is one of the highest in the world. However, diesel generators are also a rather poor alternative;

Operating them is not only expensive, they also considerably pollute the environment.

Fossil fuel consumption lastingly reduced

A 230 kWp photovoltaic installation was installed on the roof of the hospital in 2014. In the beginning of 2015, Qinous was given the order for the supply of a 200 kW energy storage system. This has to fulfill several tasks: The Qinous ESS not only stores energy that is not immediately required, but also handles the intelligent management of hybrid grids. »This ensures safe and stable operation at any time by enabling a diesel generator to start up only if there is no sun for a long period and the batteries are empty,« explains Steffen Heinrich, technical general manager at Qinous. »During



Qinous GmbH develops and sells standard plug and play energy storage solutions that are optimally tailored to hybrid grids. In this way, electricity produced from wind turbines or photovoltaic plants can be stored, thus enabling the use of diesel generators to be considerably reduced. Founded in 2013, the company has been running a 100 kW island grid demonstration site in Berlin since 2014. A total of 6.7 MWh of battery capacity is under construction or already in operation in five countries.

www.qinous.de



▲ Diesel PV battery hybrid system



The Albert Schweitzer Hospital (HAS) was founded in 1956 for the medical care of over 350,000 people in the Artibonite valley in Haiti. In Deschappelles, almost 60 kilometers north of Port-au-Prince, the HAS has a 131-bed hospital, where operations, internal examinations and rehabilitation programs are carried out. HAS Haiti also offers care services for mothers and children as well as laboratory tests. The «Swiss Partnership HAS Haiti» is an important partner organization of the hospital. It finances the children's department and provides logistic support. The organization also supports the solar project, accident surgery, the laboratory and social services.

www.hopitalalbertschweitzer.org

this time, however, the diesel generator can be completely switched off. Something that is absolutely unique in this rating class.« This saves around 30 % of the diesel fuel every year: »The equivalent of 130,000 liters,« Steffen Heinrich emphasizes. »The investment in a photovoltaic battery system with a slimline lithium-ion battery thus pays for itself within a few years.«

M1 at the core

Qinous uses long-life lithium-ion batteries and new aqueous hybrid ion batteries for its standard plug and play energy storage solutions. All the components required are housed in a container solution. In addition to the battery system, this also houses the power inverters for the battery as well as the energy management system. »This measures the grid variables and regulates the voltage and frequency of the converter in order to maintain the stability of the connected island grid and reliably supply all consumers with the required power,« explains Steffen Heinrich. »We use the M1 automation system from Bachmann as the central control unit.« The MX 213 processor module here runs with input/output modules, a CAN master and

an interface module. The processor module is thus provided directly with all the relevant data from different sensors, the energy meters, as well as the power inverters and batteries. Choosing a Bachmann system was a straightforward decision. »Our ESS are in operation in Southeast Asia, Africa, South America and Australia. And in places here that are unreachable or reachable only with great difficulty,« Steffen Heinrich says. »It was therefore all the more important for the automation to operate reliably.« However, the robustness of the Bachmann M1 controller is also a key reason: »Let's take Haiti, for example, which has a tropical climate. A temperature of

» The very wide range of telecontrol protocols already integrated is also very useful. «

