Off to Your Dream Journey

But First – Meet Lotte and Gijs

Hi there! First off, thank you so much for reading our eBook! We're thrilled you've decided to dive into the world of camper van electrics with us. By purchasing this eBook, you're helping us grow our website, allowing us to assist even more camper builders just like you!

Allow us to introduce ourselves: We're Lotte & Gijs (and let's not forget our dog, Noor!). Back in March 2020, we had plans to set off on an epic adventure along the PanAmerican Highway, from Alaska all the way down to Chile. Our plan was simple—fly to Canada, buy a camper van there, and journey through both North and South America. But, as you probably guessed, COVID threw a wrench into those plans. Borders closed, and the trip we'd spent two years dreaming about had to be put on hold.

So, we found ourselves asking, "What's next?" Should we buy a house, build a tiny home, or perhaps buy a bus and convert it into a camper van? No prizes for guessing our decision! In June 2020, we purchased 'Bas', a 2011 Mercedes Sprinter with 92,000 kilometers on the clock, and got ready to build our dream home on wheels.

But honestly, where do you even start with a camper conversion? We began by watching countless YouTube videos, browsing Pinterest endlessly, and devouring numerous blogs. After 12 months of hard work and learning on the go, our camper was finally ready to hit the road! During our journey, we realized crucial information about camper electrics was scattered across the internet, and existing resources seemed outdated—think Excel spreadsheets or paper-based electrical schematics. We knew there had to be a better way, so we decided to make a change.

That's why we created www.camper-elektra.com (our Dutch website), and now Gridless Solutions!

With our website, we aim to simplify complex camper electrics so that you too can power your camper van with ease. We have published over 23 blogs on camper electrics and developed useful tools such as our energy consumption calculator, which allows you to easily estimate your electrical needs. Additionally, we've created our newest software: Gridless Solutions—a tool used successfully by many to design their own electrical layouts. It's highly recommended for your project!

Our first van 'Bas"

After developing these tools, we felt something essential was still missing: a clear and comprehensive collection of information to help anyone tackle the fun challenge of installing their own camper electrics. This brings us to this very eBook, in which we aim to explain camper electrics as clearly and simply as possible, guiding you step-by-step through creating your own electrical schematic.

Yes, this includes you! We want to introduce you to installing your own camper electrics, so you can confidently equip your camper with power. We hope we've provided you with enough information and explained everything clearly enough for you to make your own electrical schematic and connections yourself. If you have questions, if anything is unclear, or if something doesn't seem right, please send us an email at info@camper-elektra.com.

Oh, and before we forget—

We've put a lot of time and care into creating this eBook: it's designed to be both easy to follow and technically accurate.

Throughout the guide, you'll find links to products we personally use in our own campervans. If you decide to purchase something through one of those links, we earn a small commission — at no extra cost to you.

If you've found value in this eBook, this is a simple way to support our work and say thanks. Just use the links inside when buying your electrical components. We really appreciate it!

Before you start

For many people, electricity is one of the **most challenging** aspects of building a camper van. And honestly, that's understandable, since there's a lot to consider. For instance, you'll need to think about how you plan to camp and what types of appliances you'll be using. This makes it essential to buy the right equipment and understand precisely how to install everything safely.

But don't worry—that's exactly what we're here to help you with. In this eBook, we will guide you step-by-step through the process of setting up your camper's electrical installation. And don't be intimidated: we'll keep the explanations as simple and clear as possible, ensuring everyone can follow along, even if your current knowledge on the topic is zero!

So, what can you expect from this eBook? We'll cover how to install electrical systems in your camper van, what equipment you'll need, and important considerations you should keep in mind. Over the past few years, we've received numerous questions about camper van electrics, and we'll be addressing all these questions to ensure your knowledge is as comprehensive as possible.

Disclaimer

Working with electricity can be dangerous! This eBook is written based on extensive research and our own practical experience installing electrical systems. While we've made every effort to provide accurate information, mistakes could still occur. Therefore, we are not liable for any damage that may result from using this eBook or camper electrical schematics.

You are always responsible for ensuring a safe electrical installation. We cannot be held accountable for any complications you might encounter during the installation process. Always consult the manual of each electrical product and follow the manufacturer's instructions carefully. If you're ever unsure, please have a professional inspect your installation or outsource the entire electrical setup.

If you happen to notice an error, we'd greatly appreciate it if you could let us know. Feel free to reach out to us at info@gridless-solutions.com. We've worked very hard on this eBook. Please note, it is strictly prohibited to publish, copy, or share any part of this eBook without our written permission.

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Camper Electrics

Explained the easy way

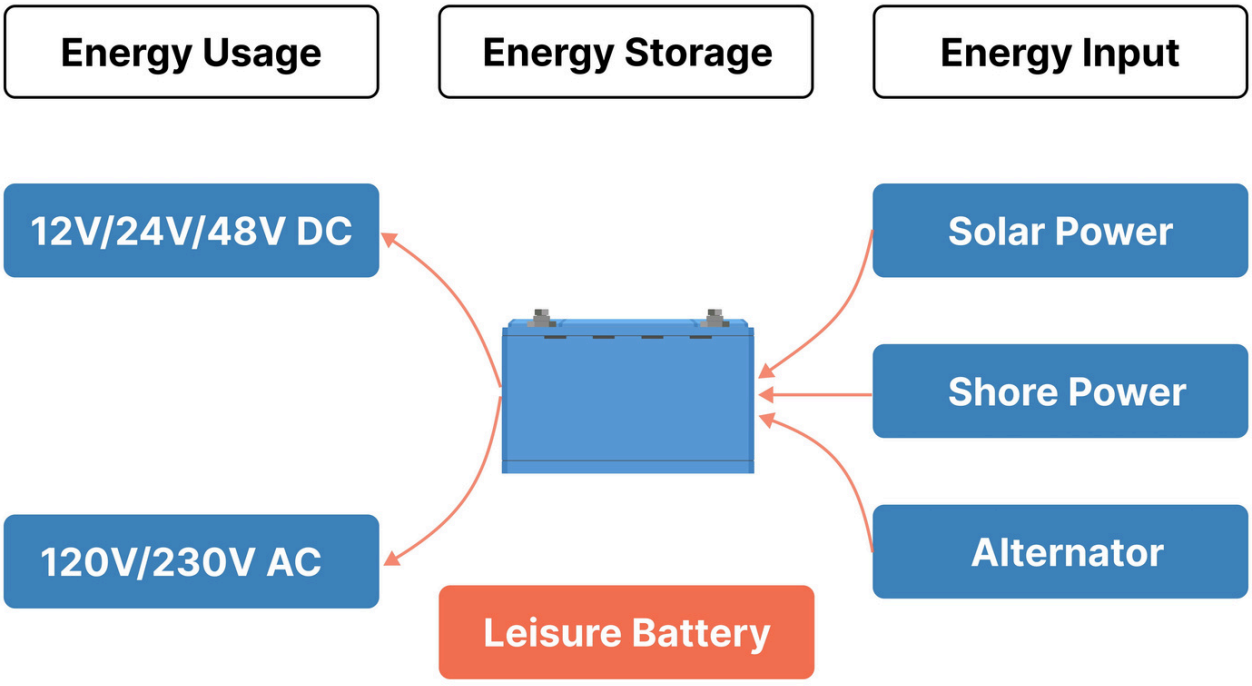
Before we dive into all the details of camper electrics, it makes sense to start with the basics. That way, you'll better understand the more complex topics we'll cover later on. Of course, we'll keep it as simple and clear as possible.

Just like every car, a camper has a starter battery. This battery is used to start the engine. But in a camper, you usually add a second battery so you don't have to rely on the starter battery for everything else. This second battery is called a **leisure battery** (also known as a house battery).

The job of the leisure battery is to store and provide power — so you can turn on your lights or charge your phone, wherever you are. But the energy in that battery will run out at some point, so you'll need to recharge it again. It's a bit different from how things work at home.

When we talk about camper electrics, we usually break it down into three parts:

- Energy storage: the leisure battery
- Energy usage: the devices that consume power
- Energy input: how you recharge the battery



We'll cover all of these chapters in detail later on, but before we do that, let's first go over twenty key terms you need to understand before diving into camper electrics. Once you've got those down, we'll take a closer look at energy storage, starting with the leisure battery.

Glossary of Terms

You probably already have a basic idea of what electricity does: it powers the devices you use.

But electricity works a bit differently in a camper than it does at home.
At home, it's simple: you plug in your phone or laptop charger, connect it to a wall socket — and voilà — it starts charging. The same goes for running a washing machine or making coffee. You just flip a switch, and the device works. We don't usually think about it much, because power at home always seems to be available.

But in a camper, things work a little differently.

We'll go into that in more detail later in this eBook. For now, we believe it's easier to understand how camper electrics work if you first get familiar with a few important terms.

In this chapter, we'll explain them one by one.

Want to skip this list and jump straight into the next chapter? That's totally fine — and if something doesn't make sense later on, you can always come back here.

Voltage (Volt): The Pressure

Voltage is like the pressure in a garden hose. The more pressure, the further the water sprays. In the world of electricity, voltage is the push that drives electricity through your cables.

Current (Ampere): The Flow

Current is like the amount of water flowing through the hose. The more water, the higher the current. In electrical terms, it tells you how much electricity is moving through the system.

Power (Watts)

Power is the result of voltage times current. If we go back to the hose analogy, power is what the water can actually do, like filling a bucket or washing off mud.
In other words, power is the work electricity can do. The more watts, the bigger the job.

Direct Current (DC) (12V/24V)

Imagine water flowing in one direction — like a waterfall into a river.
Direct Current is just like that: electricity flows in a single direction through the wire.
Batteries — like the ones in your remote or flashlight — use DC. The electricity flows from the positive side to the negative side.

Alternating Current (AC) (120V - 230V - 240V)

Now picture ocean waves going back and forth. That's how Alternating Current works the direction of the flow keeps switching.
Most household devices (like your TV or refrigerator) use AC. One reason we use AC is because it's easier to transmit over long distances — from power stations to homes and businesses.

Leisure Battery or Battery bank:

The leisure battery is a rechargeable battery used in campers to store and deliver electricity for your lights and devices.
You can think of it as your personal power bank that helps you stay off-grid, so you can enjoy your travels without worrying about finding a power hookup.

Amp-Hours (Ah)

This measures how much electricity a battery can store. A 100Ah battery can supply 100 amps for one hour, or 10 amps for 10 hours. More Ah means more stored energy.

