GRIDCON®
ENERGY STORAGE SYSTEM
MORE THAN JUST A BATTERY.
WWW.REINHAUSEN.COM
GRIDCON® ENERGY STORAGE SYSTEM

STORE ENERGY.
ENSURE POWER QUALITY.
Renewable energies and electro mobility are pushing the development of energy storage. Today, stationary energy storage systems are primarily used to balance energy volatility resulting from renewable energy sources. However, when combined with an inverter that also provides filter functions, energy storage systems can do much more.

Shaping the energy transformation

Wind parks and solar farms can be coupled to production units using energy storage systems. These act like (virtual) power plants and continually supply energy to the grid at a predictable rate. Energy storage systems stabilize microgrids or poorly developed grids by compensating for fluctuating load and infeed amounts. Their extremely short response time is a key advantage. As a result, they can even provide inertia for the grid, mitigating the effects of sudden load variations.

Remote regions can combine energy storage systems and renewable energy generators, allowing them to build up a largely self-sufficient and reliable additional supply without any further grid expansion. Island grids benefit economically and environmentally from combining diesel generators, energy storage systems and renewable energy generation.

eMobility

Energy storage systems are an important component not only in electric vehicles but also for the necessary fast-charging infrastructure. Sports cars, city buses and electric ferries all require high charging capacities that exceed the available connection capacity in many places. Stationary energy storage systems offer an economical solution and can smooth the load.

Optimizing loads

Energy storage systems offer completely new options for energy and load management in industrial operations. For instance, they prevent cost-intensive load peaks (peak shaving) and increase productivity. The energy storage systems also allow participation in markets for ancillary services, creating additional revenue sources for industrial operations.

Keeping the grids clean

MR practices a holistic approach to energy storage systems. The experts in the Power Quality division specialize in grid analysis and grid studies as well as the implementation of concrete system solutions that ensure compliance with grid connection codes and required power quality. The GRIDCON® Energy Storage System filters grid voltage using specially developed inverters and sustains it dynamically through reactive-current injection.
SAFE AND RELIABLE.

A sophisticated overall system based around energy storage.

**Modular inverter**
- A design that always uses the same standardized power modules enables flexible solutions, redundant operation, simple service and long-term availability of replacement parts
- It is possible to connect various battery models and different energy storage types to the same inverter
- Specially developed hardware and software enables operation as an active filter, enabling numerous special functions relating to the grid

**Central control system**
- Communication with higher-level control technology or with energy management using standardized protocols
- User interfaces that include a clear representation of the operating state and can be adapted individually to customer requirements

**Special DC protection concept**
- Battery storage can never be completely discharged and imposes high standards on the DC protection design
- Visible separating points (see VDE 100)
- Due to the modular design of the inverter, the energy storage capacity can be divided into separate segments. Also because of the modular design, the potential short-circuit currents are dramatically reduced and can be securely controlled
**Flexible installation**
- Wide range of installation options
- Frequent outdoor installation in separate climate-controlled housing containers or concrete stations
- Alternative option of installation in buildings
- A custom safety and fire protection concept is always included, and automatic fire extinguishers are also available as an option

**Flexible energy storage**
- Selection based on the specific application and independent of any manufacturer
- In addition to lithium-ion batteries (high power density and long storage periods), other battery technologies are possible depending on the application
- Option of substituting or combining with capacitors or flywheels (for fast and frequent load cycles)
- Output: from the kW range to the MW range thanks to the modular design
- Due to the high DC voltage and high power and energy density, installation and maintenance must be carried out by specially trained service technicians

---

**MODULAR CONCEPT – FLEXIBLE CONFIGURATION – CUSTOM SOLUTION**

**Performance-oriented configuration**
e.g. 350 kW / 88 kWh / C-rate* 4

**Balanced configuration**
e.g. 350 kW / 350 kWh / C-rate* 1

**Energy-oriented configuration**
e.g. 88 kW / 350 kWh / C-rate* 0.25

**Freely scalable up to large energy storage systems**
e.g. 2 MW / 10 MWh / C-rate* 0.2

*) C-rate: Its reciprocal indicates how long an energy storage system can provide the maximum output. C-rate 1 corresponds to 1 hour, C-rate 2 corresponds to 30 minutes

---

**Climate control**
- Precise and reliable adherence to the specified operating temperatures is crucial for ensuring the service life of the energy storage system
- Years of experience and a tried-and-tested climate control concept result in a homogenous and reliable temperature distribution in the interior
AN ENERGY STORAGE SYSTEM WITH ADDITIONAL ADVANTAGES.