Steffen Heinrich,
Technical general manager
at Qinous



▲ The Qinous team at the commissioning

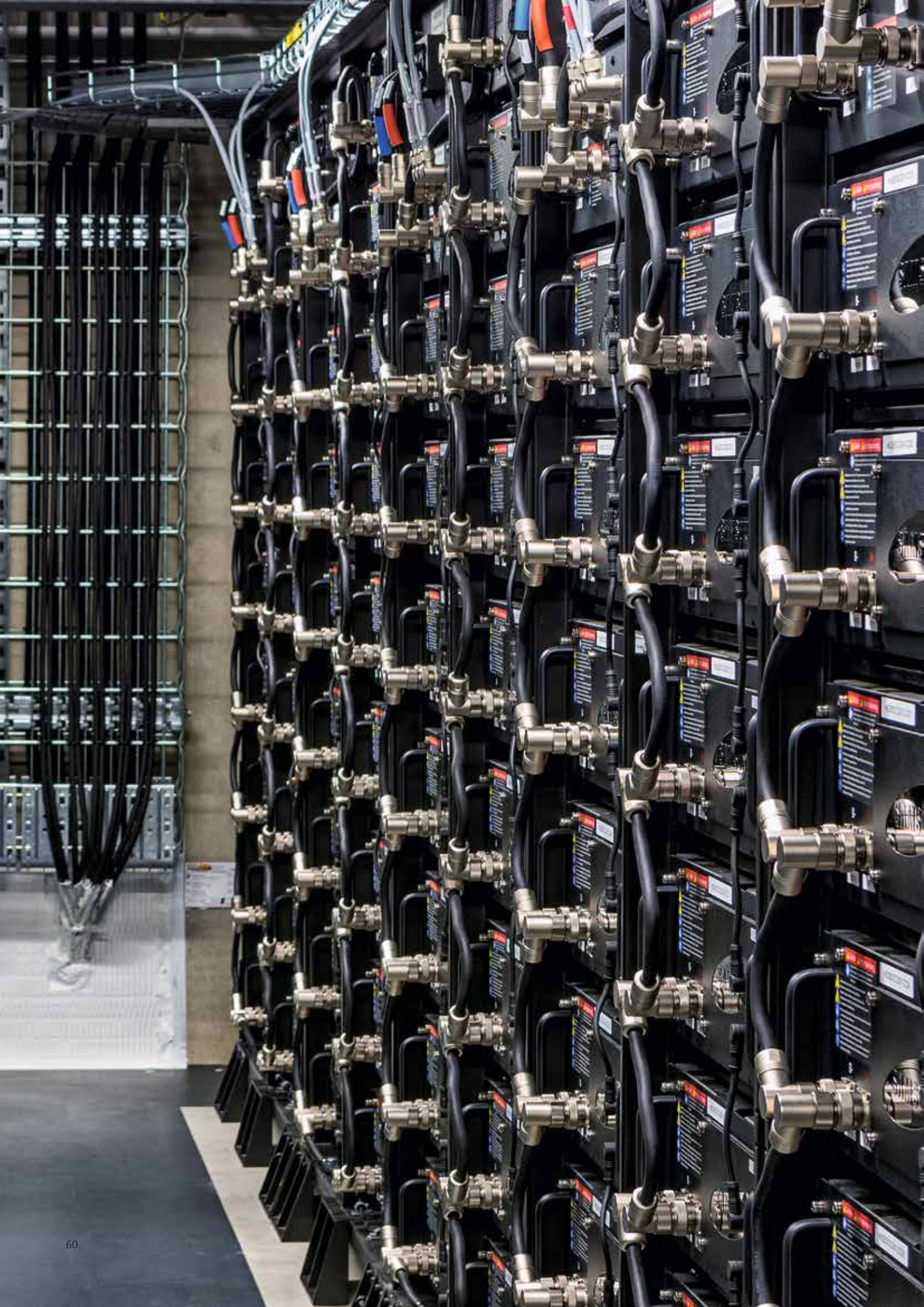
over 30° C is present all year round. With two rainy seasons a year, the weather is also very humid. The average precipitation on the capital, Port-au-Prince, is 1,250 millimeters a year. The controller has to operate perfectly in spite of this. The Bachmann controller meets this requirement,« Steffen Heinrich confirms.

The decision-makers at Qinous also liked the high degree of flexibility that the automation system offers. »The wide range of telecontrol protocols already integrated is also very useful,« Steffen Heinrich continues. »This is a requirement that the operators often stipulate.«

Promising future

Qinous is extremely satisfied with the collaboration with Bachmann. We have a good line to Bachmann,« Steffen Heinrich confirms. Qinous will also be relying on Bachmann in the future; »We are currently looking at the GMP 232 for grid monitoring and protection. At present we are also evaluating the M1, with which we can replace our onsite visualization through modern and functional web visualizations,« Steffen Heinrich describes a possible option.





INTELLIGENTLY CONTROLLED ENERGY STORAGE SYSTEMS

Smart grid and energy storage solutions from Younicos

Reliable grid operation fed 100 % by renewable energy sources is one of the key objectives of the energy transition. Younicos, a supplier of battery-based smart grid and energy storage solutions, has devoted itself to this goal. Besides battery technology, smart software and not least robust and modular control technology play a major role here.

