nilar

ENERGY

Product catalogue

Nilar Energy Product Series

Safe and environmentally friendly batteries supplying long term power for sustainable energy storage solutions.

Who we are

Nilar manufactures advanced batteries for energy storage. Our unique combination of Nilar Hydride® technology and modular bi-polar construction provides an environmentally conscious and reliable power source with essential safety benefits.

With significant investment in design and innovation, Nilar batteries have evolved into the solution that is ideal for storing solar and wind power and charging electrical vehicles for long term use in private households, commercial properties and industrial plants. With production powered by 100% renewable energy at our state-of-the-art manufacturing plant in Gävle, Sweden, Nilar is revolutionizing energy and power supply technology and is taking automated battery production to the next level. Read more at www.nilar.com.

Contents

Nilar Energy battery series

Nilar Energy batteries, based on the Nilar Hydride® chemistry, are the only commercially available bi-polar nickel metal hydride batteries. Within the patented Nilar Hydride® design, the cells are stacked horizontally on top of one another with a metal bi-plate in between. The outer contact plates act as current collectors for all the cells within the module, reducing the volumetric overhead and inherently resulting in a uniform current flow across the cell. The ruggedness of the design along with the uniform current and resistance paths promote uniform heat generation, enabling consistent ageing of the cells, and a stable performance curve in various conditions, with operating temperatures ranging from -10°C to +40°C.

One Battery - Lasting Potential

ENERGY

BENEFITS IN BRIEF

- Long term power
- Superior safety benefits
- Environmentally friendly
- Optimal for peak power applications
- Expedient energy availability for medium power applications
- Suitable for shorter cycle duration applications

BATTERY FEATURES

- Rated capacity of 10 Ah
- Rated energy from 0,96 to 1,44 kWh
- Max charge/discharge rates of 2C/3C

Through the deployment of our previous battery product, our dedicated research and design staff gained significant insights into improvements and innovations towards a better battery. The plastic material used in the laser-welded module was replaced with a more resilient material. Operational guidance was fine-tuned for outstanding efficiency and the battery was upgraded for better processing of the dynamic data and communication with external systems. The result is this newly unveiled Nilar Energy Battery. The 10 Ah Energy Battery has retained the volumetric size and quality performance of its predecessor, operating expertly at a continuous 1C charge and discharge rate.

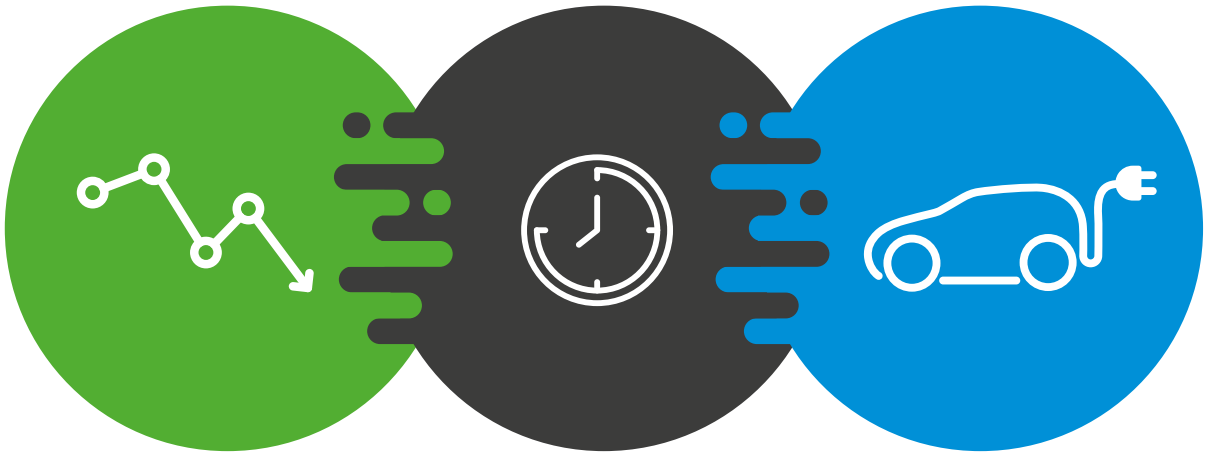
Unique benefits

Safe
The water-based electrolyte is non-flammable. Uniform current flow paths lead to no concentrated hot spots and more efficient heat dissipation. The structural components within the battery paired with the non-flammable electrolyte means there is no spontaneous ignition and no uncontrolled heat propagation.

Environmentally friendly
The Nilar R&D process focuses on the Circular Economy philosophy, with every innovation striving towards component renewal and waste reduction. All Nilar products are produced at our factory in Sweden with 100% renewable energy and are able to be recycled at end of life.

Long term power
The unique combination of Nilar Hydride® technology and our patented bi-polar construction provides a reliable source of power designed to last for more than 20 years.

Key energy storage functions



Peak Shaving
Reduce the peaks in your energy use by strategically employing energy storage for efficiency and cost savings.

Time Shifting
Enhance your intermittent renewable energy resource investment by repositioning your surplus self-generation for more efficient and convenient operation.

EV Charging Support
Minimize the load increase of electric vehicle charging for energy optimization.

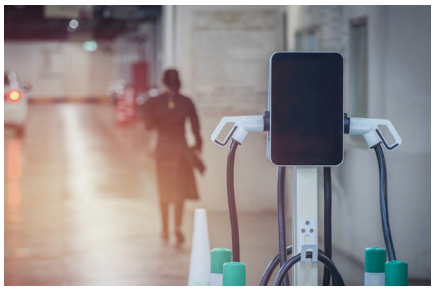
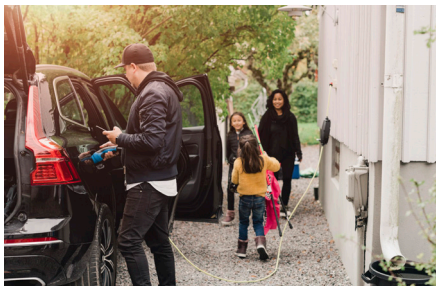
Nilar Applications

A. Safe and affordable energy storage systems that reduce peaks in power for private households.

B. Optimize the use of an existing solar energy solution in an apartment building . Store solar energy during the day and transfer to apartments in the evening.

C. Create new energy efficient structures in shopping malls & office buildings that promote energy conservation and utilise renewable energy resources.

D. Regulate energy supply in the form of a frequent containment reserve to the national grid to meet country wide demand.

Applications

One single Nilar Hydride® battery pack can store up to 1,73 kWh of energy and charge and discharge multiple times per day without impacting performance. With our powerful and compact solution we provide more energy at a lower cost, when and where it's needed.

Home & residential storage A B

Nilar offers small to medium scale solutions that are ideal for safe energy storage in homes, businesses, apartment blocks and housing estates. When connected to solar or wind power stations, you get full advantage of the intermittent nature of sustainable energy. The combination of Nilar's smart Battery Management System (BMS) and our energy compact batteries delivers the ideal energy buffer to boost grid supply during busy and peak periods in order to lower tariff fees.

The Nilar solutions gives you the possibility to take control of your energy consumption, also known as Electricity Bill Management.

Commercial storage C

According to the European Environmental Agency, energy consumption will increase dramatically over the coming years. Thousands of cars will be charged simultaneously in relatively concentrated areas. To prepare for this, Nilar offers energy storage solutions for reliable EV-charging while relieving stress on the grid.

Fast EV-charging requires powerful energy storage solutions that enables tariff fee reductions while delivering peak-shaving capabilities. The Nilar solutions are reliable and able to handle continuous charge and discharge for years to come. Many stations will be located in busy, well-populated areas, for which the safer Nilar solutions are suitable. For environments with fluctuating climates, the use of Nilar batteries is advantageous with its ability to operate in a wide temperature range. In addition, Nilar provides you with environmentally-friendly solutions.

Industrial storage C

With electricity prices fluctuating throughout the course of the day, utilizing energy stored during low-tariff fee periods can deliver considerable savings. With the right energy storage system and an understanding of the tariff fee structures of energy providers creating strong financial viability, production plants can run the way they were intended, at a lower cost.

For further savings an energy storage solution can be connected to sustainable energy sources. Energy will only be transferred from the grid at off-peak times if the intermittent sources have not provided enough energy for full charge.

Grid storage D

Today's grid cannot handle the new demands from mass electric vehicle charging and overall increased electrification. The ever increasing growth of renewable energy in the power grid poses new challenges when it comes to grid stability and reliability of supply. Without substantial investments into power line upgrades from utility companies and governments, energy storage is the only viable solution. Using energy storage from Nilar can help smooth out the irregular power patterns of renewables such as wind turbines and solar panels, allowing us to move faster towards a carbon neutral society.