Depth of Discharge (DoD)

This shows how much of a battery's energy you've used, shown as a percentage. If you use 50Ah from a 100Ah battery, your DoD is 50%. To keep your battery healthy, it's best not to go below 50% (especially for lead-acid batteries).

Household Battery or leisure battery

A rechargeable battery in your camper that stores and delivers power to your lights, devices, and appliances. It lets you live off-grid without worrying about plugging in.

Battery Capacity

How much electricity a battery can store—like the size of your camper's energy tank. Bigger capacity means more hours of power.

Ah (Amp-hours) in a leisure battery

"Ah" stands for amp-hours, and it's the unit we use to measure a battery's capacity. It tells you how much current (in amps) a battery can deliver over one hour.
For example, a 100 Ah battery can give you 100 amps for one hour, or 10 amps for 10 hours, and so on.
The higher the Ah number, the more energy the battery can store, and the longer your camper devices will keep working without needing a recharge.

Wh (Watt-hours): Total energy available

Watt-hours (Wh) show how much energy a battery can deliver in total, basically the size of your electrical fuel tank. (*We'll explain in in detail later on)*

For example, 12V × 100Ah = 1,200Wh.
Enough to power a 100W device for about 12 hours.
We'll cover this in more detail later in the book.

DoD (Depth of Discharge)

DoD means Depth of Discharge. It shows how much energy has been used from a battery compared to its full capacity.

It's usually shown as a percentage. For example, if a 100Ah battery is used down to 50Ah, the DoD is 50%.

Keeping an eye on DoD is important. Fully draining a battery can shorten its lifespan. For many types, like lead-acid batteries, it's best not to go below 50% to make them last longer.

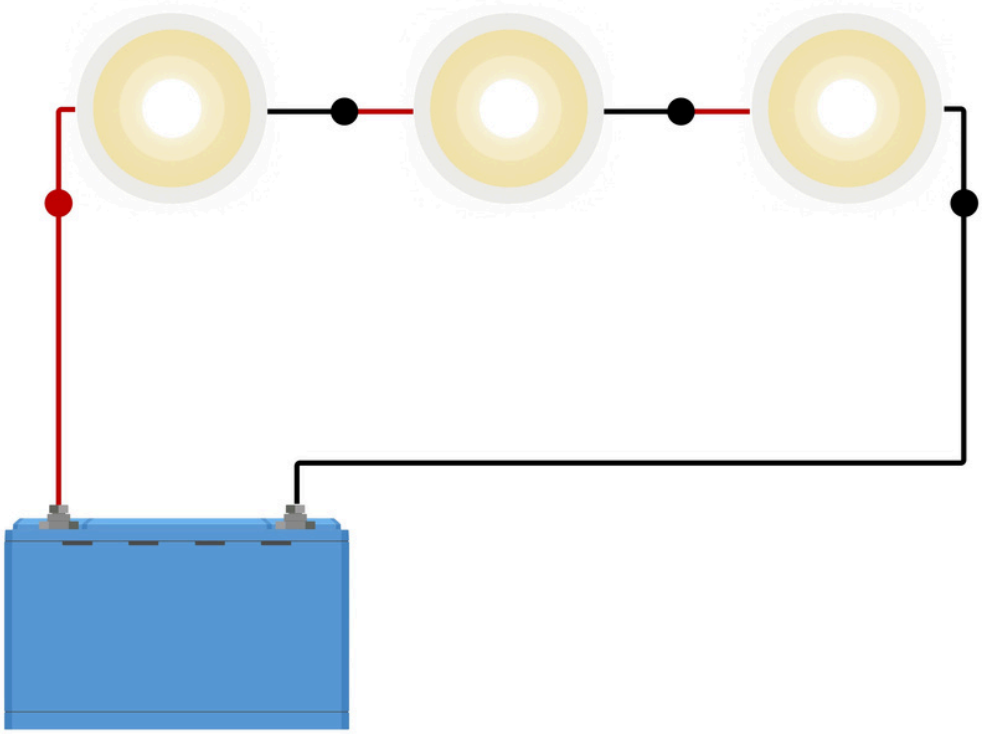
Series connection

Think of a string of Christmas lights. If one bulb breaks, they all go out. That's because in a series connection, the current must pass through each light one by one to complete the circuit.

In the image below, you see a battery connected to three lights in series. The positive wire (red) goes from the battery to the first light, then from that light to the second, and from the second to the third. Finally, the black wire goes from the last light back to the negative terminal of the battery.

Because the current flows through every light, all three must be working for the circuit to function. If one light fails or gets disconnected, the entire loop is broken and none of them will work.

This setup helps explain how current behaves in a series. If you wire batteries in series (instead of lights), **their voltage adds up, but their amp-hour capacity stays the same.**

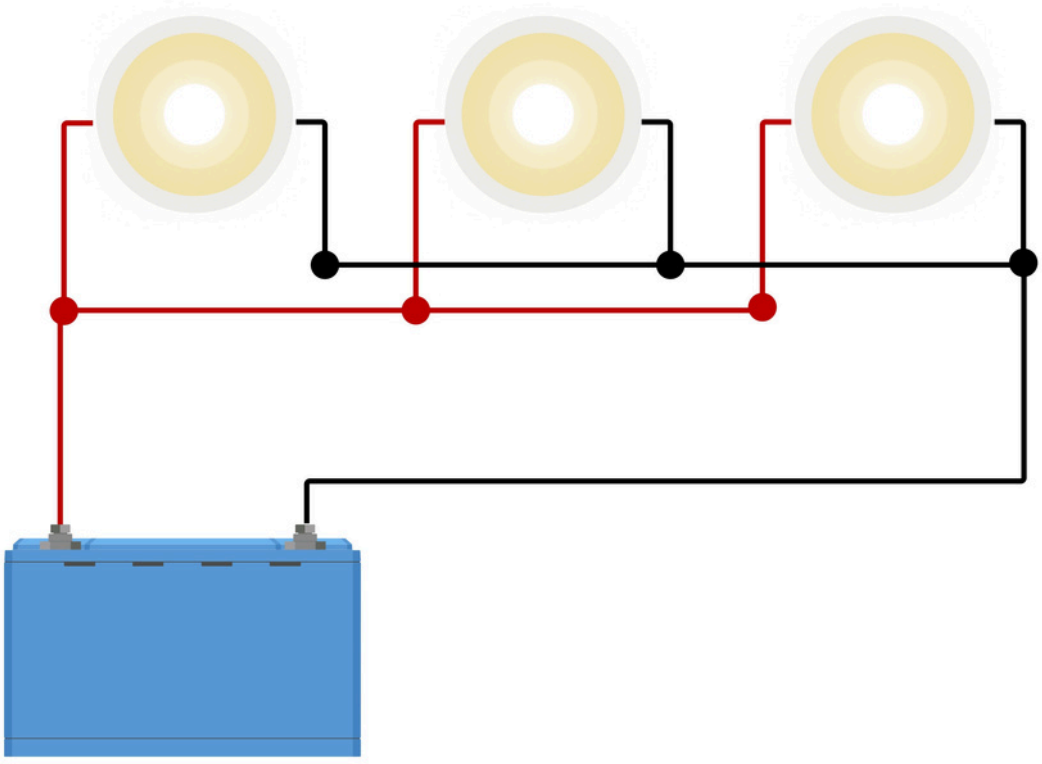


Parallel connection

Imagine you need to charge several phones at the same time. You'd probably use a power strip, plugging each charger into its own socket. Each device gets power through its own path, but they all work at the same time. That's a parallel connection every item has its own direct line to the power source.

In the image example, you'll see a battery connected to multiple lights. Each light is wired directly between the positive and negative terminals of the battery, forming its own circuit. That means the current doesn't have to go through one light to reach the next. If one light fails, the others still keep working.

This type of setup is very common in campers. When you connect two batteries in parallel, their **amp-hour capacity (Ah) increases, but the voltage stays the same.** It's a great way to increase how long your system can run, without changing the system's voltage.



Solar panels

A solar panel is a device that turns sunlight into electricity. It contains small cells that capture sunlight and convert it into usable power for your camper setup.

MPPT charge controller

An MPPT charge controller is a smart device that makes sure your solar panels work as efficiently as possible. It adjusts the power flow to get the most energy from the sunlight at any given moment.

Smart alternator

A smart alternator is a modern type of alternator found in many newer vehicles, including campers. Unlike traditional alternators that supply a constant charge, a smart alternator adjusts the power output based on what the starter battery and onboard systems actually need. This helps extend battery life and makes energy generation more efficient.

Shore power

Shore power is electricity from an external source, like a hookup at a campsite or at home. In a camper, you can use shore power to charge your batteries and run electrical devices without draining the batteries. You simply plug your camper into a power outlet using a special cable.

Inverter

An inverter converts the 12V DC power from your camper battery into 230V AC — the type of electricity you use at home. Many everyday devices like TVs, laptops, and kitchen appliances need AC power. An inverter lets you use them even when you're off-grid and not connected to shore power.

Battery monitor

A battery monitor helps you track the condition and performance of your camper batteries. It shows how much power is going in and out, how much charge is left, and how long your system can keep running. With a battery monitor, you get a better understanding of your energy use and learn how to manage your batteries more effectively.

Fuse

A fuse is a safety device used in electrical systems to prevent too much current from flowing through a wire. If the current gets too high, it can cause overheating or even fire. A fuse contains a thin wire that melts when overloaded, breaking the circuit and protecting your system.

Wire size

Wire size refers to the thickness of an electrical cable. In Europe, this is measured in square millimeters (mm^2), and in North America in American Wire Gauge (AWG). Thicker wires can carry more current without overheating.

For example, 6 mm^2 is roughly the same as 10 AWG. Choosing the right wire size is important for both safety and efficiency. If a wire is too thin, it may overheat and pose a fire risk. If it’s too thick, it adds unnecessary weight and cost.