Grid integration and power quality incorporated by design.

Harmonic filtering
Reliable compensation of harmonics up to 2.5 kHz by measuring the current and voltage and injecting exactly opposite currents
→ Grid-compliant connection of photovoltaic power stations (p.12)
→ Elimination of interferences in industrial operations (p.11)

Reactive power compensation
The system injects the required amount of reactive power
→ Photovoltaic power stations or industrial operations do not need a separate system for providing reactive power (p.11, 12)

Stable voltage
Targeted injection of reactive power for stabilizing the grid voltage
→ Adherence to the voltage range at the transfer point in the higher-level grid (p.12) or in the case of island grid operation (p.14)

Microgrid
Network forming with stable voltage and frequency as well as compensation for fluctuating power balance
→ Microgrids using diesel generators, energy storage systems and renewable energy sources as an environmentally and economically superior alternative to pure diesel supplies for remote regions (p.12, 14)

Asymmetrical grid load
Compensation of asymmetrical load distribution in the grid
→ Reduced load on the equipment (p.14)

Flicker
Reduction in flicker caused by voltage fluctuations thanks to dynamic injection of the corresponding reactive power
→ Prevention of disruptive light fluctuations

ADDITIONAL FUNCTIONS OF THE INVERTER
For further details on the technology, see the flyers GRIDCON® Power Conversion System and GRIDCON® Active Filter
BASIC FUNCTIONS OF THE ENERGY STORAGE SYSTEM

Variations: Batteries, capacitors, flywheels (can also be combined)

**Energy management / peak shaving**
Intake of energy during low utilization and output of energy at peak times as part of load management
- Reduction in costs through prevention of load peaks (p.11)
- Increase in productivity (p.11)

**Increased in-house consumption**
Storage of excess energy for consumption at a later time
- Energy consumption is a more attractive option, economically speaking, than injecting generated energy into the grid

**Power leveling**
Compensation of fluctuating amounts of generated energy
- Wind farms and solar parks feed continuous and predictable amounts into the grid as required for grid operation and energy trading (p.12)

**Balancing power**
Provision of revenue-earning balancing power for the grid operator
- Additional revenue source (p.11)

**Protection in case of voltage interruptions**
Compensation for short-term voltage interruptions
- Protection of sensitive infrastructure using an uninterruptible power supply (p.15)

**Emergency power**
Temporary supply of the grid from the energy storage system following a supply failure
- Continuation of important functions following short interruptions (p.15)
MORE POWER. MORE VALUE.

GRIDCON® Energy Storage System – custom designed by experts.

Expertise in system solutions
- MR Power Quality provides guidance throughout the entire project, from analysis, including economic feasibility calculation, to commissioning and subsequent service
- MR has been an expert in power quality and grid integration for over 25 years, offering original system solutions at all voltage levels
- MR’s comprehensive expertise in model design and simulation guarantees compliance with even the most sophisticated grid connection requirements

Flexibility through modularity
- Future-proof: Easy expansion of energy storage capacity, filter and reactive power functions allows for flexible adjustments at any time
- The separation of power to independently working inverter modules enables various charging states as well as the expansion or replacement of batteries
- Economical solutions using a uniform technology for a variety of applications, accumulator technologies and sizes

High reliability
- The modular design provides high operational reliability thanks to redundancy
- The separation of the energy storage into multiple segments limits short-circuit currents to values that can be reliably controlled
- For maintenance work during ongoing operation, individual inverter-battery groups can be deactivated and isolated from the network with DC switch disconnectors

True quality
- Tried-and-tested electrical engineering: Developed by MR as a special inverter for Power Quality applications and made in Germany
- Carefully selected energy storage technology that suits the specific application
- MR Power Quality is a reliable partner and relies on original, tried-and-tested technology platforms

Easy maintenance
- Service-friendly structure always made from the same assemblies, which can simply be replaced in their entirety in the event of a failure
- Reduced cost and time investment thanks to the remote maintenance option as well as easy fault analysis thanks to operating data acquisition and malfunction recording
- Service technicians from MR specially trained for battery applications are available to train local operating personnel to carry out simple service and maintenance tasks
DOUBLE THE ADVANTAGES FOR INDUSTRY.