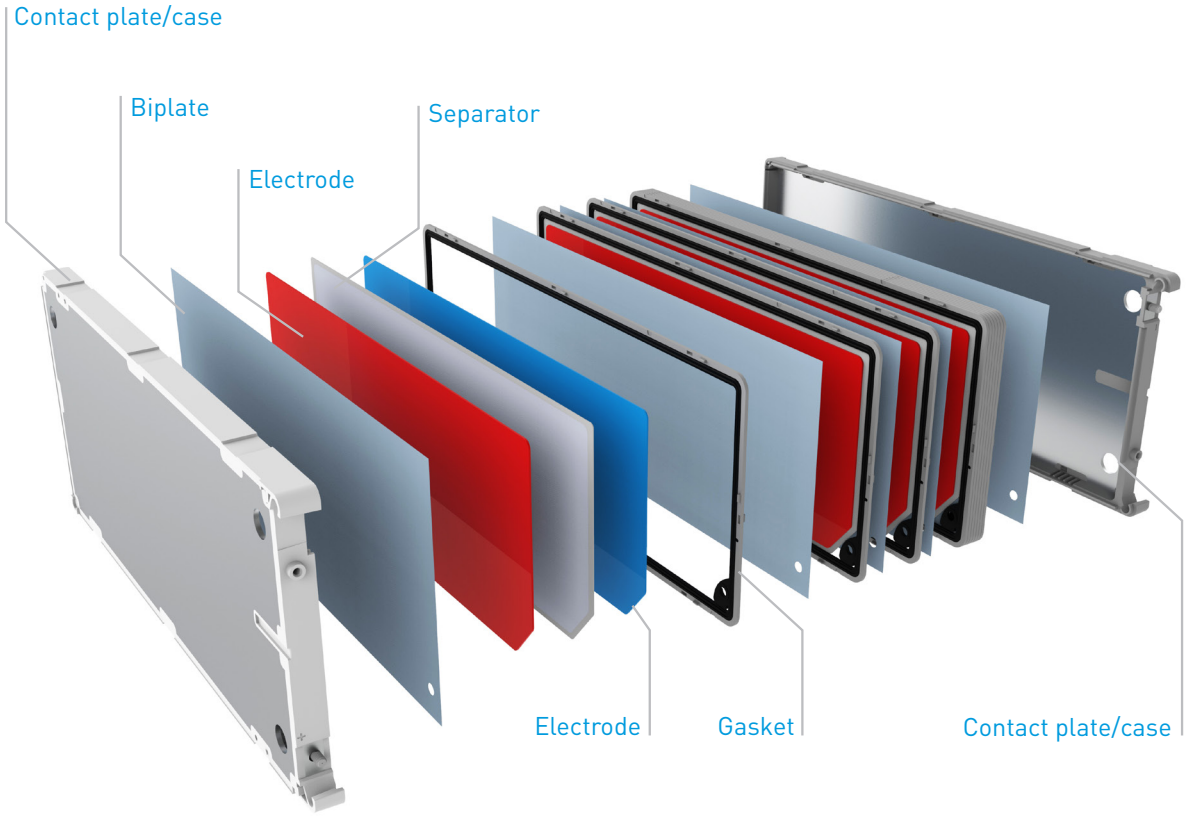
Energy storage providing grid support will prove to be an important part of the electrical infrastructure of the future. Nilar offers a range of scalable energy storage solutions to meet the needs of large projects. Nilar Cabinets and Racks with energy content ranging from kWh to MWh can be scaled incrementally and run in parallel.

Nilar bi-polar modular design

The 12 V Module is the building block of Nilar battery packs. As a building block, it provides excellent flexibility in battery pack voltage together with easy sizing towards different requirements and monitoring for battery management. The patented Nilar bi-polar cell design and electrode technology allows for a high quality and fully automated manufacturing process. The design is comprised of several patented and unique solutions developed by Nilar. The Nilar inventions cover important areas regarding environment, safety, product quality, life and cost. The 12 V module is sealed and contains no screws.

The unique and patented Nilar Hydride® battery is based on a bi-polar design, where cells are laid horizontally and stacked on top of one another to gain maximum space efficiency.

This also contributes to the easy assembling and disassembling. The outer contact plates acts as current collectors for all cells in the module, thus reducing the volumetric overhead and inherently results in a uniform current flow across the cell. As a result of this, the bi-polar design has great advantages compared to the cylindrical and prismatic technologies in terms of volumetric overhead. The uniform current and resistance paths promote uniform heat generation, which enables even ageing of the cells and ensures longer cell life.



Battery module expanded view.

Electrodes
The positive and negative electrodes are manufactured by a patented method for compression of dry powders without any expensive plate support material, binders or volatile organic solvents. Active materials and additives, as dry powders, are mixed with each other before being compressed in a calendar system to form continuous sheets of compressed electrode material. The sheets of active materials are cut into electrode plates.
The electrode manufacturing process produces electrodes with very high accuracy on dimensions, weight and capacity, contributing to the high quality of Nilar battery packs.

Separator
The separator prevents electrical contact between the positive and negative electrodes in the cell while holding the electrolyte necessary for ionic transport. The superior conductivity and safety of the water-based electrolyte used in the cells allows for the separator to act as an electrolyte reservoir. The high conductivity of the electrolyte also allows for a relatively thick separator, effectively preventing short circuits from any potential defects in the separator or foreign particles.

Electrolyte
The electrolyte in the cell provides means for ionic conductivity in the cell. The water-based electrolyte has important intrinsic features like low cost, fast filling time and excellent ionic conductivity over a wide temperature range. The electrolyte also possesses attractive safety features such as non-combustibility and energy-absorbing capability.

The electrolyte is a solution of potassium hydroxide. The design is a so-called starved electrolyte design with little free volume of electrolyte in the cells. All of the electrolyte volume is absorbed by the positive and negative electrodes and the separator.

Biplate
The biplates, together with the gaskets, are means for sealing each cell. The biplates also provide electrical contact between cells. In the Nilar bi-polar design the current is perpendicular to the electrode and bi-plate surface, making the whole biplate area used for current transfer between cells. This substantially reduces resistance and optimizes uniformity of current distribution over the biplate and electrode surface. This biplate design is part of the Nilar patent portfolio.

Gasket
Each cell is surrounded by a gasket. The gasket together with the biplates provide a seal between the interior of the cell and the exterior. The hydrophobic properties of the gasket prevent the creation of electrolyte bridges between adjacent cells.

Case
The case is part of the sealing of the module together with the contact plate. The case is extruded onto the sides of the contact plate. The two case/contact plate units on each side of the 10 cell stack are connected by laser welding, forming a sealed 12 V module. Fittings in the case also make sure that all 12 V Modules are aligned when assembled into battery packs.

Contact plate
The contact plate is the positive and negative terminal on the module and is also a part of the module enclosure. The contact plate is made of aluminum. Besides transferring electrical current, the contact plate also serves as a heat conductor moving heat from the cells to the long sides of the 12 V Module. This solution is patented by Nilar and enables efficient and low-cost air cooling of battery packs.

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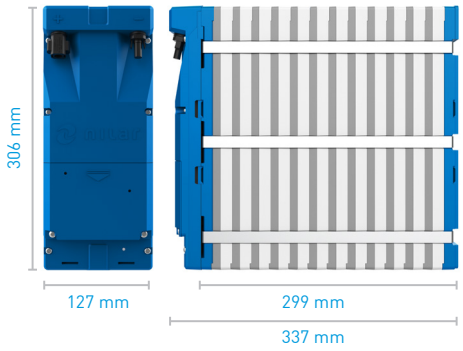
Nilar Energy Battery Packs

Each battery pack contains up to 12 modules (12 V per module). In turn, every module contains 10 battery cells. At low cycle duty, more charge and discharge power can be available, depending on the battery system and application. Battery packs are designed to be used in systems with a maximum nominal battery voltage up to 600 VDC.



Measurement illustration with length incl. and excl. Integrated Monitoring Unit for 1,44 kWh Energy battery pack

- Nilar Hydride® bi-polar design enables us to offer safe and sustainable batteries, providing long term power for energy storage solutions.
- Nilar batteries have a sealed design with no emissions of gases or electrolyte during its service life.
- Nilar batteries are easy to transport and aren't affected by any costly or complicated transport regulations.
- Nilar batteries contains none of the regulated heavy metals mercury, cadmium and lead. The design has been developed to enable a cost efficient recycling process and a high degree of reusable materials.

Battery Pack Features

Nominal voltage
The cell voltage of a battery cell is governed by the electrochemical potentials of the active materials used in the negative and positive electrodes and the electrolyte. For the hydride system used in Nilar battery packs, the nominal cell voltage is 1,2 V. The Nilar 12 V module is comprised of 10 cells connected in series within the module, achieving a nominal module voltage of 12 V. The nominal voltage of Nilar battery packs is determined by the number of 12 V modules connected in series within the battery pack. Battery packs are connected in series to match the required system voltage, forming a string. The nominal voltage of a string equals the number of battery packs multiplied by the nominal battery pack voltage.