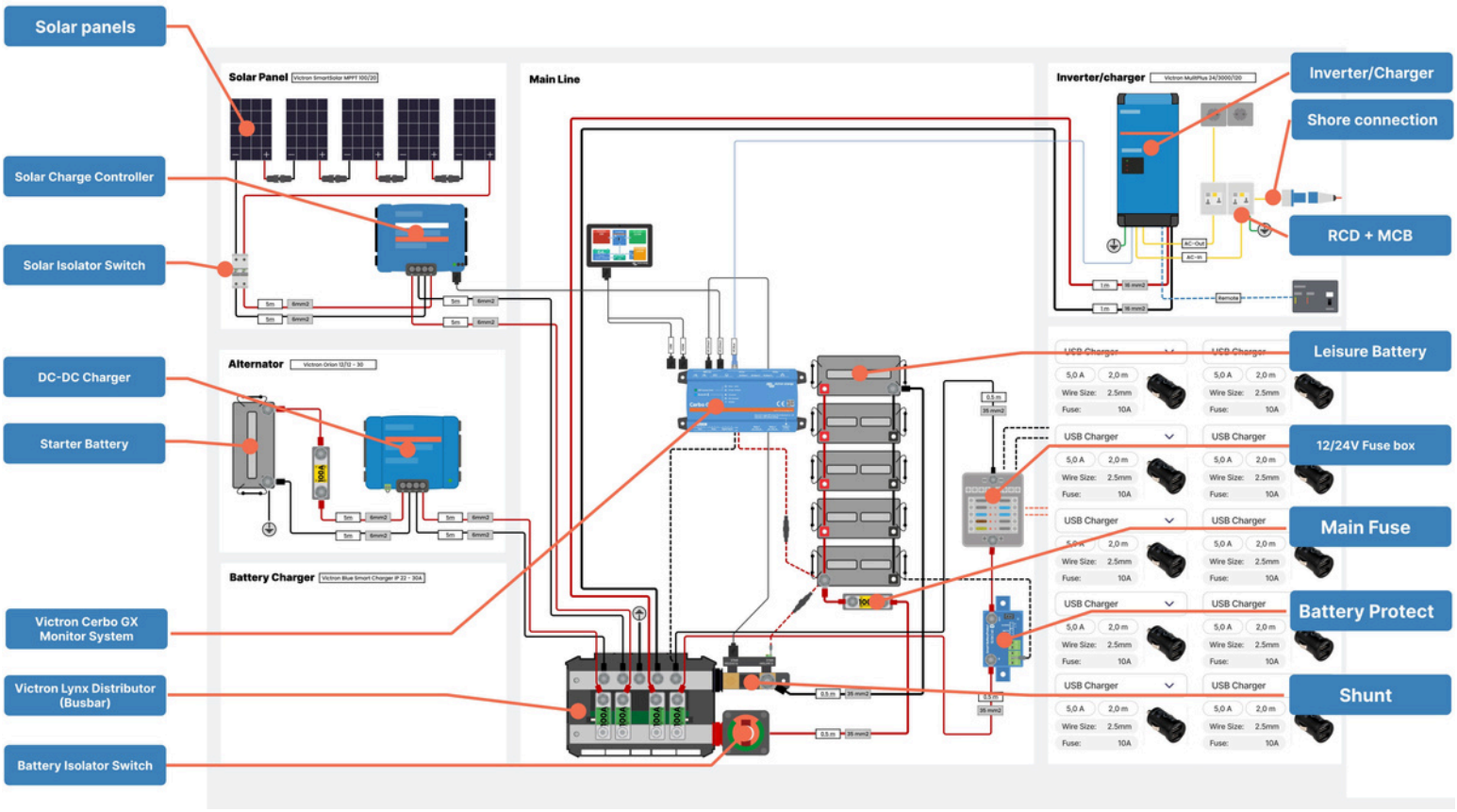
Our software automatically calculates the correct wire size for you, based on your setup and the total cable length — whether you measure in meters or feet.

Wiring diagram

A wiring diagram is a visual overview of the electrical components and connections in your camper's system. It helps you understand how everything is connected and how electricity flows through the setup.

In the next chapters, you'll see illustrations from our **Wiring Diagram Software**. Below is a small legend showing the most important components you'll come across.

Our software has a lot of different options, and what you see here is just a glimpse.



Chassis

The chassis is the frame of your vehicle — the structure everything else is built on. In camper electrics, the chassis is often used as the common grounding point. This means that the negative wires from your components can be connected to the chassis to complete the electrical circuit safely and efficiently.

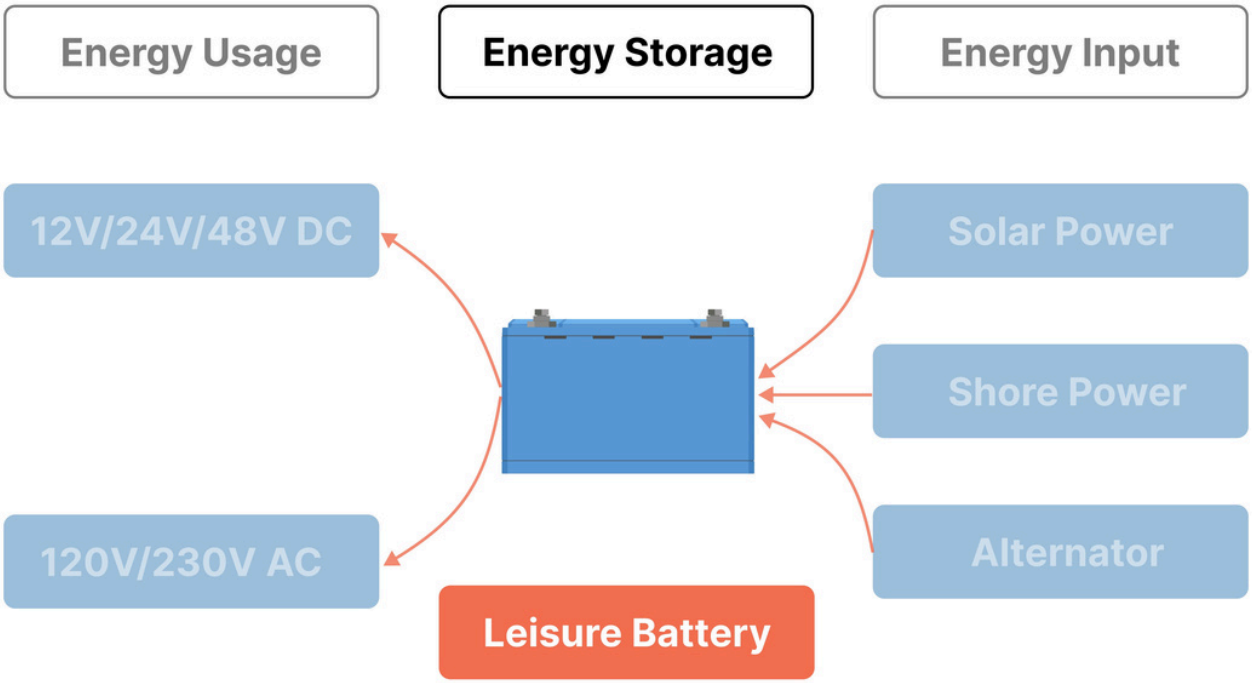
Busbar / distribution strip

A busbar, or distribution strip (Victron Lynx Distributor above), helps keep your wiring neat and organised. It also makes it easier to expand or adjust your setup later, by giving you a central point to connect multiple cables.

Energy storage in a leisure battery

The heart of your electrical system

Let's start with the heart of your electrical setup: energy storage in a leisure battery.



Every camper, just like any car, has a **starter battery**. This battery powers the engine when you start the vehicle.

But campers also have a second battery, called the **house or leisure battery**. This one powers everything inside your camper that needs electricity, such as the lights, fridge, or USB charger.

The energy you use from the leisure battery has to be recharged. Luckily, there are several ways to do that: using solar panels, charging while driving, or plugging into shore power at a campsite.

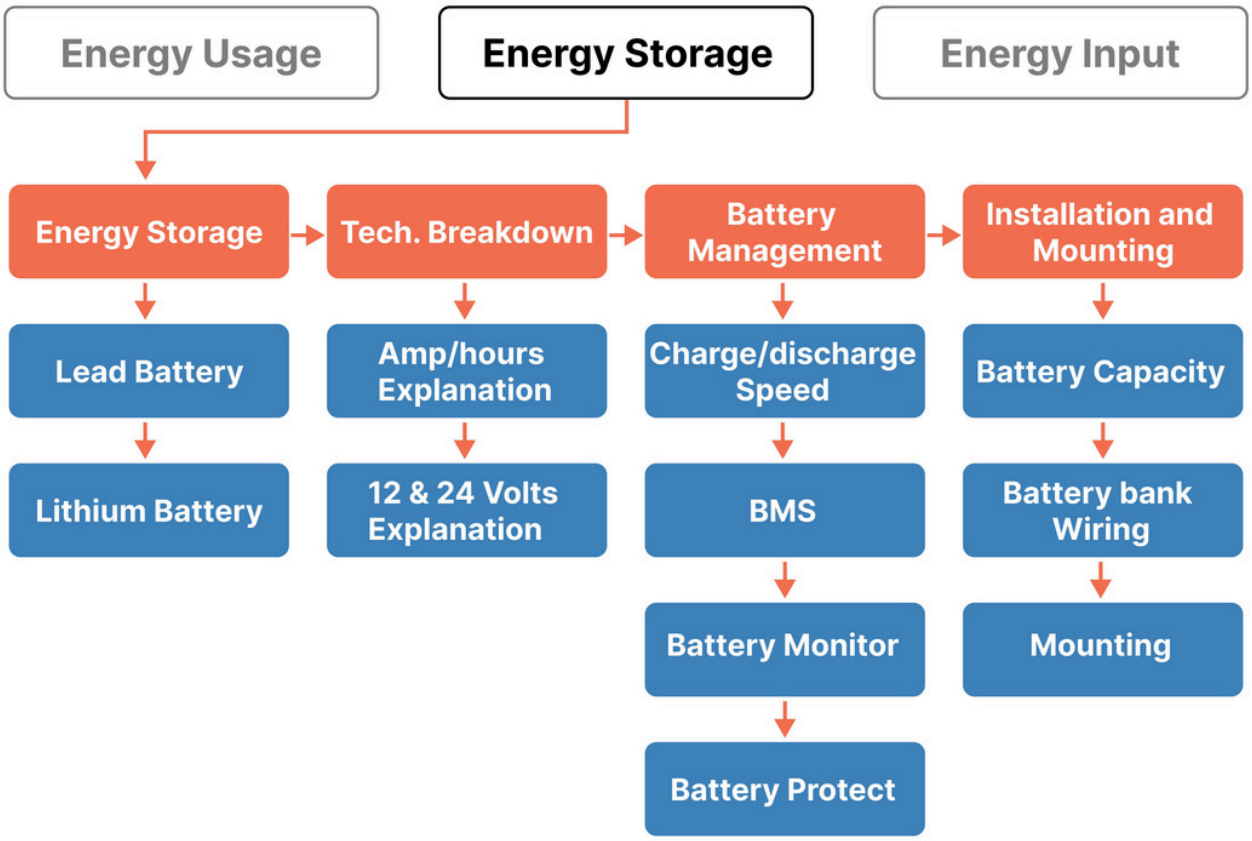
Choosing the right leisure battery can feel overwhelming. There are many types, and quite a few things to consider. That's why we'll start by explaining the different types of batteries available. After that, we'll look at the technical details, go over battery protection, and finally explain how to connect multiple batteries and how to mount them safely.