Optimized energy costs – flexible production – clean grids.

Task

A mid-sized industrial operation receives energy over the high-voltage grid but the connection power is technically limited to 15 MW.

Load management challenge

- The energy requirement at full load is over 17 MW of power. As a result, complicated production planning attempts to ensure that no load peaks occur.
- Despite this, the automatic load management system switches off parts of production multiple times per month. The result is production disruptions and unnecessary setup times.

Power quality challenge

- Non-linear loads distort the voltage in the company’s own low-voltage grid.
- Modernization measures (LED lighting, automatic circulating racks) break down due to insufficient power quality, resulting in high maintenance costs and disruptions.

Solution

Distributed in the grid, three energy storage systems provide the additional energy needed for the load peaks, providing flexibility in production. Thanks to the additional functions of the inverter, active filtering takes place continuously for the grid voltage, even if the energy storage itself is not operating. This ensures sufficient power quality. In months of low utilization, the operator provides its extra energy storage capacity to the energy supplier as revenue-generating balancing power.

<table>
<thead>
<tr>
<th>Energy storage systems with active grid voltage filtering</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Power</strong></td>
</tr>
<tr>
<td>(Corresponds to a service price of 180,000 euros/year at 90 euros/kW)</td>
</tr>
<tr>
<td><strong>Energy</strong></td>
</tr>
<tr>
<td>(Up to 30 minutes of full power available)</td>
</tr>
</tbody>
</table>

**Customer benefits**

- Productivity increase: Higher part counts and lower power costs per unit during full loads.
- Easy manufacturing planning and more flexibility in production.
- Prevent disruptions: Costs no longer incurred by disruptions or standstills due to voltage breakdowns; no defects in lamps and electronic devices.
- Additional revenue from balancing power.

---

![Power over 24 hours with restrictions due to connection power](image1.png)

![Power acquisition with support by GRIDCON® Energy Storage System](image2.png)
ADVANCE THE ENERGY REVOLUTION.

Optimal and economical solutions for even the most sophisticated network connection conditions.

Task

In a remote region in Australia with a weak grid connection, conventional power generation is being replaced with renewable energy sources. Power must be generated locally in order to avoid overloading the existing connection line to the neighboring grid. The proportion of renewable energy sources is being gradually expanded. In this particular case, through the installation of a 20 MW photovoltaic power station.

Challenge

- The supply grid is poorly developed and vulnerable to load and generation fluctuations as well as circuit feedback
- Renewable generators do not have inertia for grid stabilization; conventional power plants sometimes have to continue working in no-load operation
- The voltage at the high-voltage connection can deviate upward from the nominal value by up to 30%
- Stringent limit values apply to the emission of harmonics for the photovoltaic power station; in addition, reactive power must be provided in accordance with specifications
- In the event that the higher-level grid experiences a failure, supply to the nearby town must be maintained

Solution

An energy storage system balances out the fluctuations in the energy generation system. This allows predictable usage of the conventional power plants on the grid. Individual systems can therefore operate at peak performance while others are switched off. Operation at the optimal point reduces fuel consumption and mechanical wear.

A grid study by MR Power Quality shows that the connection of the photovoltaic power station requires filtering measures. Instead of separate, passive filters, this function is taken over by the inverter of the GRIDCON® Energy Storage System.

The energy storage system provides balancing power and virtual inertia which lessens load fluctuations. This makes it possible to reduce the reserve capacity needed for conventional power plants.

In the event of a grid failure, the energy storage system automatically forms a locally restricted island grid that is used to provide a temporary and self-sufficient supply to the nearby location.

The transformer of the energy storage system is designed to be regulated by an MR on-load tap-changer, which further increases the system’s efficiency.

Large energy storage system for renewable energy generation

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Power</td>
<td>1.4 MW / 1.4 MVA</td>
</tr>
<tr>
<td>Energy</td>
<td>4.8 MWh</td>
</tr>
</tbody>
</table>

Customer benefits

- Grid connection condition fulfilled without additional filters
- Injection of a constant energy amount (power levelling)
- Self-sufficient emergency supply of a nearby sub-grid
- High efficiency
SELF-SUFFICIENT ENERGY IN AN ISLAND GRID.