Rated capacity
The battery capacity is rated in ampere-hours (Ah) and denotes the quantity of electricity a fully charged battery can deliver at a 5 h discharge to 1 V per cell at +20°C. Nilar has two different 12 V modules; one has a capacity rating of 10 Ah and the other has a capacity rating of 12 Ah. Nilar battery packs are made with a number of 12 V modules connected in series to achieve the battery pack capacity of 10 Ah or 12 Ah. To meet the required capacity of a Nilar battery installation, the battery packs, or battery strings, are connected in parallel. The total battery capacity is given in multiples of 10 Ah or 12 Ah.

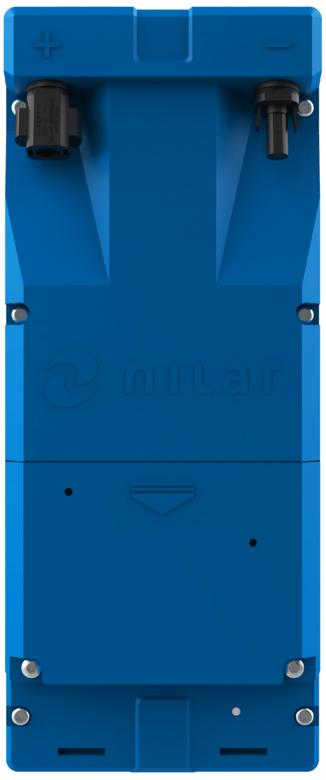
Operating voltage
Typical cell operational voltage is minimum 1,1 V per cell at discharge to maximum 1,6 V during charge. This corresponds to a 11 - 16 V range for the module.

Operating temperatures
The batteries can be operated in ambient temperatures from -10°C to +40°C. For optimal performance the recommended operating temperature is between +10°C to +30°C

Intermediate state-of-charge
Batteries can be stored or operated at an intermediate state-of-charge (SOC) without loss of performance.

Reliability
The Nilar battery is a stable electrochemical system. The design mitigates corrosion to prevent premature and unpredictable end of life. The design is virtually shock and vibration resistant. Testing shows a graceful decline in performance over the life of the pack.

Storage
Nilar battery packs can be stored several years without loss of performance.

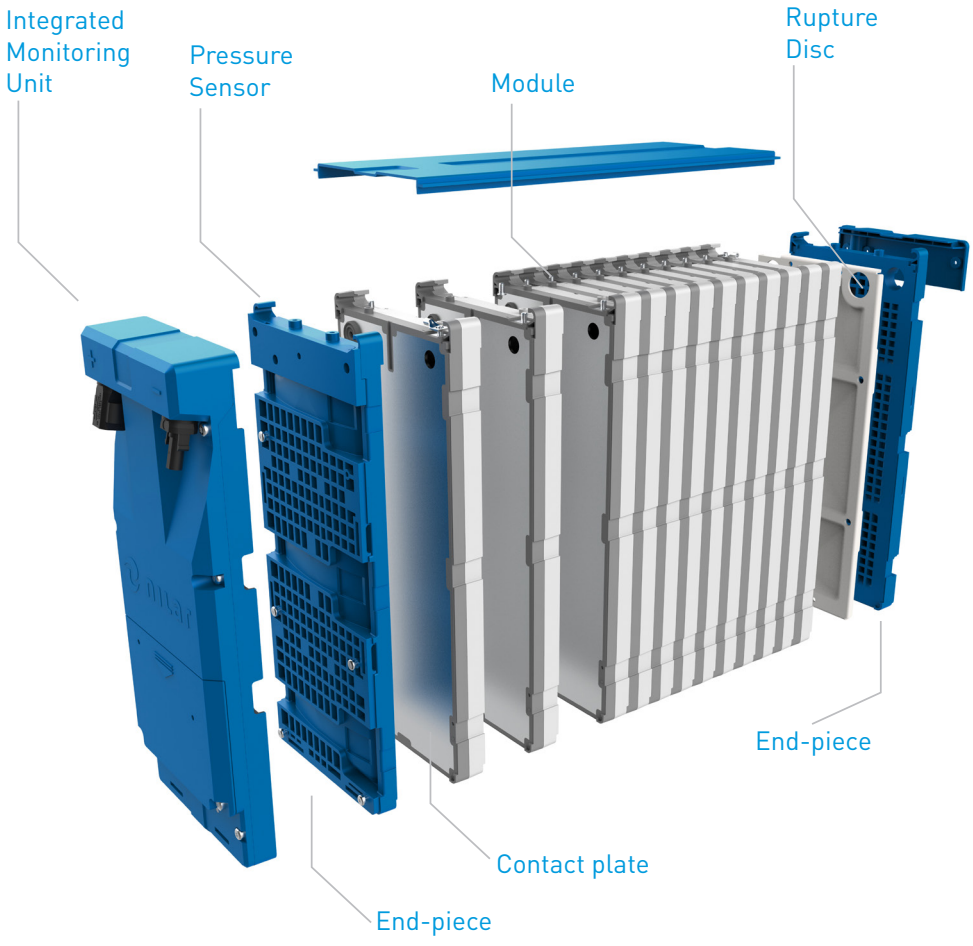


Front view of Energy battery pack.

Nilar Battery Design

The bi-polar design enables Nilar to produce modular batteries with improved volumetric power density and simplified battery construction. The main advantage of the bi-polar design utilized by Nilar is the common and shared large area current collector. This important feature reduces the volumetric overhead and inherently results in uniform current flow across the cell. Uniform current and resistance paths promote uniform heat gradients over the electrodes. A uniform battery temperature promotes a uniform electrochemical aging of the electrodes in the modules, which translates into a long service life.

Nilar battery packs are optimized for installation in energy storage systems, whether it be for a home, business or infrastructure projects. An Integrated Monitoring Unit is integrated on the battery packs together with industrial connectors for electrical and communication interfaces. The electronic battery pack system, communication bus and the battery packs are designed to fulfill requirements for electrical safety in battery systems with a nominal voltage up to 600V.



Expanded view of Energy battery pack

Pack design

The pack designs achieves a compact assembly of cells and other components required in a battery pack to meet required system voltage and run-time. They are assembled into a pack by a pick-and-place manufacturing process, followed by electrolyte filling and formation using a few charge/discharge cycles to activate the electrochemical system in the cells.

End-piece
There is one end-piece on each side of the battery packs. Together, with the steel bands, the end-pieces provide uniform cell compression over the electrode surfaces, impact protection to the cell stack, and electrical insulation from the pack potential.

The end-pieces also serve as a support structure for the Integrated Monitoring Unit mounted on one of the end-pieces of the Energy battery packs.

Integrated Monitoring Unit
The Integrated Monitoring Unit (IMU) is an electronic monitoring system, enclosed in a case and attached to the battery pack end-piece. The IMU monitors the conditions of the battery pack and communicates the measured data to the BMS.

Pressure sensor
The integrated pressure sensor enables recording of battery pack pressure. This signal is used for battery pack diagnostics and for high precision charge management. The risk of venting by overcharging the battery pack is eliminated by this unique feature.

Rupture disc
Nilar battery packs are fitted with a rupture disc located on the rear side of each battery pack that is activated at a pressure of 7 bar. During normal and mildly abusive conditions, the battery pack is sealed with no emission of gases or electrolyte. In normal operation, the internal pressure of Energy battery packs is below the activation pressure of the rupture disc.

Module
The 12 V module is the building block for all Nilar batteries. The 10 cells are connected in series to create modules with a nominal voltage of 12 V.

Contact plate
The contact plate electrically connects the adjacent modules in the pack and thus eliminates the need for external connectors between modules.

Heat dissipation
The patented design has the heat conducting from the contact plates to the long side surface of the 12 V module, where stacked modules increase the effective surface area for air cooling.