To give you a clear overview, we've broken down the topic of **energy storage** into four sections:

Energy Storage Basics, Technical Breakdown, Battery Management, and Installation and Mounting.

Each section builds on the one before it, starting with the types of batteries you can use, and ending with how to mount and wire them safely. The flowchart below shows you the full path we'll follow, from choosing a battery to understanding charge speeds, voltage, capacity, and how everything connects.

You don't need to memorize this, but it helps to see where you are and what's coming up. Let's take it step by step.



Now it's time to talk about energy storage in your camper!

We'll walk through it in the same order as shown in the diagram above.
We can divide batteries into two main groups: **lead-acid batteries** and **lithium batteries.**

Lead-acid Batteries

Lead-acid batteries use a combination of lead and acid to store and deliver power. We can divide them into three main types:

- **Starter battery**: Just like in a car, this battery is used to start the engine.
- **Semi-traction battery:** This type can not only start the engine but also power basic devices in the camper, like lights or the fridge.
- **Gel** and **AGM** batteries: These can't start your camper, but they're great at slowly and steadily delivering power over time.

One type we often see in camper setups is the **AGM** battery, which stands for Absorbed Glass Mat. In this battery, the acid is absorbed into special glass fiber mats. This design allows the battery to deliver a solid amount of power without draining too quickly. AGM batteries also perform well in cold weather, both when charging and discharging.

However, they do come with a few downsides. You can only discharge them to about 50 percent before risking damage, and they're **not suitable for high-power devices** like induction cooktops or microwaves. So if you're dreaming of cooking up a storm in your camper, an AGM battery won't get you far.

Another thing to consider: they're heavy. A 220Ah AGM battery weighs around **65 kg (143 lbs)**, which is a lot if you're trying to keep your setup lightweight.

Key Features of a AGM Battery

✓ **Commonly used in campers**
✓ **Works well in both high and low temperatures**
✓ **Delivers steady power over time**

✗ **Heavy and bulky**

Victron AGM Battery

★★★★☆

More information at:

Amazon.com

Lithium Batteries

Lithium batteries are another popular option in camper setups. They work a bit differently than lead-acid batteries like AGM. Instead of using acid absorbed in glass fiber mats, lithium batteries rely on tiny particles called lithium ions to store and release energy.

Inside the battery, there are two poles: an **anode and a cathode**. Between them is a super thin layer called a **separator**. This layer lets lithium ions move back and forth, while preventing the two poles from touching directly, which would cause a short circuit. As you charge and discharge the battery, the lithium ions travel through this layer from one side to the other. That's how energy is stored and used.

This system is efficient, but also a bit sensitive. If you discharge a lithium battery too far, or try to charge it when it's too cold, the delicate separator can become **damaged**. In some cases, tiny needle-like structures called dendrites can grow and pierce the separator, potentially causing permanent damage or even making the battery unsafe. That's why high-quality lithium batteries include built-in protection systems. These systems stop charging or discharging automatically when conditions are outside the safe range.

One of the biggest advantages of lithium batteries is how deeply you can discharge them without causing harm. In most cases, up to **90** percent (sometimes even more) of the battery's capacity can be used. That's a big improvement over AGM batteries, which should only be discharged to around 50 percent. As a result, lithium batteries last longer between charges.

They're also excellent at delivering **large amounts of current** in one go. This makes them ideal for powering high-demand devices such as induction cooktops or microwaves. Not only can they discharge quickly, but they also charge much faster than most lead-acid batteries.

It's also helpful to know that the term "**lithium battery**" covers a whole family of battery types. Each type has its own strengths and limitations. The most common lithium battery used in camper systems is **$LiFePO_4$**, short for Lithium Iron Phosphate. This type is especially popular because it's safe, long-lasting, and very stable—even during heavy use. **If we talk about lithium batteries in this book, we talk about $LiFePO_4$ batteries.**

Other lithium chemistries, such as **NMC** (Nickel Manganese Cobalt) or $LiCoO_2$, are more often found in smartphones, laptops, or electric cars. These types offer higher energy density, meaning more energy in less space. However, they're also more sensitive to heat, have shorter lifespans, and are less stable under stress. That's why $LiFePO_4$ is the preferred choice for off-grid setups. It offers the best mix of safety, lifespan, charging speed, and reliability.

There are also newer lithium chemistries, like LTO (Lithium Titanate), which are extremely durable and have a very long cycle life. However, they're heavier, bulkier, and significantly more expensive. Because of that, they're rarely used in camper builds.

That said, lithium batteries aren't perfect. Most of them **can't be charged below freezing (0°C or 32°F).** This is something to keep in mind if you plan to travel in colder regions. In that respect, AGM batteries have an advantage, as they can operate across a wider temperature range. There are, however, cold-weather lithium batteries available that are designed to handle sub-zero temperatures safely.

Another major benefit of lithium is their weight. A lithium battery with the same capacity as an AGM typically weighs about **30 kilograms (66 pounds)**, while the AGM equivalent might be around **65 kilograms (143 pounds)**. That weight difference can make a big impact in your camper, especially if you're trying to keep the build light.

Key Features of a Lithium Battery

✓ **Increasingly popular in camper builds**
✓ **High charge and discharge rates**
✓ **Lightweight compared to AGM batteries**

✗ **Usually not suitable for charging at low temperatures**

Li Time Lithium Battery

★★★★★

More information at::

litime.com

*Get **5%** of your **Li Time** lithium battery with the code: **camper elektra***

We've been using LiTime batteries in our campervan for the past few years and have been really happy with their performance.

If you're finding this eBook helpful, feel free to use our discount code camper elektra when you order. You'll get a small discount, and we'll receive a small commission at no extra cost to you, which helps us keep creating more useful content like this!

AGM vs. Lithium: Key Differences

AGM and lithium ($LiFePO_4$) batteries are both common in camper setups, but they offer different benefits.

AGM batteries are affordable, reliable, and work well in both hot and cold temperatures. They use fiberglass mats to hold acid, but you can only safely use about 50% of their capacity. They're also heavy and not ideal for high-power devices.

Lithium batteries use lithium ions to store energy. They're much lighter, can be discharged up to 90%, and last much longer (over 4000 cycles). They charge faster and handle high-demand appliances better. However, they usually can't charge below freezing, unless designed for cold weather, and they cost more upfront.

In short: AGM is great for basic setups on a budget. Lithium is best for longer trips, more power, and better long-term value.

100Ah AGM Battery		100Ah Lithium Battery
± 30 kg (66 lbs)	Weight	± 12 kg (26 lbs)
50% (usable ± 50Ah)	Max. discharge	90% (usable ± 90Ah)
± 600 cycles	Charge cycles	± 4000 cycles
20% ± 20Ah	Charging speed	50% ± 50Ah
5 – 7 years	Lifespan	10 – 15 years
± €100,-	Upfront cost	± €200,-

Technical Explanation

Now that we've explained the differences between lead-acid and lithium batteries, let's move on to some other important aspects of batteries: **capacity**, measured in *amp-hours (Ah)*, **voltage**, measured in *volts (V)*, and **energy**, measured in *watt-hours (Wh).*

We'll do our best to make this as easy to understand as possible. It gets a little more technical, so take your time. We'll use practical examples to make things clearer.

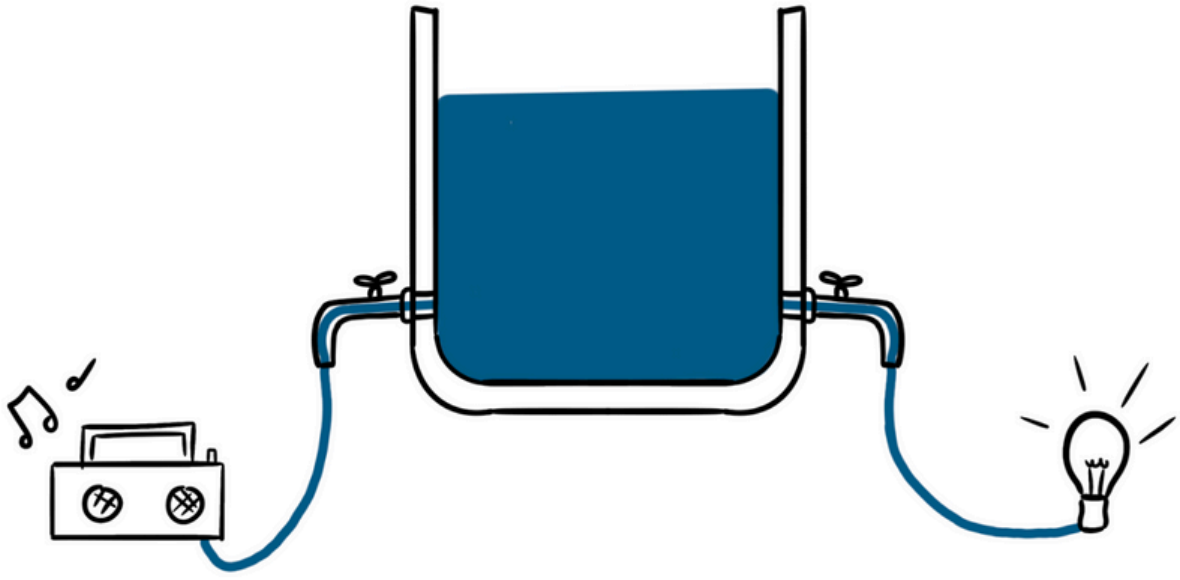
Amp Hours (Ah)

Let's start with a basic example: a regular starter battery found in many vans. These often come labeled something like "100Ah 12V." But what does that really mean? Imagine your battery as a large tank full of water. That water represents the electrical energy. Your devices — like a radio or interior lights — are like faucets connected to the tank. When you open the faucet, water (electricity) flows out so the devices can function.

"100Ah" means the battery can theoretically deliver 100 amps for one hour, or 50 amps for two hours, or 10 amps for ten hours — and so on. This helps you estimate how long your devices can run on a fully charged battery.

Let's say your radio and lights together draw 5 amps. That means:
100Ah ÷ 5A = **20 hours** of use.

But in practice, you never want to fully drain your battery. Doing so can reduce its lifespan — especially with lead-acid batteries.



Watt Hours (Wh)

To truly understand how much energy your battery stores and how much your devices consume, we use **watt-hours (Wh)**.