Younicos has been supplying battery storage solutions to different sectors and application areas since 2005. Worldwide, 37 energy storage projects with outputs of 150 MW have been installed to date. »The aim of the founders of Younicos was to improve the technical and economic integration of renewables in the energy system by using storage systems,« says Ines Auweiler, head of Marketing and Communications. These pioneers, based in Adlershof, Germany, are repeatedly setting new standards here: In 2009, a megawatt battery was installed in European grids for the first time. A unique technology center was formed, in which the supply of grids with up to 100 % renewable energy at any location in the world was simulated and readjusted with actual current flows. In 2012, a battery was prequalified in Europe for the first time for the supply of control energy. Younicos subsequently designed and constructed Europe's first commercial battery park, as well as Europe's first multi-functional battery power station. A number of game-changing systems were also developed at the same time in America.

Today, Younicos is a leader in smart grid and energy storage solutions based on battery technology. Its customers include energy suppliers, independent electricity producers, industrial or commercial electricity consumers as well as is-

land grid operators. Since 2015, the company has focused on the commercial and industrial sector. Storage systems have really »grown up« and are not just of interest to grid suppliers or idealistic private users.

The portfolio in detail

»Medium-sized plug-and-play systems offer several benefits, particularly for industrial or commercial users of electricity. These kinds of storage systems secure production by ensuring optimum supply quality. They also optimize energy consumption and thus save a lot of money. At the same time, the storage systems can be used in different markets, generating also additional income,« Auweiler explains. »Our storage systems can be used for different applications, even simultaneously, in line with this wide range of requirements.« She gives the following examples: absorbing load peaks, implementing an uninterruptible power supply, compensating reactive power etc. »These applications are implemented in the software and can be run together or individually,« Auweiler explains. The Younicos portfolio essentially comprises two solutions: the Y.Cube plug-and-play solution and the pre-engineered building solution Y.Station. The core of both solutions is the intelligent Y.Q. »Younicos Quotient controller software«, containing all our experience,« says Auweiler. All Younicos storage solutions consist

Younicos

Younicos is the pioneer and market leader in smart grid and energy solutions based on battery storage. The company was founded in 2005 and has 130 employees at sites in Berlin, Germany, and Austin, Texas.

www.younicos.com



▲ A look inside the Notrees 36 MW battery park – the largest battery storage system in the USA connected to a wind farm.



▲ Test rig for lithium-ion batteries in the Younicos Technology Center in Berlin-Adlershof.

of different battery cells from different manufacturers enclosed in modules, which are then combined in a rack. They are controlled via a battery management system, the so-called ACBM (AC Battery Manager), for example, via CAN bus or Modbus. A Bachmann controller solution is used on this level: An M1 controls several racks and provides the connecting link to the converter. »The capability of the converter determines the number of battery racks that can be connected to it,« says Philipp Hundemer, requirements engineer. He further explains: »Several of these racks are used inside a power station, according to the combined output (MW output) required. Between 700 kW and 2 MW can be effectively used on average, depending on the converter.«

An air conditioning system and fire extinguishing system are some of the additional variables that are monitored and regulated within a system. »If necessary, we also use Bachmann controllers for the fire extinguishing systems. Air conditioning systems have their own controller, although they can be connected to the M1 via their integrated interface,« Hundemer explains. Bachmann's GMP module is also used, for example, to measure the grid frequency. The GMP232/x offers an outstanding measuring accuracy of 1 mHz, as is required in energy applications. »The data from the system worlds are routed via an IoT protocol, such as MQTT, to higher-level systems, such as the Battery Power Plant Manager (BPPM), or

the Web User Interface, such as Data Historian. In the stand-alone power station, the BPPM represents virtually the highest level on the software layer. It can route commands to the individual system components,« the software expert explains.