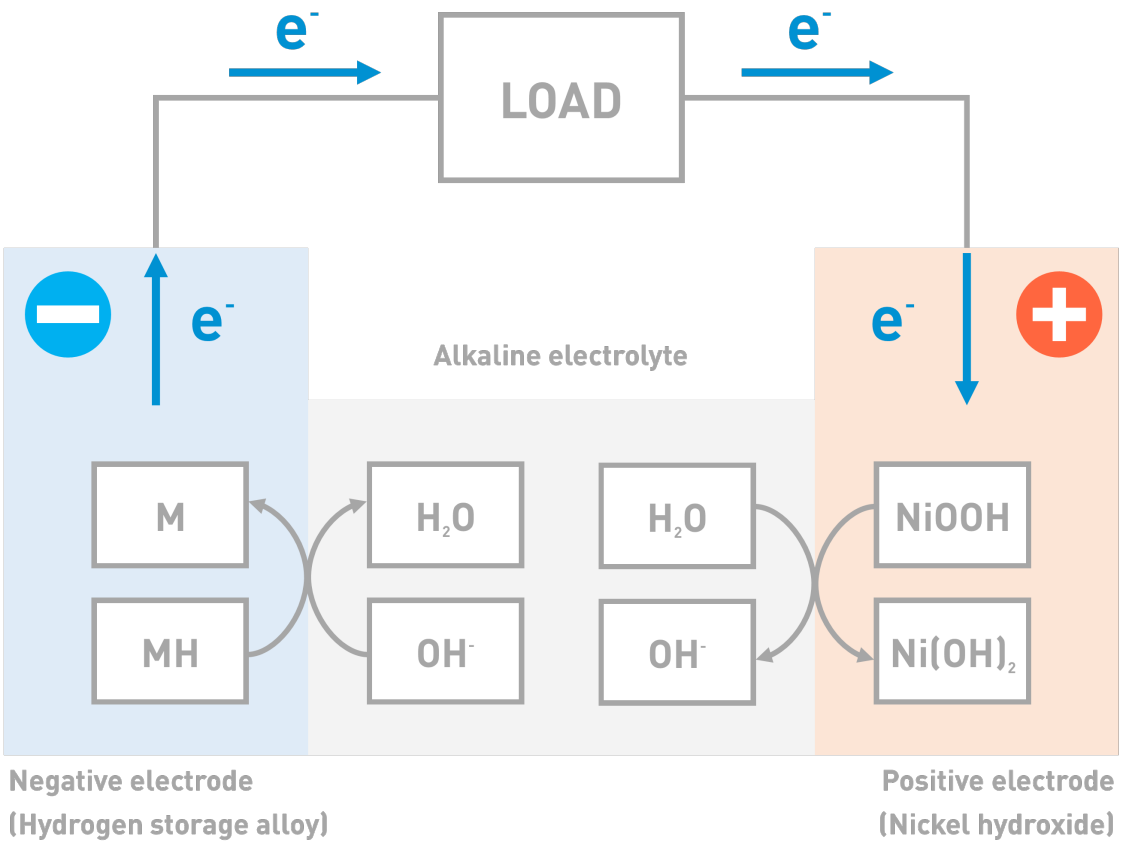
Electrochemistry

The Nilar advanced bi-polar Nickel Metal Hydride (NiMH) battery module consists of ten cells in series. Each cell contains two electrodes (a positive and a negative), electrolyte, and a separator in-between the two electrodes. The table below describes the compounds in the cell that are active during charge and discharge of the cell. The electrolyte is involved in the chemical reactions at the electrode surface together with the active material during charge and discharge, but is not consumed by the reactions. The strength of the electrolyte is not changed during any of these modes.

	Charge products	Discharge products
Positive material	Nickel (III) oxyhydroxide (NiOOH)	Nickel (II) hydroxide ($Ni(OH)_2$)
Negative material	Metal hydride (MH)	Metal alloy (M)
Electrolyte	KOH	KOH

Discharge

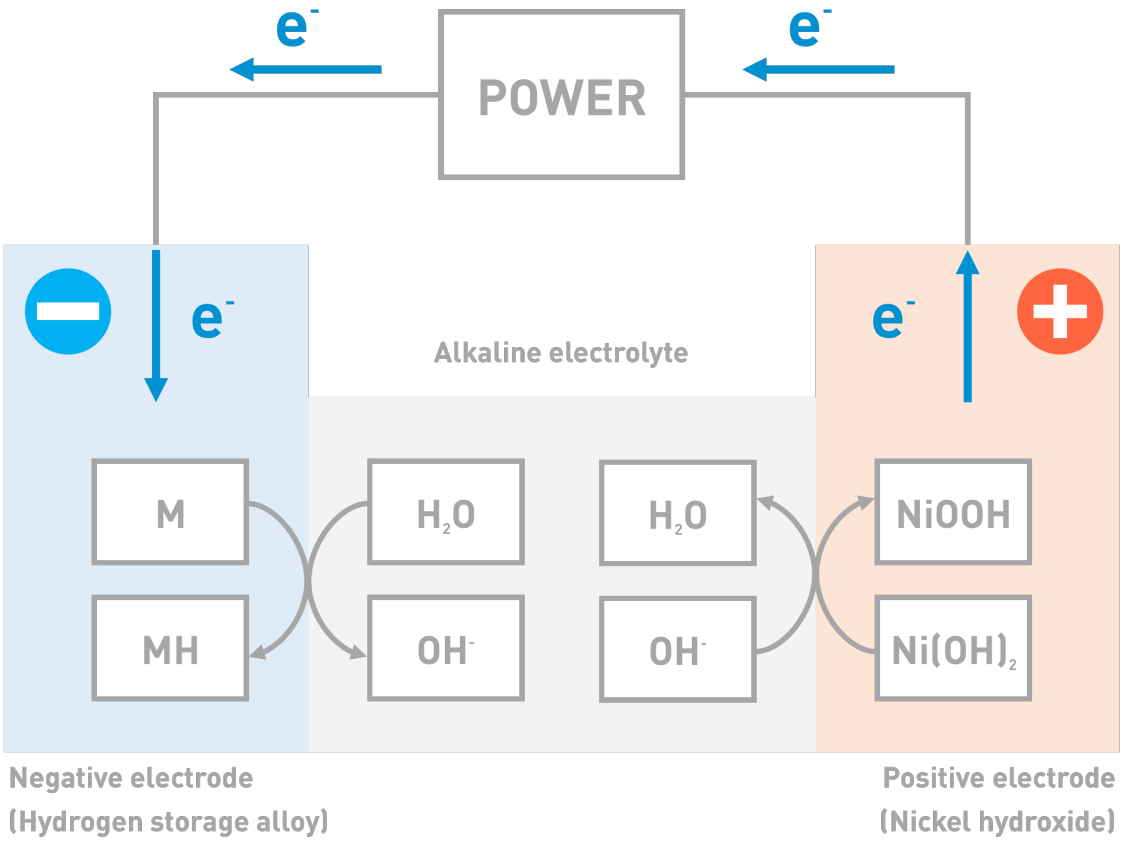
When a NiMH battery is discharged, hydrogen moves from the negative active material (MH) to the positive active material (NiOOH). In this process, the metal hydride (MH) is drained of hydrogen and the positive active material is reduced to Nickel hydroxide (Ni(OH)2).



Electrochemical reaction during discharge.

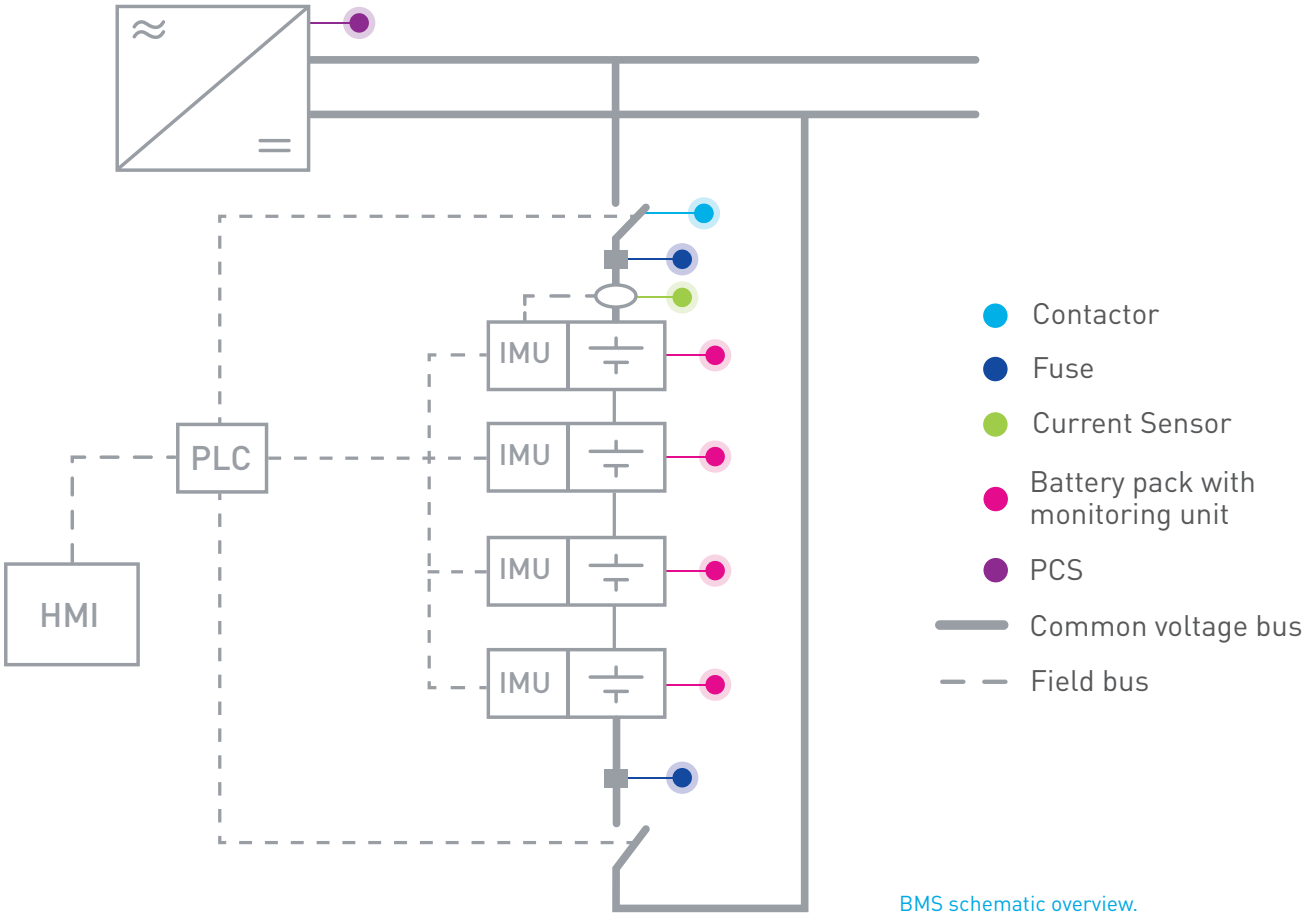
Charge

During charge, the hydrogen moves in the opposite direction as compared to the discharge. As the battery is charged, Nickel hydroxide ($Ni(OH)_2$) in the positive electrode loses hydrogen and the metal alloy (M) takes up hydrogen to form a metal hydride (MH). When losing hydrogen, the Nickel hydroxide ($Ni(OH)_2$) oxidizes and the positive active material becomes Nickel oxyhydroxide (NiOOH).