Amp-hours (Ah) tell you how much current is available. Watt-hours tell you how much energy is available or used over time.

Here's how it works:
Power (W) = Voltage (V) × Current (A)
Energy (Wh) = Voltage × Ah

Going back to our earlier example:
If your radio and lights use 5 amps at 12 volts, the total power is:

12V × 5A = **60 watts**
So every hour, they use **60 watt-hours (Wh)** of energy.

A 100Ah 12V battery contains:

12V × 100Ah = **1200 Wh** of energy.

If your setup uses 60Wh per hour, you can run it for:

1200Wh ÷ 60Wh = **20** hours

That matches our earlier amp-hour calculation, but watt-hours make it easier to compare total energy needs — especially when dealing with devices that have different voltage requirements.

💡 Quick note: In some countries like the US, you'll also see energy measured in kilowatt-hours (kWh).
1 kWh = 1000 Wh. So, 1200 Wh = 1.2 kWh.

12V vs 24V system

Now let's talk about another technical term: voltage. Most camper systems run on either 12V or 24V.

To see the difference, let's look at a 10-watt car radio.

In a 12V system:

Current = Power ÷ Voltage = 10W ÷ 12V = **0.83 amps**

In a 24V system:
10W ÷ 24V = **0.42 amps**

So at 24V, the same radio needs less current to do the same job. That's a big deal, because lower current means:

- Less heat
- Less voltage drop
- Thinner (and cheaper) wires

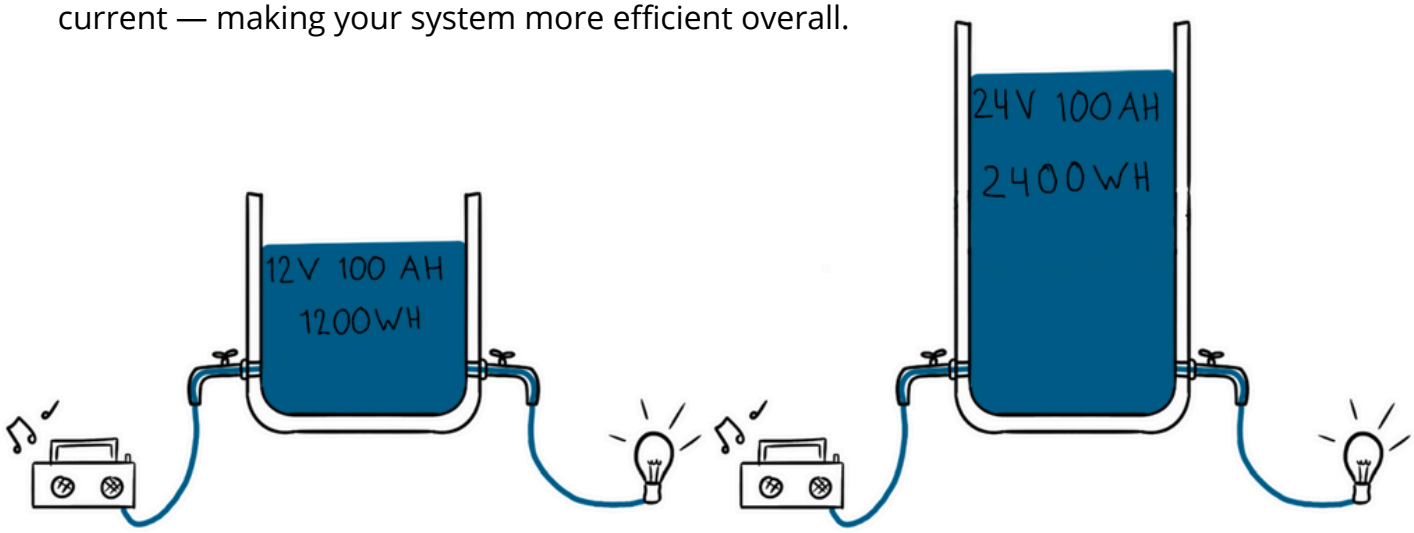
That's why 24V systems are often used in setups with higher power demands.

Now let's go back to batteries:

- A **12V 100Ah** battery has:
- 12V × 100Ah = **1200 Wh** of energy
- A **24V 100Ah** battery has:
- 24V × 100Ah = **2400 Wh** of energy

Even though both batteries are labeled 100Ah, the 24V version holds twice as much energy. The voltage makes the difference.

🔧 Helpful comparison: A 100Ah 24V battery is roughly equal in energy to a 200Ah 12V battery. But since it runs at higher voltage, it does the same work with less current — making your system more efficient overall.



Summary

- **Amp-hours (Ah) tell you how long a battery can deliver current.**
- **Watt-hours (Wh) tell you how much energy is available or consumed.**
- **Voltage (V) affects how much current your devices need to perform the same task.**

Battery Management

Charging and discharging

Great job — you've already learned a lot about batteries. By now, you know the differences between battery types, how amp-hours and watt-hours work, and what voltage means. Now it's time to dive into something just as important: how to charge and discharge your battery safely.

This part has a big impact on how long your battery will last, especially if you're using l**ead-acid batteries** like AGM or gel types.

To keep your battery in good condition, you should avoid charging or discharging it too quickly. A good rule of thumb for lead-acid batteries is to **charge and discharge at a maximum of 20% of the battery's total capacity.**

Let's say you have a 100Ah AGM battery. That means:

- You should charge it at no more than **20 amps**
- You should discharge it at no more than **20 amps**

This slower pace helps protect the battery from stress and overheating, and it increases its overall lifespan.

Also, lead-acid batteries don't like being emptied completely. You should only use about 50% of the total capacity. In a 100Ah battery, that means you're only using around 50Ah before recharging.

Lithium batteries, like $LiFePO_4$ types, are much more flexible. They have an internal safety system called a **Battery Management System** (BMS) that protects them from overcharging, deep discharging, and overheating.

Thanks to this system, lithium batteries can handle much higher charging and discharging currents. Let's look at that same 100Ah battery, but this time a lithium version.

You can usually (check your battery supplier):

- Charge it at up to **50 amps**
- Discharge it at up to **100 amps**

And unlike lead-acid, you can safely use up to 90% of the battery's capacity. That means almost 90Ah is available for use.

Different lithium batteries have different specs, so always check the manual of your specific model to know the exact limits.

What is a Battery Management System (BMS)?

You may have already seen the term **BMS** mentioned earlier. As promised, here's what it actually means.

The BMS is all about **battery safety**. If you're thinking about buying a lithium battery, it's absolutely essential that the battery is properly protected. That's where the Battery Management System — or BMS — comes in.

A BMS is an electronic system built into (or added onto) a lithium battery. Its job is to **monitor and protect the battery** from all kinds of things that could damage it. That includes:

- Overvoltage and undervoltage
- Charging or discharging with too much current
- High or low temperatures

But that's not all. A good BMS also balances the voltage between individual cells, making sure that all parts of the battery stay healthy and in sync. This helps extend the battery's lifespan and ensures safe and efficient performance.

So to put it simply: if you're using a lithium battery, you must have a BMS. Most lithium batteries on the market already come with one built in. But in some cases — for example, with DIY battery setups — you may need to install a BMS separately.

Important note:
Not all lithium batteries come with a low-temperature cut-off feature. This specific protection makes sure that the battery won't charge in freezing conditions. Charging a lithium battery below 0°C (32°F) can permanently damage it. So if you're using your battery in cold environments, make sure your BMS includes this safety function.

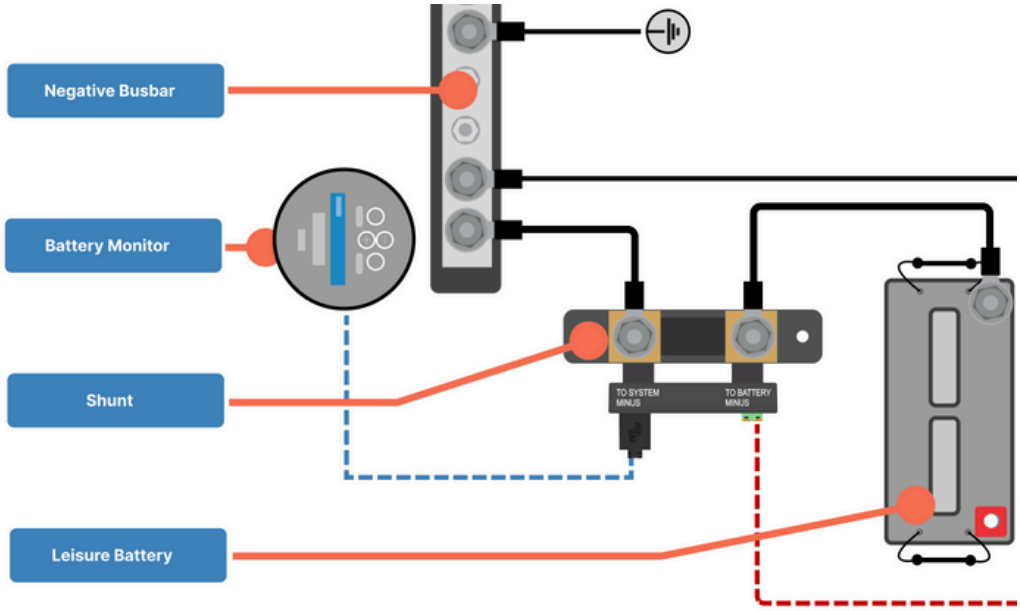
Having a BMS is not just a technical detail — it's a must-have for safe and long-lasting battery use.

Battery monitor

To extend the life of a lead-acid battery, it's important to avoid deep discharging. Lead-acid batteries should never be discharged more than 50% of their total capacity. One of the best ways to keep track of this is by installing a battery monitor, also known as a battery gauge or battery meter.

Battery monitors work by measuring the difference between the power going into your battery (charging) and the power being drawn out (discharging). This is done using a special component called a **shunt**.

A shunt is placed between the **negative terminal of your house battery and all of your electrical devices.** This is crucial. If you don't place the shunt here, it won't measure all the current flowing in and out of the battery — and you won't get accurate information about your energy usage.



The battery monitor display connects to the shunt and shows you real-time data such as:

- Battery voltage
- Current flow
- State of charge (percentage full)
- Power consumption in watts or amp-hours

Some battery monitors come with a physical display, while others are wireless and show all the information on your smartphone via Bluetooth.

In short:
A battery monitor helps you understand the true status of your battery and prevents you from accidentally draining it too far. For lead-acid batteries in particular, this tool is incredibly useful if you want to keep your battery healthy and reliable.