Satisfied reference customers

The data can be visualized remotely in parallel. »The idea behind it is to completely prevent with our software the possibility of critical states developing in devices like the converter. This means that additional safety controllers on this level become unnecessary,« he continues. The BPPM can also be used to measure the energy content of batteries. Alternatively, if several strings are connected together in a power station, it is important to know the SOC of the individual components, otherwise the compensation currents may be too high in certain circumstances. »In such cases, we disconnect the appropriate batteries, and charge or discharge them in order to adjust them to the SOC of the

others,« Hundemer explains. The control options of the ACBM also enable different storage solutions to be run as hybrid systems. All information of the individual units, such as operating data, error states etc. are shown via the web interface. The 37 projects implemented so far worldwide includes the project at Wemag, headquartered in Schwerin, Germany. In the autumn of 2014, Europe's first commercial battery park for stabilizing short-term grid fluctuations was connected to the grid. The large-scale turnkey storage system implement-

»Storage systems have really
»grown up« and are not just
of interest to grid suppliers
or idealistic private users.«

Ines Auweiler,
Head of marketing and communications
at Younicos

ed by Younicos in lithium ion technology helps to stabilize the grid frequency on the transmission network level and integrate wind and solar power safely into the existing grid. Coal-fired power stations, which previously performed this function, can be left out during good »energy weather«. Here too, the battery management was implemented with the M1 controller system from Bachmann. The control system for the converters and batteries was implemented on the MX220-CPU of the M1 automation system. It provides a standard interface to the BPPM at the same time. Younicos highlights the high CPU performance, as well as the ability to program in C++, as the benefits of the Bachmann solution. This also comes with the important interfaces and protocols, such as CAN, Profinet, IEC 61850 and IEC 60870-5-104, already on board. The high availability and EMC performance of the M1 system were other reasons for choosing Bachmann. Over a dozen M1 controllers have now been successfully controlling the battery management of the 5 MWh storage system at Wemag since the second half of 2014.

The latest and largest Younicos projects include the delivery of a 49 MW battery storage system at Centrica, the UK energy supplier. From the winter of 2018, the lithium ion system will respond in less than one second to fluctuations in current consumption in the UK grid. The installation is being built at the site of the former Roosecote coal-fired power station in Barrow-in-Furness in northwest England. The intelligent controller ensures here that the battery system meets the demanding requirements of the British transmission network operator, National Grid. Here too, the Bachmann solution stood out on account of its wide range of interfaces. The project was also a highlight for Bachmann: In all, 63 M1 controller systems are deployed here. »The M1 is a stable, certified hardware that is designed for industrial applications and long-term availability. Expansion modules can be connected quickly thanks to the modular design. It also offers software developers the benefits of a comprehensive software library,« says Hundemer.

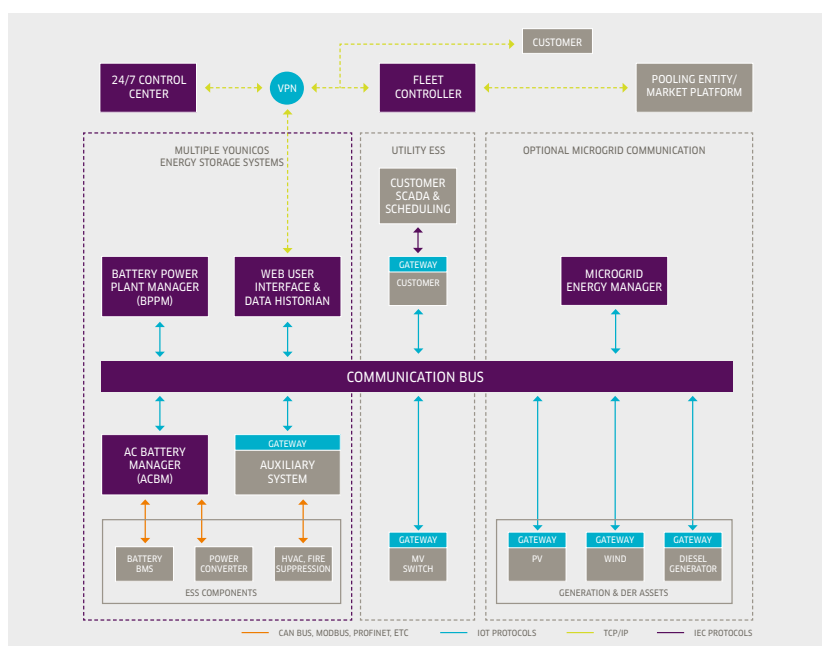
Conclusion and outlook

Energy storage systems can be used for a wide range of reasons. »For Wemag, the storage system was used for storing primary energy with which the company intends to earn money,« Auweiler explains. In other cases, such as on the Portuguese island of Graciosa, the project involved the replacement of the diesel units in place and the implementation of up to 100 % renewable energy usage. »In India, energy storage solutions are used to prevent pro-