Electrochemical reaction during charge.

Battery Management System



BMS schematic overview.

Battery Management System schematic overview

The Electrical Energy Storage (EES) is controlled by a Battery Management System (BMS) that protects and controls the batteries to maintain a long service life. The BMS includes Programmable Logic Controller (PLC), Human Machine Interface (HMI), fuses and contactors in a master set-up. Each battery has its own Integrated Monitoring Unit (IMU) that communicates via an isolated communication bus to the PLC system. The EES can be scaled up in order to tailor the energy demand depending of the required capacity for the application. The maximum number of units an EES can be extended to is four (4) units, one master BMS (HMI/PLC) and three (3) servants (PLC). Each PLC can handle up to 40 monitoring units which gives an energy storage capability of up to 57,6 kWh per PLC. The Integrated Monitoring Unit (IMU) is placed on each battery pack and connected to the PLC by insulated CAN communication. In multiple configurations (more than one unit), the HMI is collecting all data from the batteries and provides easy access for the Energy Management System (EMS) with just one access point. Further information about the BMS functions and interface data can be found in the documentation Nilar Function description, which is provided by Nilar upon request.

Operating features

Charging

The recommended charge procedure is constant current charge with charge termination based on rate of temperature increase (dT/dt), together with a maximum allowed pressure and pack temperature. The charge procedure can be used for charging battery packs with battery pack temperature in the range of -10°C to +40°C. Within this temperature range, a fully discharged battery is recharged within 3,5 hours.

An inherent feature of the Nilar Hydride® electrochemical system at charging is the build-up of pressure and temperature at the end of the charge. The unique battery pack pressure sensor, integrated in Nilar battery packs, together with measured battery pack temperature, are efficient means to secure charge termination over the whole temperature and power range. At low temperatures, the charge rate can be limited by an increased voltage. At elevated temperatures, the maximum charge rate is limited by the rise in temperature and pressure at end of charge.

Self discharge

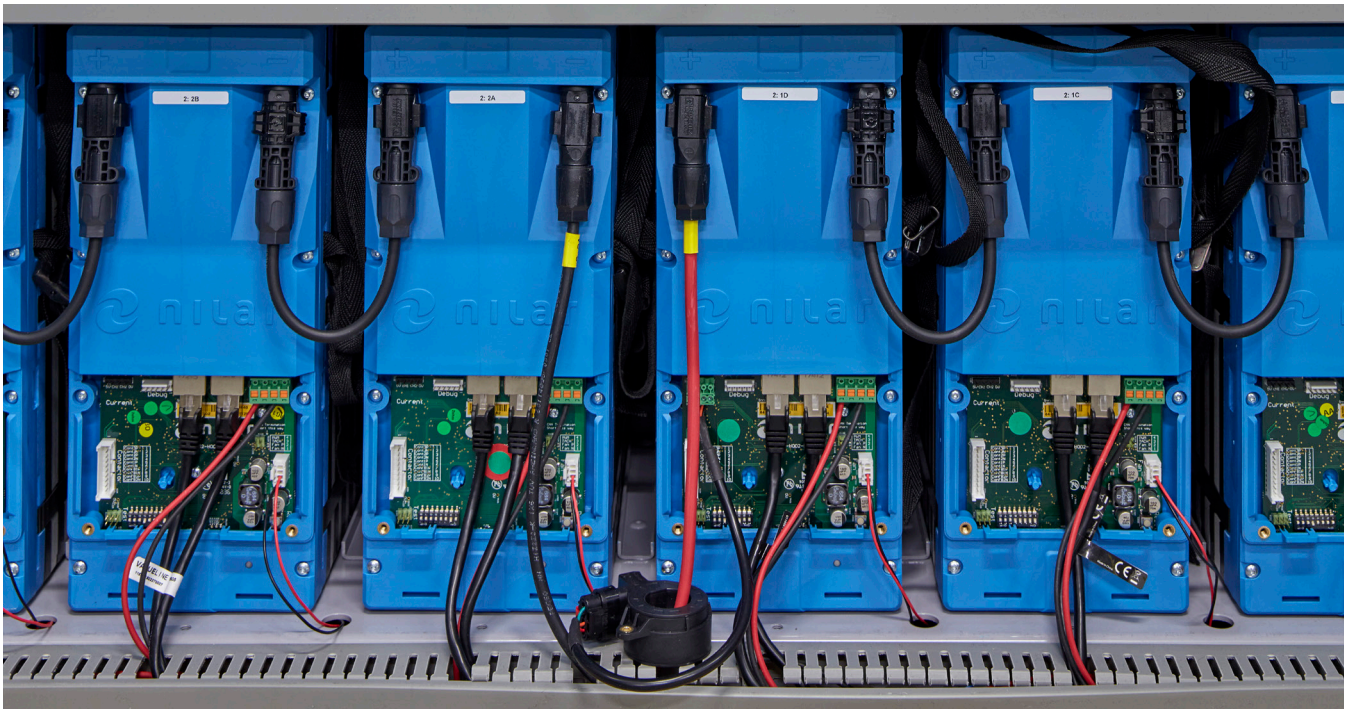
The state-of-charge (SOC) of a Nilar battery pack during storage slowly decreases with time due to self-discharge. The self-discharge is caused by internal electrochemical side reactions that slowly discharge the battery. The self-discharge rate is high over the first days of storage, but then levels out to a few percent per month depending on temperature. The rate of self-discharge is increased at elevated temperatures and decreases at low temperatures. A fully charged Nilar battery pack stored at +20°C will lose about 6% capacity after one day and 13% capacity after 28 days. Parasitic loads on the battery from charger, load and electronic systems will increase the rate of capacity loss during storage. This is common with all Hydride (NiMH) chemistries.

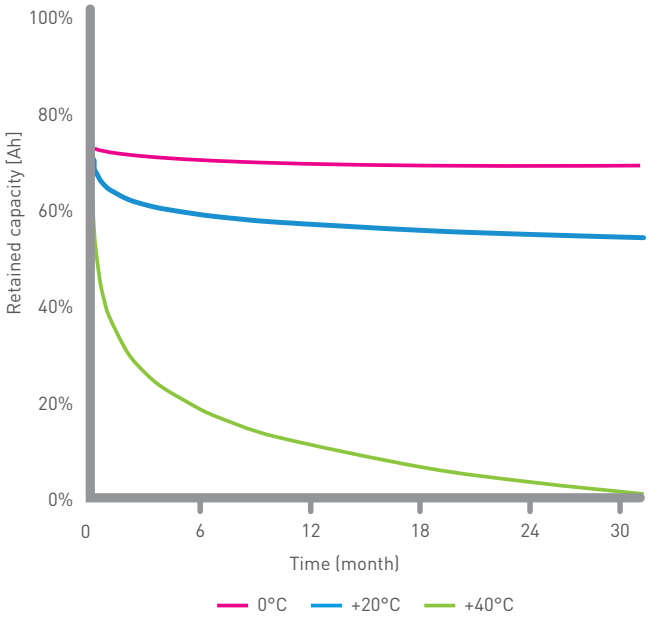
Cycle life

Cycle life is the number of charges and discharges a battery can achieve before the discharge capacity drops to a predetermined capacity. A number of circumstances have to be considered when estimating cycle life. Among the most important are temperature, charge method, charge and discharge rates, depth-of-discharge (DOD) and environmental aspects. The largest impact on the cycle life comes from the battery pack temperature, the charge procedure, and the SOC operating window. The more shallow a battery is cycled, the higher the number of cycles until the battery is unable to sustain the required service.