Battery protect

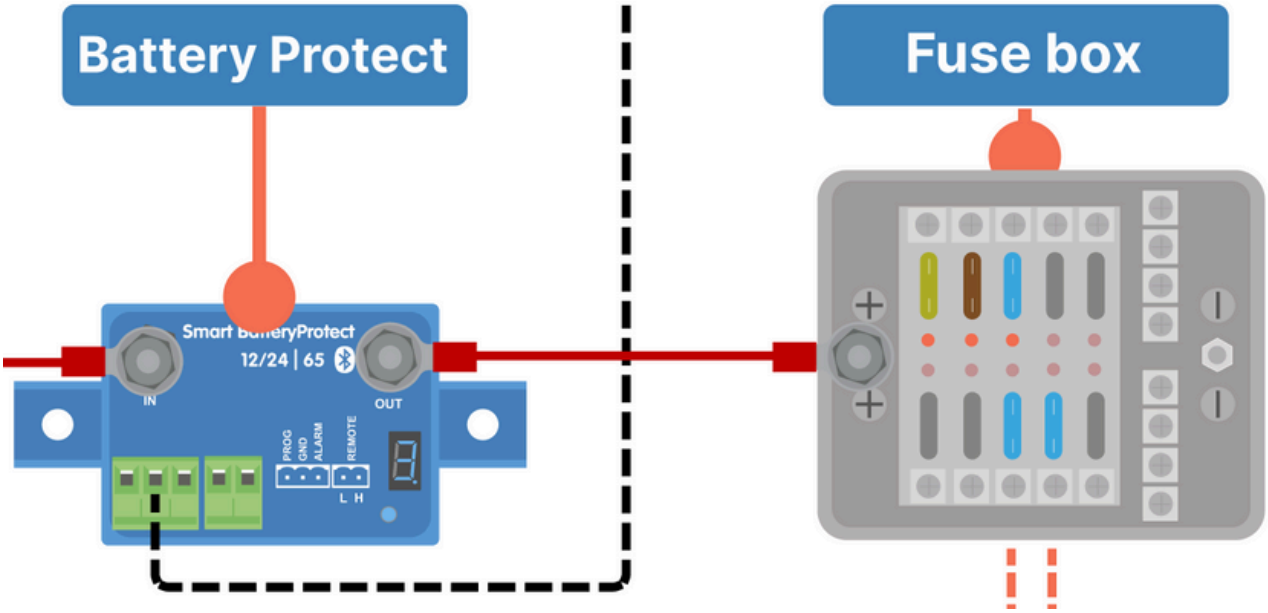
To avoid damaging your battery by discharging it too far, it's important to have a way to automatically cut off power when voltage drops too low. One commonly used device for this is the **Victron BatteryProtect.**

This small device acts as a **low-voltage disconnect**. It monitors your battery's voltage, and when it falls below a set threshold — for example, **11.09V** — it automatically disconnects a group of consumers. These are usually all your 12V devices connected to the fuse box, such as lights, fans, or pumps. This helps protect your battery from being drained too deeply, which can shorten its lifespan or even damage it permanently.

This is especially useful if, for example, you accidentally leave your lights on overnight. The BatteryProtect cuts the power before the battery gets dangerously low.

⚠️ **Note**: We typically only use a BatteryProtect with **lead-acid batteries.** Lithium batteries that have a built-in BMS (Battery Management System) already include over-discharge protection. These systems automatically disconnect the battery when voltage drops too low, so a separate BatteryProtect is usually not needed.

If you're using lithium batteries without an internal BMS (for example a Victron Smart battery), then you must ad a BatteryProtect so the BMS can disconnect the load.



Installation and Mounting

Battery capacity

When designing your camper's electrical system, one of the most important things to consider is your battery capacity. You want to make sure there's enough stored energy to power all your devices for as long as you need.

To figure this out, you'll need to think about **what appliances** you plan to use in your camper — such as lights, fridge, fans, chargers, or even an induction cooktop.

Later in this eBook, we'll show you exactly how to **calculate your daily energy usage** and determine the battery capacity you need. But first, it's helpful to understand the basics of how battery capacity works and how multiple batteries can be combined. Don't worry — we'll walk you through everything step by step.

Connecting multiple batteries

Sometimes, a single battery isn't enough to power everything you want to use. To increase your system's capacity or voltage, you can combine batteries in one of two ways: in series or in parallel.

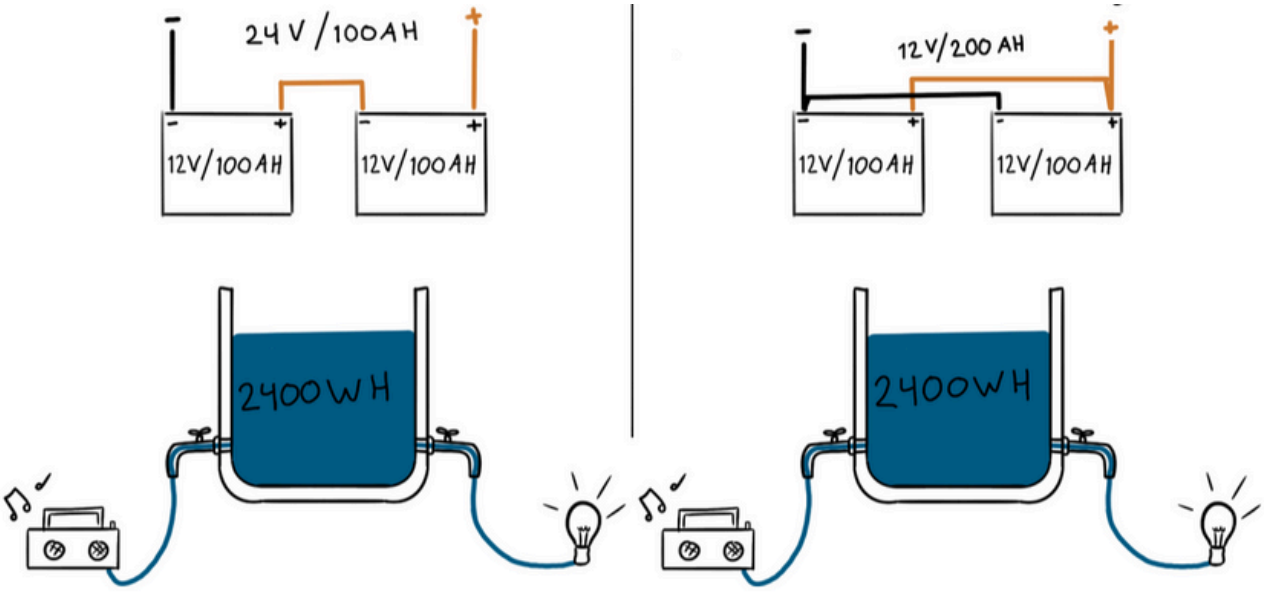
Let's break this down using a familiar analogy: water tanks and taps.

Imagine you have two water tanks, each with its own tap.

- Tank A represents a 12V system (like a parallel connection)
- Tank B represents a 24V system (like a series connection)

The water pressure inside each tank stands for voltage (V), and the flow rate from the tap represents current (A).

In Tank A (12V system), there's average water pressure and a steady flow rate — similar to what you need for everyday camper devices like lighting or a radio. In a parallel connection, you connect the positive to positive and negative to negative terminals of the batteries. This way, voltage stays the same, but the total amount of water (or in this case, usable energy in Ah) increases — because you now have two tanks feeding the system instead of one.



Tank B: Batteries connected in Series | **Tank A** Batteries connected parallel

In Tank B (the 24V system), the water pressure is higher and the water flows out of the tap faster. This represents more powerful electrical devices that require higher voltage to run properly.

In a series connection, you connect the negative terminal (-) of one battery to the positive terminal (+) of the next. This increases the voltage (V) — like raising the pressure in your tank — but the total amount of energy stored (capacity in Ah) stays the same.

In summary:

- **A parallel connection gives you more capacity (Ah)** but keeps the voltage (V) the same.
- **A series connection increases the voltage (V)** but keeps the capacity (Ah) the same.

Which one is right for you depends on the type of appliances you want to power and how much energy they require. Parallel is ideal for 12V setups with lots of moderate users, while series is useful when you need a higher voltage system (like 24V) for heavier loads.

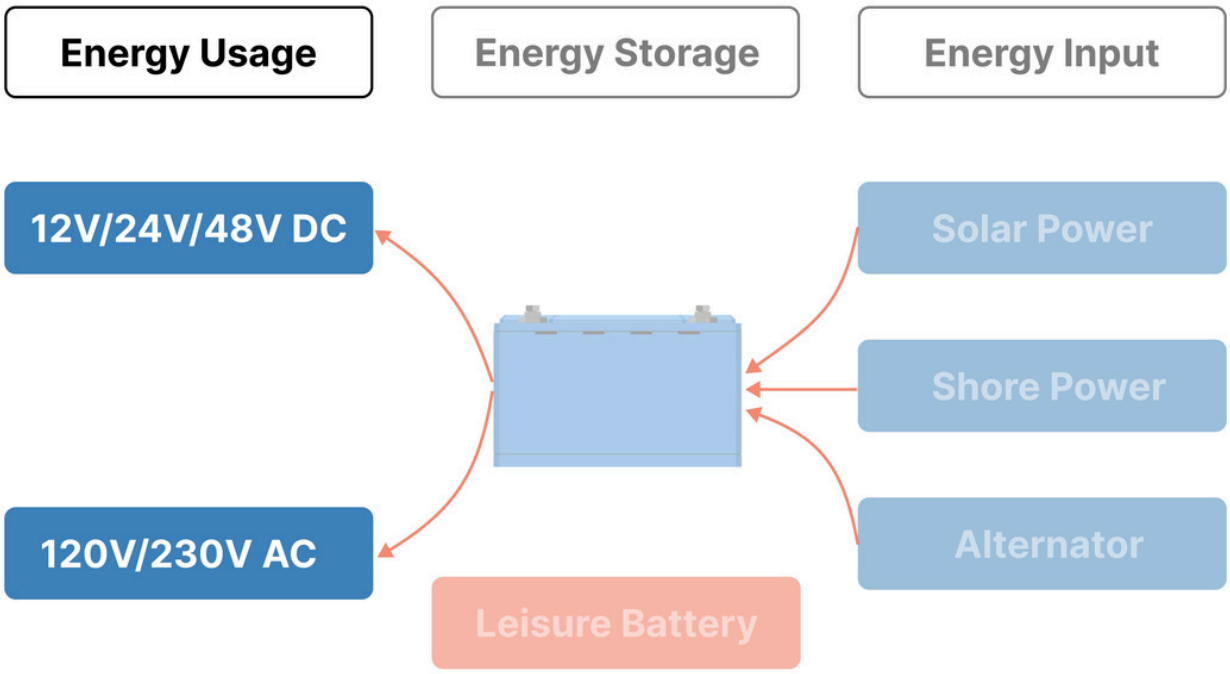
So, just like with water tanks:
Parallel = more water (Ah), same pressure (V)
Series = more pressure (V), same amount of water (Ah)

Battery mounting

Properly securing your leisure battery is extremely important for both safety and stability. Batteries can weigh tens of kilograms, and letting them move freely inside your camper is dangerous — especially while driving or during sudden stops.