Stable energy supply – environmentally and economically optimized.

Task
A vacation resort on an island in the Philippines does not have a grid connection and generates its own power with two diesel generators. Operating the generators is expensive. The mechanical stress on the generators due to severe load fluctuations creates a need for substantial maintenance efforts. The generation system is to be replaced by a photovoltaic system to the greatest extent possible.

Challenge
- Severe load fluctuations (climate control systems, water supply pumps)
- Few load predictions available
- Sudden, irregular generation (e.g. clouds moving quickly over the solar panel)
- Significantly asymmetrical load distribution from single-phase consumers

Solution
A hybrid power plant consisting of a photovoltaic system, energy storage system and diesel generator. The operation of diesel generators is reduced to a minimum and takes place under optimal operating conditions. Diesel consumption and maintenance costs are lowered. Reduced CO₂ and noise emissions preserve the environment and climate.

<table>
<thead>
<tr>
<th>Small energy storage system for an island grid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power</td>
</tr>
<tr>
<td>Energy</td>
</tr>
<tr>
<td>Customer benefits</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

Customer benefits
- Significantly reduced diesel costs
- Lower emissions / improved climate and environmental protection
- Lower maintenance cost and time investment
- Self-sufficient energy supply
FURTHER FIELDS OF APPLICATION.

GRIDCON® Energy Storage System opens up new possibilities.

EMERGENCY POWER MODE – WITHOUT ANY UPS SYSTEM OR BACK-UP GRID

**Task**

A building complex is to be implemented without emergency power generators. To increase the in-house consumption of solar energy generated by the building’s system, an energy storage system is purchased.

**Challenge**

- In the event of a power failure, safety-related areas/functions of the building (e.g. elevators) should continue to receive power.

**Solution**

An energy storage system is installed. It is dimensioned such that one part ensures the emergency power supply and the other part is integrated into the energy management system of the building. The storage system even ensures an uninterrupted power supply (UPS) through continuous operation in grid-forming mode and quick decoupling of a restricted emergency grid in the event of a failure.

<table>
<thead>
<tr>
<th>Energy storage system for emergency power supply</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Power</strong></td>
</tr>
<tr>
<td><strong>Energy</strong></td>
</tr>
<tr>
<td><strong>Customer benefits</strong></td>
</tr>
</tbody>
</table>

FAST-CHARGING STRUCTURE FOR ELECTRIC VEHICLES

**Task**

A city bus route is being made electric. Fast charging is to take place at the terminal stops.

**Challenge**

- At the terminal stops, only low-voltage connections with 63 A are available.
- The bus only remains at these terminal stops for a few minutes. The bus must be sufficiently charged within this time period.

**Solution**

Energy storage systems at the terminal stops continually take in energy from the grid in order to supply the bus with power quickly. The minimized load peaks reduce the expansion requirements for the grid and prevent high-demand charges.

<table>
<thead>
<tr>
<th>Energy storage system for fast-charging infrastructure</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Power</strong></td>
</tr>
<tr>
<td><strong>Energy</strong></td>
</tr>
<tr>
<td><strong>Customer benefits</strong></td>
</tr>
</tbody>
</table>
LOW-VOLTAGE SOLUTIONS:
Maschinenfabrik Reinhausen GmbH
Power Quality
Wiebestr. 46
10553 Berlin, Germany
Phone: +49 30 330915-0
Fax: +49 30 330915-25
E-mail: support.pq@reinhausen.com

MEDIUM-VOLTAGE SOLUTIONS:
Maschinenfabrik Reinhausen GmbH
Power Quality
Alte Chaussee 73
99097 Erfurt, Germany
Phone: +49 361 30103-0
Fax: +49 361 30103-20
E-mail: support.pq@reinhausen.com

Maschinenfabrik Reinhausen GmbH
Falkensteinstrasse 8
93059 Regensburg, Germany
Phone: +49 941 4090-0
Fax: +49 941 4090-7001
E-mail: info@reinhausen.com

Please note:
The data in our publications may differ from
the data of the devices delivered. We reserve
the right to make changes without notice.

©Maschinenfabrik Reinhausen GmbH 2017