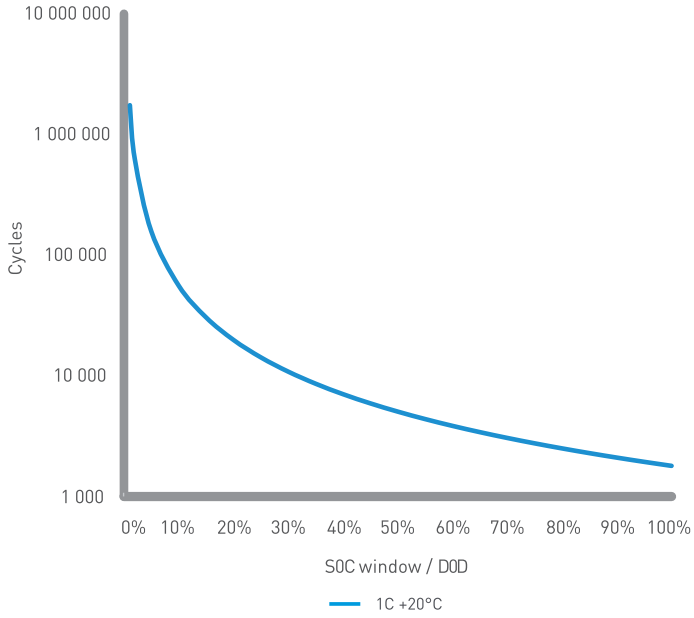
One of the superior features of Nilar batteries is the very stable performance over life. Typically, the impedance of a battery increases when the battery is used. This results in reduced run time and finally, depending on how end of life is defined, the battery is not able to perform as required. The stable and well defined performance over life experienced with Nilar batteries is a consequence of the intrinsic features of the Nilar Hydride® technology together with the high manufacturing quality gained by the Nilar patented bi-polar design. The main ageing mechanism is dry-out, causing a slow increase in impedance over cycles.

Capacity is not deteriorated during cycling. Nilar Hydride® batteries can be stored for many years without loss of performance. There is no decomposition of the electroyte at full charge nor solid electrolyte interface consuming charge carriers with detrimental effect on capacity and impedance. Cell impedance in a Hydride (NiMH) cell is determined by the amount of electrolyte in the separator. Over time, the electrolyte in the separator decreases (dry-out) with a slow decrease in conductivity. Finally, depending on the load, the run time of the battery is down to a level where the battery is considered as spent. End-of-life is often defined as 80% of initial capacity but can be based on other application specific constraints or capacity levels.





Self discharge when charged to 75% SOC. Typical charge retention at +20, +40 and 0°C at various storage periods.



Cycle life as a function of SOC window.

Cell balancing

All batteries in a system are not identical; they often have small differences in energy capacity. When each string is connected, the batteries are matched to make sure that each string contains batteries that are the utmost alike.

In operation, as a battery string is cycled, the SOC of the individual batteries may become uneven over time, causing a very slight lowering in capacity. Although these varied levels may be imperceptible, the imbalance can accumulate through continuous cycling and will eventually be detectable.

Fortunately, a process called cell balancing can be used to reestablish the equilibrium. This functionality is intrinsic to Nilar's battery management system and is present as an easily activated maintenance routine. When triggered, the batteries are steadily charged to 100% SOC, and then undergo a few short sequences of pulse charges. This pushes any batteries that may have lowered back to their original maximum capacity, bringing the system back to its best possible performance. When cell balancing is complete, the system is fully charged and ready to return to normal operation

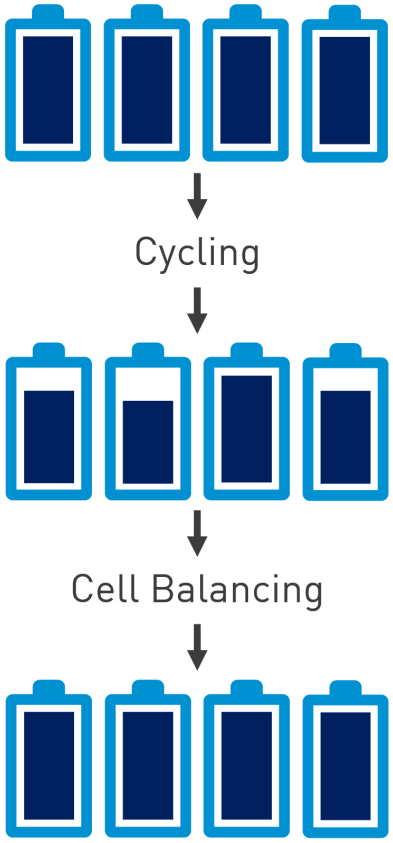


Illustration of cell balancing.

Nilar system components

Nilar offers a multitude of solutions to fit many applications and locations. An energy storage system ready to be connected to the grid requires several components that handle monitoring, control and conversion.

The following components are found in a battery string (example based on a battery string consisting of 4 battery packs):

- Battery packs with BMS and Integrated Monitoring Units (4 pcs)
- Programmable logical controller (1 pcs)
- Circuit breakers (2 pcs)
- String fuses (2 pcs)
- Current sensor (1 pcs)
- Fans (4 pcs)
- Cut-off contactor (1pcs)
- RJ-45 network cables (5pcs)
- 24 VDC power cable for IMU (1pcs)
- String power cables (5pcs)

Battery packs connected in series

Each EES consists of several battery strings, with battery packs connected in series to match the required system voltage. To meet the required energy content, battery strings are connected in parallel. The battery strings are fitted with circuit breakers on both sides of the string and one current sensor for monitoring of charge and discharge currents.

Standards

EMC standards:

- EN 61000-6-2-2005
- EN 61000-6-3:2007

Electrical cabinet standards:

- IEC 61439 -1& -2
- EN 61010-1:2010

Battery pack standards:

- Safety: IEC 62485-2
- Performance: IEC 62675
- Transport UN38,3 Test T1 Altitude & Test T3 Vibration
- Transport ADR-S SP238 Test A

Cabinet cross-section view.

Integrated Monitoring Unit

The Integrated Monitoring Unit (IMU) is mounted on each battery pack. The unit is monitoring voltages for every 10 cells in the pack together with pack temperature and pressure. Processed data is communicated via a field-bus interface to the PLC. The IMUs are powered by an external power supply of 24 VDC (not from the pack). The communication between the PLC and the IMU is a CAN bus using the CANopen application programming interface. CANopen uses ISO-11898:2003 standard CAN with an 11-bit identifier. The range of bus signalling rates is 125 Kbps to 1 Mbps. The monitoring unit bus rate is set to 250 Kbps.

Signals IMU

The following signals are monitored by the IMU. The IMU is tested according to standard IEC 61010-1.

- **Module voltages**

The voltage monitors detect the voltage of each module. If the actual voltage is out of the defined range an alarm will be triggered. In addition to the module voltages, the combined voltage of the battery pack is also measured and presented as a total voltage value.

- **Current**

The current sensor give information about the current flow direction and value.

- **Pressure**

An internal battery pressure sensor measures the relative pressure in each battery pack. Due to common gas space in the Nilar bi-polar pack design, all the cells in the battery pack have the same pressure. If the pressure is out of the defined range, an alarm will be triggered and communicated to the external battery management system. The external battery management system is programmed to disconnect the battery pack if it reaches the pressure limit.

- **Battery temperature**

There is one temperature sensor in each battery pack that measures the temperature. If the temperature is out of the defined range, an alarm will be triggered and communicated to the external battery management system to prevent the battery from overheating. The communicated information also has the purpose to detect when a full charge cycle is completed.

- **Fan**

The settings for the fan can either be adjusted as a 0-100% speed or as a target temperature. These settings are defined in an external battery management system.

BMS

Nilar BMS is based on specific characteristics of Nilar battery packs and is developed to optimise utilisation of installed battery capacity and service life. The BMS will issue warnings or alarms to higher level EMS when battery conditions are out of range. If critical conditions are detected in a string, the BMS will disconnect the string. The settings are optimised by Nilar depending on the system and application.

Circuit breakers

Two circuit breakers per string are required to enable disconnection of the string from the common voltage bus. The circuit breakers are hardwired to and controlled by the PLC.

String fuses

Each battery string is equipped with two fuses, one on the negative side and one on the positive side.

Current sensor

The current sensor provided by Nilar is an automotive grade current transducer. It has galvanic isolation between the primary circuit (high power) and the secondary circuit (electronic circuit). The open loop transducers use a Hall-effect integrated circuit. There is one current sensor per string, mounted on the battery pack.

Programmable logical controller (PLC)

The controlling system that controls the BMS consists of a PLC. It ensures that the battery system runs in a safe way and manages information from the IMU, EMS and the PCS. The PLC monitors data from the IMUs and controls switching on and off each battery string. It also manages alarms and presents the actual status of the battery system. The PLC also shows the needed information on an HMI screen for our Cabinet and Rack products.

Insulation monitoring

The insulation monitor is used for an IT-setup installation. The insulation resistance between system lines and system earth is measured. If this falls below the adjustable threshold values, the output relays switch into the fault state. The coupling unit is used to achieve measurements up to 1000 VDC.

Cut-off contactor

The cut-off contactor is used to open and close a battery string when the BMS signals that the battery string is going to be charged or discharged. There is one contactor on the positive side for each battery string. On the negative side, there is one large contactor that handles all the battery strings in the battery system.

Fans

In order to cool the battery packs, fans are placed inside the Home Box and on the back of the Cabinets and Racks. Each fan is controlled by an IMU. The BMS communicates to the IMU which temperature is desired and the IMU controls the fans in order to maintain that temperature.