duction breaks caused by unreliable grids,« she adds. However, many other scenarios are conceivable in future. Hundemer: »A fleet controller enables several of our Y.Cube container solutions to be connected together. This makes it possible to achieve a higher storage volume.« As one example, he states discount stores, wishing to offer charging facilities for electric cars in their parking lots around Germany and provide an energy storage solution for this task. »Each individual energy storage system is too small for primary control.

However, some interesting possibilities are created if several of these individual energy storage systems are combined together as a group. This is what we are working on at present,« says Hundemer. »This example also illustrates the potential of the commercial and industrial sector, which is only just beginning,« Auweiler explains. She expects this sector to grow quickly in the near future. »Customers have now realized what storage solutions involve. Four to five years ago, many still believed that energy storage systems were mainly deployed as a long-term storage system. We are now far away from this situation, so that larger industrial companies are asking about systems for the already described tasks increasingly more often,« says Auweiler optimistically about the future.

▼ What intelligent energy management looks like: architecture of the Y.Q software from Younicos.



BACHMANN **TRAININGS** **OFFERINGS**

Benefit from our expertise

Solid know-how combined with first-class products is the key to perfect automation. We offer you both. Take advantage of our extensive training program, which we will gladly adapt to your individual needs.



SOLUTIONCENTER

The SolutionCenter as an integrated and user-friendly engineering tool for project engineering, commissioning, configuration and diagnostics. The training also includes an introduction to programming and visualization.



MODEL BASED DESIGN

The MATLAB® program package from MathWorks offers a software tool for model-based development of controller applications. »M-Target for Simulink«® enables the user to integrate seamlessly in this development process inside the M1 controller environment.



REDUNDANCY CONTROL

This training course provides a rapid introduction to configuring and creating redundant applications with the M1 automation system.



POWER MANAGEMENT

The safety and efficiency of the electrical energy supply are placing increasing demands on generation, transmission and consumers. This training seminar provides the knowledge required to use Bachmann grid measurement, monitoring and synchronization modules in the M1 controller system.



SAFETY CONTROL

This seminar offers a practical and basic understanding of how to implement functional safety. You are shown how to program safety applications based on the Bachmann safety products in hardware and software.



M1 WEBMI PRO

atvise® provides the user with a web-based visualization for different applications and visualizations. Mobile application, HMI up to SCADA solutions can be implemented with only one visualization. Standards such as HTML5, SVG and JavaScript enable very open and flexible solutions for any application. At the end of this training seminar each participant will have created an extensive sample project.

ALWAYS KEEPING UP-TO-DATE

Engineering training seminars

Even if the training needed for engineering is kept to a minimum thanks to the standard development environment: Updating and deepening one's knowledge of individual engineering areas at regular intervals is worthwhile. The combination of the user's sound knowledge with first-class products is ultimately the key to perfect automation.

Benefits of engineering training

- Perfect program adaption to individual requirements thanks to the modular concept
- Intensive knowledge transfer through hands-on training
- Training seminars held on site at Bachmann or as webinar
- Access to the in-depth knowledge of Bachmann application engineers

Precisely tailored training seminars

Bachmann's training offering ranges from the proven standard training seminars right through to workshops tailored to your individual requirements. The modular training concept enables the creation of training programs tailored precisely to company requirements. The training is always centered around an intensive knowledge transfer and hands-on practice with special problem solving tasks. The training sessions are held either in a Bachmann branch office or directly on site at the customer's premises. Individual modules can

also be offered as webinars if required. Following each training course, the participants will receive a personalized certificate.

No questions unanswered

If a question remains unanswered despite the extensive training offer, Bachmann customers benefit from the know-how of several application engineers. These work in close proximity to the development team. They know every small detail of the Bachmann solutions and can therefore make use of all options available.