Ideally, your battery should be placed in a corner or against a wall and secured firmly. It's best to mount the battery to the floor and use a ratchet strap or heavy-duty tie-down to hold it tightly in place. This prevents movement, minimizes vibration, and helps protect both your battery and your electrical system.

Energy usage



As you've learned by now, batteries are available in different voltages, but most camper setups use a 12V battery. That's why it's common to use 12V appliances throughout the system.

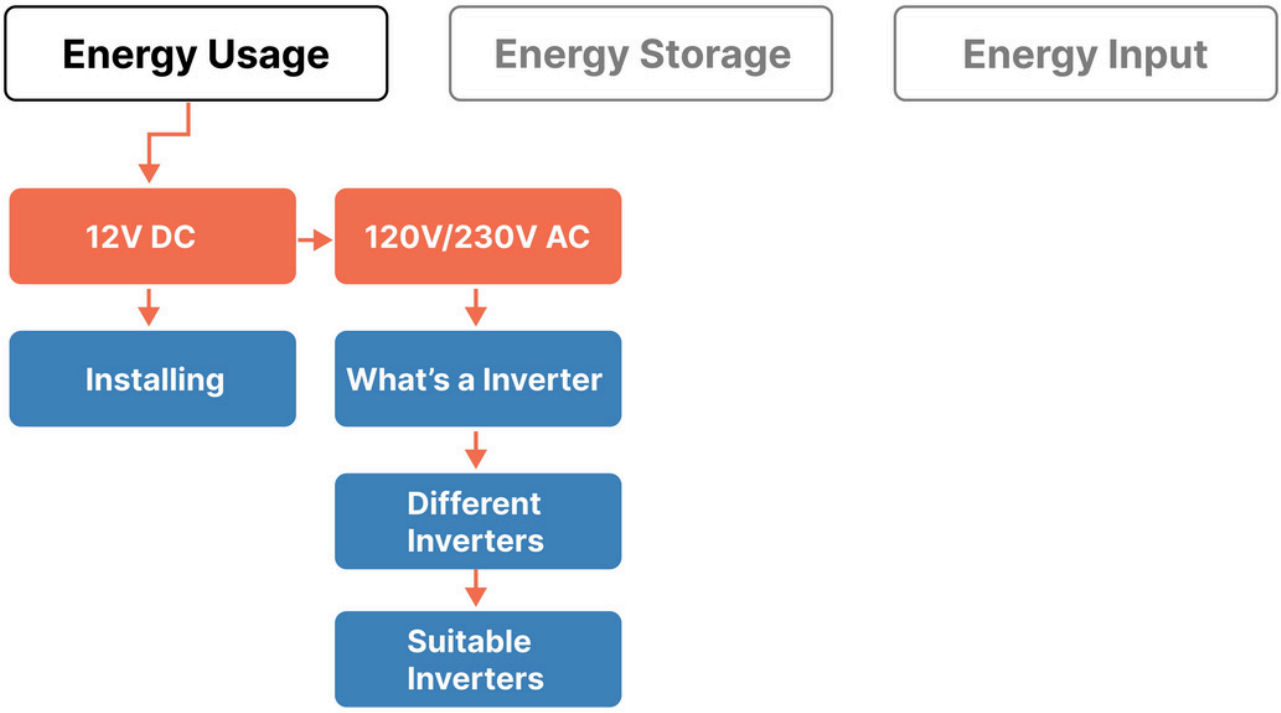
Fortunately, many devices on the market are designed to run on 12V — especially for boats and campers. Think of things like **fridges, lights, and fans.**

But what if you want to use something that doesn't run on 12V? For example, your phone charges at 5V. For that, you can use special built-in USB chargers that convert 12V to 5V.

And what about household appliances, like a microwave or an induction cooktop? These typically run on 230V, which means you'll need a device called an inverter to convert 12V power into 230V AC.

In this chapter, we'll walk you through the different types of electrical consumers, and what kind of equipment you need to power each of them safely and efficiently.

DC Consumers (12V/24V)



Power consumption in your camper

Depending on where you live, your home's electrical outlets provide either **120V**, **220V**, **230V**, or **240V** of AC (**alternating current**).

In North America, the standard is typically 120V, while in most parts of Europe it's 230V. But most of the devices you use every day don't actually run directly on this high voltage.

Take a look at your laptop charger, e-bike charger, or phone charger. You'll notice a **bulky block built** into the plug. So, what's that block for?

That block plays an important role: **it converts the high-voltage AC** from your wall outlet i**nto lower-voltage DC** (direct current), which your electronic devices actually use. For instance, your laptop charger might convert 230V AC into 19.5V DC — exactly what your laptop needs to charge safely.

Now here's the catch: this conversion process isn't perfect. **Some of the energy is lost as heat.** So when you're charging your laptop, a bit of that electricity turns into warmth inside that chunky adapter.

If you look at the diagram from earlier in this chapter, you'll see two ways of using power: 12V DC and 230V AC (or 120V AC, depending on your region). As we just learned, converting power (from one voltage or type to another) always comes with energy loss — usually in the form of heat.

At home, this isn't really a problem because power seems endless. But in a camper, your house battery has a limited supply. Unless you're plugged into shore power at a campground, every watt counts. So it's smart to reduce conversions and make the most of your battery.

So What's the Smartest Approach?

Use devices that match your battery's voltage — 12V or 24V — as much as possible. That way, you avoid unnecessary conversions and preserve your battery capacity.

Most modern campers use 12V house batteries, which is why you'll find a wide range of 12V products designed for RVs and boats, such as:

- Fridges
- Lighting
- Ventilation fans
- Water pumps
- Diesel heaters

For charging smaller devices like phones or tablets, you've got **two** options:

1. Use an inverter to convert 12V DC to 230V or 120V AC, and then plug in your usual charger. That charger will then convert AC back down to 5V DC — **not the most efficient path.**
2. Install USB chargers that convert 12V DC directly to 5V DC. This method involves only one step, not two, which means less energy lost and more battery life saved.

The Key Takeaway
Most devices at home use a built-in converter to turn 230V or 120V AC into 12–20V DC.

Every time you convert voltage or current type, you lose energy as heat.
In a camper, energy is precious. Use equipment that matches your battery voltage to stay efficient.

Connecting your DC devices

Alright — since converting power between voltages costs energy, it's best to run as many devices as possible directly on the voltage of your house battery. But how exactly do you connect these devices?

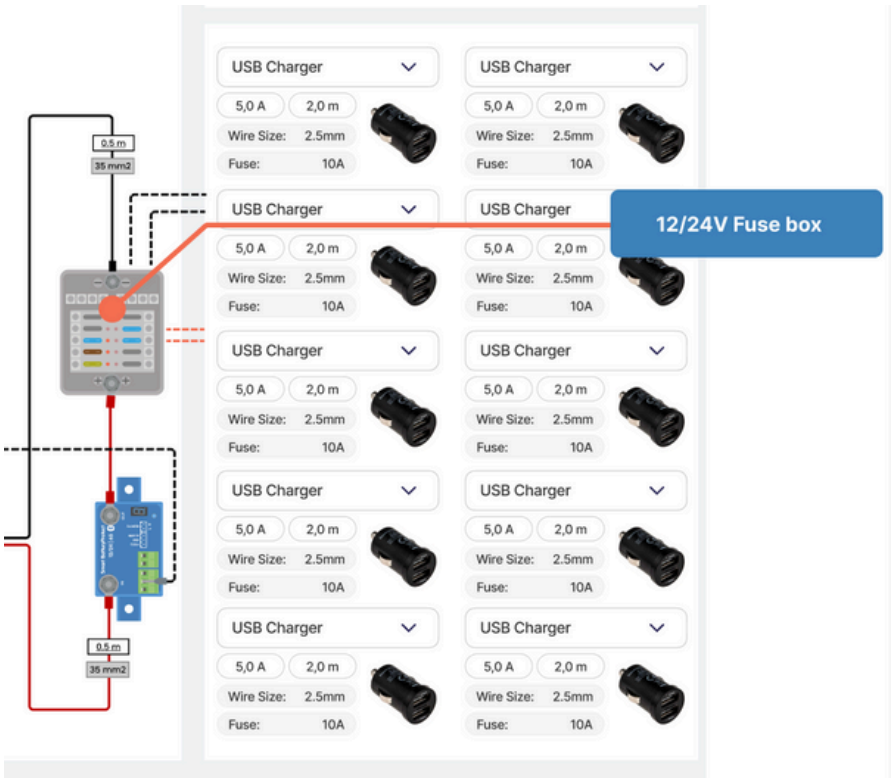
12V/24V Fuse Box

More information at:

Amazon.com

To connect all your 12V devices, you'll need a 12V or 24V fuse block. You can think of it like the fuse panel you have at home, but in this case, you'll usually connect just one device per fuse.

Take a look at the diagram below. It's our **Wiring Software Blueprint**, which helps you design your own system. It might look a bit overwhelming at first, but don't worry — in the middle, you'll see the fuse block, where you can connect all your 12V or 24V appliances in a clear and organised way. (And yes, you can select more than just USB chargers..😅)



AC Consumers (230V/120V)

AC Power: using an inverter to convert 12V to 230 or 120V

Not every device in your camper can run on 12 volts. Some appliances are designed for household voltage — that's 230V in many countries, or 120V in places like the US and Canada. To use those devices, you'll need a **power inverter**. In this chapter, we'll explain how inverters work and the different types available, such as those with built-in battery chargers. In the next chapter, we'll go deeper into the topic of shore power charging.

What is an inverter?

If you want to use household devices in your camper — like a microwave, induction cooktop, or coffee machine — you'll need an inverter. But what does that actually mean?

Let's back up for a second. Devices that plug into a wall socket at home are typically designed to run on AC (alternating current) power: 230 volts in Europe or 120 volts in North America. Your camper's house battery, however, only provides 12V DC (direct current). So how do you bridge that gap?