Close-up of contactors

Integration

Simple integration with Nilar
If you are looking for an alternative to lead and lithium-ion batteries, the Nilar Hydride® batteries offer the ideal products. The Nilar Energy series promises safe and powerful performance without being detrimental to the environment.

Batteries for all applications
We realize that applications can be different and, therefore, offer a versatile battery. The modularity of the Nilar Energy series allows configurations of voltages from 96 to 600 V, giving you the solution that your customer needs without compromise.

Easy communication and control
The Nilar energy storage solutions support several communication interfaces together with an advanced software that monitors the batteries down to every module. The energy storage system can be configured to perform several different tasks, giving you the best solution for your needs.

Modular energy storage solutions
Nilar offers a multitude of solutions to fit many applications and locations. An energy storage system ready to be connected to the grid requires several components that handle monitoring, control and conversion. Nilar Home Box, Cabinets and Racks contain our BMS and Nilar battery packs with a built-in Integrated Monitoring Unit (IMU). In addition, a Power Conversion System (PCS) is required in order to convert the battery current from DC to AC. This will then connect the Home Box, Cabinet or Rack to the electrical grid. Lastly, an EMS that can control and coordinate several energy systems may be of use in select applications.

EMS
An Energy Management System (EMS) is a higher-level system that monitors, controls and optimizes the performance of the energy system and its interaction with other installed systems. The EMS communicates with the BMS and the PCS and can command these systems to charge or discharge the batteries using different signals. The signal descriptions can be found in the Nilar Function Description, which can be provided upon request.

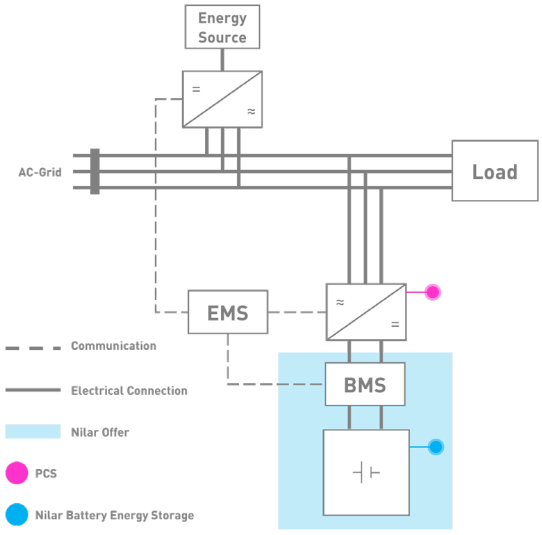
PCS
The Power Conversion System (PCS) converts the DC power of the batteries to the desired voltage and frequency of the surrounding energy system or electrical grid.
The PCS is the primary controller of when the battery is charged or discharged, as it controls the current flows in and out of the energy storage.

System configurations

The Nilar products can be connected to the electrical grid using either an EMS controlled PCS or a BMS controlled PCS. The type of configuration is decided by which component controls the operation of the energy storage. The operation can be controlled by an external EMS or by an external EMS through the BMS. An AC/DC PCS, often called an 'inverter', is required to connect the energy storage to the grid. We can assist you upon request to find the correct PCS to match your energy storage system. This PCS can then be controlled by the Nilar BMS or by an external EMS.

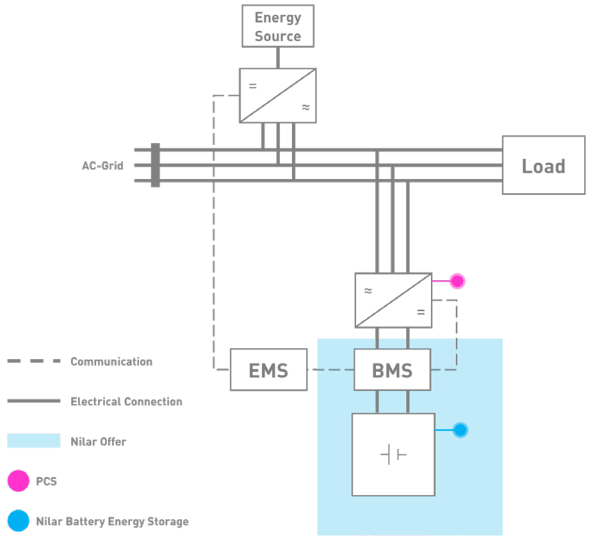
EMS controlled PCS

Our EMS controlled PCS configuration is an open integration where the customer has control over the EMS. The EMS then communicates with the PCS and BMS.



BMS controlled PCS

The BMS controlled PCS configuration has a BMS controlled PCS. The customers EMS then communicates with the BMS which relays the commands to the PCS.



Communication

The standard communication interfaces supported by the BMS are Modbus TCP/IP and Modbus RTU. In custom integrations, communication via CANopen is also available.

Sustainability

Nilar batteries are made with minimal hard-to-recover raw materials. Unlike most industrial batteries, Nilar Hydride® batteries do not contain, nor need cadmium, mercury or lead to deliver powerful results. And unlike many other chemistries, which are often more costly to recycle than mine, nickel is an actively recycled and reused material.

Nilar batteries are are designed with recyclability in mind. From the nickel used to power them to the seals and casing used to the contact plates transferring the energy, the different elements that make up the battery can be reused in industrial manufacturing, such as the production of new Nilar batteries. The Circular Economy philosophy has been a central part of the R&D process for the Nilar Energy series, reducing cost and the environmental impact of the batteries.

Handling of battery waste in Europe is regulated according to Battery Directive 2006/66/EC and EU Member state national legislation. Nilar takes full responsibility for taking back Nilar batteries and for the recycling process of them. Returned batteries are systematically recycled and the materials are re-used either in new batteries or in other industries.

When your Nilar battery is ready for disposal, it is recommended to send the battery to the local Nilar battery dealer or to Nilar AB.

Nilar products are compliant with the following directives and regulations:

- EU-directive 2006/66/EG ('Battery Directive'). The batteries do not contain the heavy metals mercury or cadmium.
- Waste Electrical and Electronic Equipment (WEEE) Directive 2012/19/EU
- Restrictions of certain hazardous substances according to RoHS Directive 2011/65/EU.
- Nilar products are in compliance with Regulation (EC) No. 1907/2006 concerning the Registration, Evaluation, Authorization and the Restriction of Chemicals (REACH).

Nilar innovations for high recycling efficiency:

- Developed method for the re-use of battery material in our production line.
- Fully recyclable
- Low usage of hard to recover raw materials.
- Produced in Sweden with 100% renewable energy.

Safety

Nilar Hydride® batteries are based on a mature technology that has been used commercially for over 25 years for a variety of applications including consumer products, electric vehicles, hybrid electric vehicles, and stationary power applications. The introduction of batteries into cars are now driving the safety regulations both for vehicles and other battery applications, such as energy storage.

The main safety benefits of Nilar batteries are:

- Battery system with water based, non-flammable electrolyte[1]: No risk of spontaneous fire or explosion.
- No risk of short circuit generation even under low temperature charging as observed in other solutions: No risk of spontaneous release of energy, rapid temperature increase with fire and explosion as potential consequences.
- Electrodes contained in Nilar modules cannot ignite or react spontaneously: No risk of heat propagation between modules under normal operation and rest periods[2].

A significant part of the BMS functionality is to keep the battery from states which may affect reliability and safety. This mainly concerns the prevention of overcharge, over-temperature and short circuits.

But even in the case of BMS failing or malfunction, Nilar batteries show a high degree of passive safety under abusive treatment[3]:

Overcharge: The Nilar systems can manage an overcharge with 0,2C for 5 hours, or with 1C for 30 minutes without venting. During overcharging with higher current over longer periods of time, the maximum pressure limit of 5,5 bar might be exceeded and, consequently, the safety vents could open, releasing gas.

Over-discharge and reversal:
Over-discharge of modules down to 0 V is not critical for safety since it does not cause a pressure nor a temperature increase. However, it does damage the battery beyond use and should be avoided. Continuous reversal can lead to an internal pressure build-up, activating the safety valves and causing a gas release. Any associated temperature increase will be modest and non-critical.

Short circuit: To prevent short circuit, Nilar has installed fuses on both the positive and negative side of each string.

External heat/fire: If an external fire would occur near the battery bank, the fire should be extinguished by CO_2, in the same way as a corresponding electronics fire. If the fire is not extinguished, the heat will eventually cause the Nilar batteries to ventilate. This scenario should be addressed in the same way as a corresponding fire in a lead-acid battery installation.

(1) Electrode materials in Hydride batteries (NiMH) are chemically stable when in contact with the electrolyte. There are no heat generating reactions taking place between the electrode materials and the electrolyte and no solid electrolyte interface is needed to protect the electrolyte from electrode materials. This can be compared to chemistries containing highly flammable organic electrolyte. If the organic electrolyte is catching fire, explosive and poisonous gases are released.

(2) Propagation is a dangerous phenomenon that can occur in batteries based on other chemistries, where one cell that has run into thermal runaway can spread the heat to other cells, in that way initiating thermal runaway in other cells and causing a cascade effect.

(3) Several battery chemistries require a very strict safety region when it comes to upper voltage limits, temperature limits and current limits. If you pass the set limits you enter the safety critical region where thermal runaway can be triggered by internal short circuits and/or external heat. For example, during deep discharge or overcharge.

Transport

One of the advantages with Nilar battery packs, as compared with many other battery types, is that UN approved packaging and marking is not required for transport by sea, road, rail and air. No dangerous goods documentation is required when transporting Nilar battery packs by road or rail. Nilar batteries are also certified for transport via road, rail, sea or air, without the need for heavy and expensive explosion-proof containers.

A dangerous goods declaration is required if batteries are transported by sea in quantities of over 100 kg in one transport unit. Nilar battery packs are then defined as dangerous goods, class 9. UN number and Proper Shipping Name are UN 3496 and Batteries, Nickel-Metal Hydride respectively.

Transportation of Nilar systems is easy to manage, since the IMDG Code provisions do not apply on Hydride batteries (NiMH) contained in or packed with equipment, according to Special Provision 963.

An Air Waybill or similar is required if batteries are transported by air. Nilar battery packs are not classified as dangerous goods and belong to the entry "Batteries, dry" in the list of dangerous goods in IATA (no UN number). If an Air Waybill is used, the words "Not Restricted" and the Special Provision number (A123) must be included in the description of the substance on the Air Waybill, according to IATA-DGR.

For several other battery chemistries, heavy regulations apply for all modes of transport, especially regarding transport by air. For those classified as fully regulated dangerous goods, strict regulations and even training courses may be required for the personnel involved in the transportation.

Standards:

- Transport UN38.3 Test T1 Altitude & Test T3 Vibration
- Transport ADR-S SP238 Test A

Nilar ENERGY product series

BATTERY PACK STRINGS	Art. no.	Product description	No. of battery packs	Pack voltage (V)	String voltage (V)	Rated Energy (kWh)	Max charge rate (C-rate)	Max discharge rate (C-rate)	Max continous charge/dis-charge rate (C-rate)	Measurements DxHxW (mm)
ES-192-1,92kWh	200069E	String, 2pcs of 96V packs, no BMS	2	96	192	1,92	2	3	1	Single Pack 248x306x127
ES-288-2,88kWh	200070E	String, 3pcs of 96V packs, no BMS	3	96	288	2,88	2	3	1	Single Pack 248x306x127
ES-384-3,84kWh	200071E	String, 4pcs of 96V packs, no BMS	4	96	384	3,84	2	3	1	Single Pack 248x306x127
ES-216-2,16kWh	200072E	String, 2pcs of 108V packs, no BMS	2	108	216	2,16	2	3	1	Single Pack 273x306x127
ES-324-3,24kWh	200073E	String, 3pcs of 108V packs, no BMS	3	108	324	3,24	2	3	1	Single Pack 273x306x127
ES-432-4,32kWh	200074E	String, 4pcs of 108V packs, no BMS	4	108	432	4,32	2	3	1	Single Pack 273x306x127
ES-240-2,4kWh	200075E	String, 2pcs of 120V packs, no BMS	2	120	240	2,40	2	3	1	Single Pack 293x306x127
ES-360-3,6kWh	200076E	String, 3pcs of 120V packs, no BMS	3	120	360	3,60	2	3	1	Single Pack 293x306x127
ES-480-4,8kWh	200077E	String, 4pcs of 120V packs, no BMS	4	120	480	4,80	2	3	1	Single Pack 293x306x127
ES-288-2,88kWh	200078E	String, 2pcs of 144V packs, no BMS	2	144	288	2,88	2	3	1	Single Pack 337x306x127
ES-432-4,32kWh	200079E	String, 3pcs of 144V packs, no BMS	3	144	432	4,32	2	3	1	Single Pack 337x306x127
ES-576-5,76kWh	200080E	String, 4pcs of 144V packs, no BMS	4	144	576	5,76	2	3	4	Single Pack 337x306x127

HOME BOX	Art. no.	Product description	No. of battery packs	Pack voltage (V)	System voltage (V)	Rated Energy (kWh)	Max charge rate (kW)	Max discharge rate (kW)	Max continuous charge/dis-charge rate (kW)	Measurements DxHxW (mm)
E-576V-5,76kWh-F incl. ESO	210017E	Home Box 5,76 kWh, F-ESO	4	144	576	5,76	5,76	11,52	3,46	305x945x900
E-288V-5,76kWh-K	210016E	Home Box 5,76 kWh, K	4	144	288	5,76	5,76	11,52	3,46	305x945x900

CABINET	Art. no.	Product description	No. of battery packs	Pack voltage (V)	System voltage (V)	Rated Energy (kWh)	Max charge rate (kW)	Max discharge rate (kW)	Max continuous charge/dis-charge rate (kW)	Measurements DxHxW (mm)
E-576V-11,52kWh	200035E	Cabinet 2 string - Energy	8	144	576	11,52	11,52	23,04	6,91	655x1033x701
E-576V-17,28kWh	200036E	Cabinet 3 string - Energy	12	144	576	17,28	17,28	34,56	10,37	655x1388x701
E-576V-23,04kWh	200037E	Cabinet 4 string - Energy	16	144	576	23,04	23,04	46,08	13,82	655x1743x701
E-576V-28,80kWh	200038E	Cabinet 5 string - Energy	20	144	576	28,80	28,80	57,60	17,28	655x2098x701

RACK	Art. no.	Product description	No. of battery packs	Pack voltage (V)	System voltage (V)	Rated Energy (kWh)	Max charge rate (kW)	Max discharge rate (kW)	Max continous charge/dis-charge rate (kW)	Measurements DxHxW (mm)
E-576V-57,60kWh-M	200039E	Rack-M - Energy	40	144	576	57,60	57,60	115,20	34,56	615x1996x1509
E-576V-57,60kWh-S	200040E	Rack-S - Energy	40	144	576	57,60	57,60	115,20	34,56	615x1996x1509

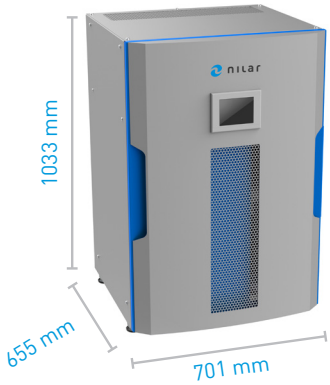
Racks

Rack 57,60 kWh

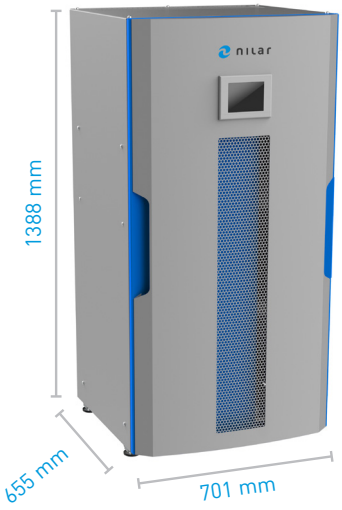
Home Box

Home Box 5,76 kWh

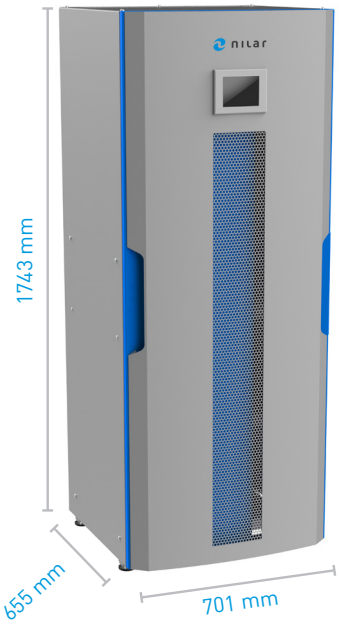
Cabinets



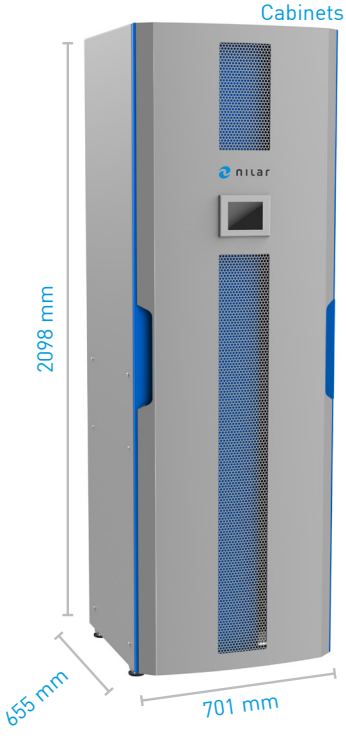
Cabinet 11,52 kWh



Cabinet 17,28 kWh



Cabinet 23,04 kWh



Cabinet 28,80 kWh

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to find out who your local distributor is.

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