There are two options:

- Plug into external power (shore power or campsite hook-up)
- Use a power inverter to convert your 12V DC into household AC voltage

When you're not connected to external power, your inverter takes the 12V from your battery and converts it into 230V or 120V, depending on where you live. That way, you can run appliances just like you would at home.

12/24V DC **Inverter** **120/230V AC**

Different type of inverters

There's a wide range of inverters on the market. The most common is a standard inverter, which converts 12V DC from your battery into 230V or 120V AC.

But there are also inverter-charger combos — devices that not only act as inverters, but can also charge your battery when you're connected to shore power. Some models even include a built-in MPPT solar charge controller, allowing you to manage solar input from your panels in one compact unit.

In your camper's electrical diagram, the inverter connects directly to your house battery, converting 12V into usable AC power for your devices.

Pure vs. Modified sine wave inverters

There are two main types of inverters:

- **Pure sine** wave inverters
- **Modified sine** wave inverters

A pure sine wave inverter produces a clean, smooth AC signal — just like the electricity at home. This makes it compatible with all devices, from laptops to espresso machines.

A modified sine wave inverter, on the other hand, produces a stepped or blocky signal. Some modern electronics can't handle this type of power and may malfunction or even get damaged. **That's why we strongly recommend using a pure sine wave inverter for any sensitive or high-performance appliances.**

Inverters with charger and transfer switch

Some advanced inverters come with an **integrated battery charger** and a built-in **automatic transfer switch**. When you plug into shore power (for example, at a campsite), the unit starts charging your house battery — but that's not all.

Thanks to the **automatic transfer switch**, any AC power coming from the outside gets passed directly to your camper's internal outlets. This means your devices can run on external power without draining your battery.

So, in short:

- The inverter converts 12V/24V DC to 230V or 120V AC.
- The charger replenishes your battery when you're plugged in.
- The transfer switch makes sure your internal outlets run on shore power instead of the battery.

Inverter with built-in charger, solar input, and automatic transfer switch

One of the most practical options for a camper electrical system is a device that combines four essential components into one:

- **a powerful inverter** (to convert 12V or 24V DC to 230V or 120V AC),
- **a battery charger** (to recharge your batteries via shore power),
- **an MPPT solar charge controller** (to manage input from solar panels), and
- **an automatic transfer switch** (to seamlessly switch between shore power and battery power).

We personally used this type of device in our very first camper build, and we can confidently say it's a Solid choice — especially if you want to keep your electrical system simple, space-efficient, and reliable. (**In our second van build we chose a Victron sytem**)

Two well-known all-in-one systems include:

Ective SSI
This German-brand unit combines a pure sine wave inverter, a smart battery charger, an MPPT solar controller, and an automatic transfer switch. It's a budget-friendly, beginner-friendly solution that's especially popular across Europe.

Victron EasySolar-II
This high-end option integrates a Victron MultiPlus-II inverter/charger with a SmartSolar MPPT controller and a built-in automatic transfer switch — all managed through the Victron GX system. It's ideal if you want remote monitoring, advanced configuration, or seamless integration with other Victron components. Available for both 230V (Europe/Australia) and 120V (North America).

Using a device like this reduces wiring complexity, saves space, and ensures your components are perfectly matched to work together — with automatic switching for added convenience and safety.

Ective SSI 10 Pro

★★★★★

More information at:

Ective.de

Which Inverter will suit your camper?

Before you can choose the right inverter for your setup, you need to decide whether you want a standalone inverter or a combined inverter-charger.

Once you've made that choice, the next step is calculating the total power consumption of the devices you want to run. Based on that, you can determine how large your inverter needs to be — and then select a suitable battery to match it.

If you don't need an inverter but still want to charge your battery, skip ahead to the next chapter!

Calculate how much power you need

Start by making a list of the devices you want to use in your camper that require **AC power** — that is, 230V if you're in Europe, or 120V if you're in North America. Think about things like charging your e-bikes, using a blender, or making coffee.

Next, find out how much power each of those devices uses, measured in **Watts (W)**. You can usually find this information on a label on the device, its charger, or in the manual. If that fails, a quick Google search with the make and model should do the trick.

You'll also need to take peak power into account. Some devices draw a much higher current for a short time when they're first switched on — like fridges or coffee makers. A refrigerator that normally uses 50W might briefly pull 200–300W when it kicks on. Most inverters can handle short bursts of high power, usually up to twice their rated continuous power.

Here's an example from our own setup:

We mainly use our inverter to charge two laptops and occasionally to run a stick blender. Here's their approximate power usage:

- Laptop charger 1: 60W
- Laptop charger 2: 80W
- Stick blender: 400W

If we wanted to use all of these at the same time, we'd need an inverter that can supply at least **540W**.

⚠️ Note: Devices that generate heat — like hair dryers or electric heaters — consume a lot of power.

- **Hair dryer: ~1700W**
- **Electric heater: ~1500W**

Choosing the right inverter size

Now that you know which type of inverter you need, and how much power (in Watts) your devices will use, it's time to figure out what size inverter is right for your setup.

To do that, you'll need to understand a few technical numbers you'll often come across when comparing inverters. Let's walk through an example using the **Victron MultiPlus 12/2000/80** — that way, you'll know exactly what these numbers mean when you see them elsewhere too.

What do the numbers 12/2000/80 mean in Victron MultiPlus 12/2000/80?

- **12**: This refers to the system voltage. In this case, the inverter works with a 12V battery setup. But the MultiPlus is also available in **24V** or **48V** versions. So if your camper or RV runs on a 12V battery, you'll need the 12V version of the MultiPlus.
- **2000**: This is the inverter's power rating, expressed in volt-amperes (VA). Note: **VA is not the same as Watts.** For this model, **2000VA equals about 1600 Watts of continuous power**, and up to 3200 Watts peak for a few seconds.
- **80**: This is the built-in charger's output — it means this inverter-charger can charge your battery with up to 80 amps per hour when plugged into shore power or a generator. (More on battery charging in the next Chapter.)

⚠️ **Important note:** Victron is one of the few brands that uses VA (volt-amperes) instead of W (watts)when listing inverter power.

Most other brands, like Renogy, use Watts.
A rough rule of thumb: VA = about 10–15% less power than the same number in Watts. So a **2000VA** inverter from Victron delivers roughly **1600W** of continuous power.

Victron MultiPlus 12/2000/80

★★★★★

More information at:

Amazon.com

Battery capacity vs inverter demands

Nice! You now know how to calculate the right size inverter for your camper setup.

If you're planning to run high-powered devices — like an **induction cooktop** — you might remember from the previous section that not every battery can handle that kind of load. That's why it's essential to understand how much power you're going to use, and whether your battery setup can keep up.

When choosing your battery capacity, there's one **critical thing to consider**: the discharge rate — how fast the battery is being drained.
Why is that important? Because not all batteries can handle high discharge currents.

Let's break it down:

- **Lead-acid batteries** (including AGM and gel) should only be discharged at **20% of their rated capacity.**
- Example: a 100Ah battery = max discharge of 20A
- **Lithium batteries** ($LiFePO_4$, for example) can usually be discharged at 100% of their capacity.
- Example: a 100Ah battery = max discharge of 100A

Now let's say you want to cook with an induction cooktop, which typically draws around 2000 Watts.

On a 12V system, that would pull:
2000W / 12V = **167 Amps**

That's a serious current draw! Let's see how big your battery bank needs to be:

- **With lead-acid**: You'd need at least **850Ah** of capacity (because 167A is 20% of 850Ah)
- **With lithium**: You'd need around **200Ah**, since lithium batteries can deliver their full rated current

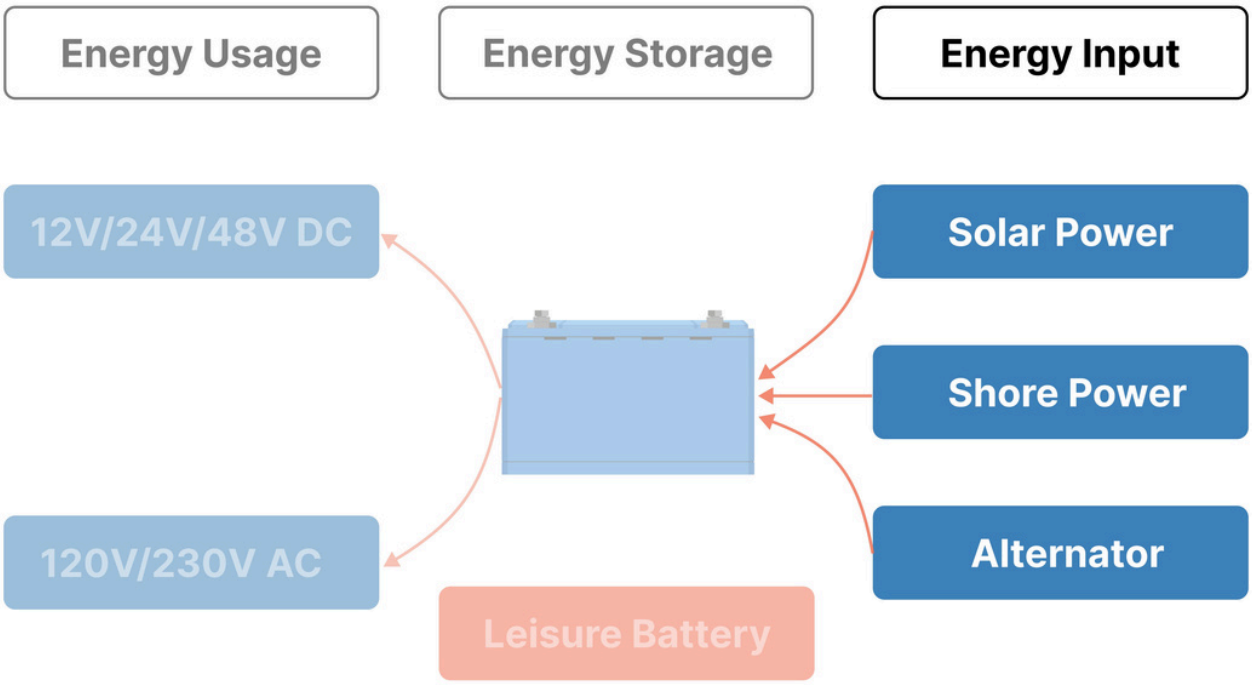
📝 *Note: Always check your battery's manual to see the manufacturer's recommended discharge limits.*

That's quite a bit of new info to take in, right?

Take a moment to review it — or re-read if needed.

Coming up next: we'll show you how to charge your battery using different methods, and finally, how to calculate your full energy balance for your camper setup.

Energy input: battery chargers

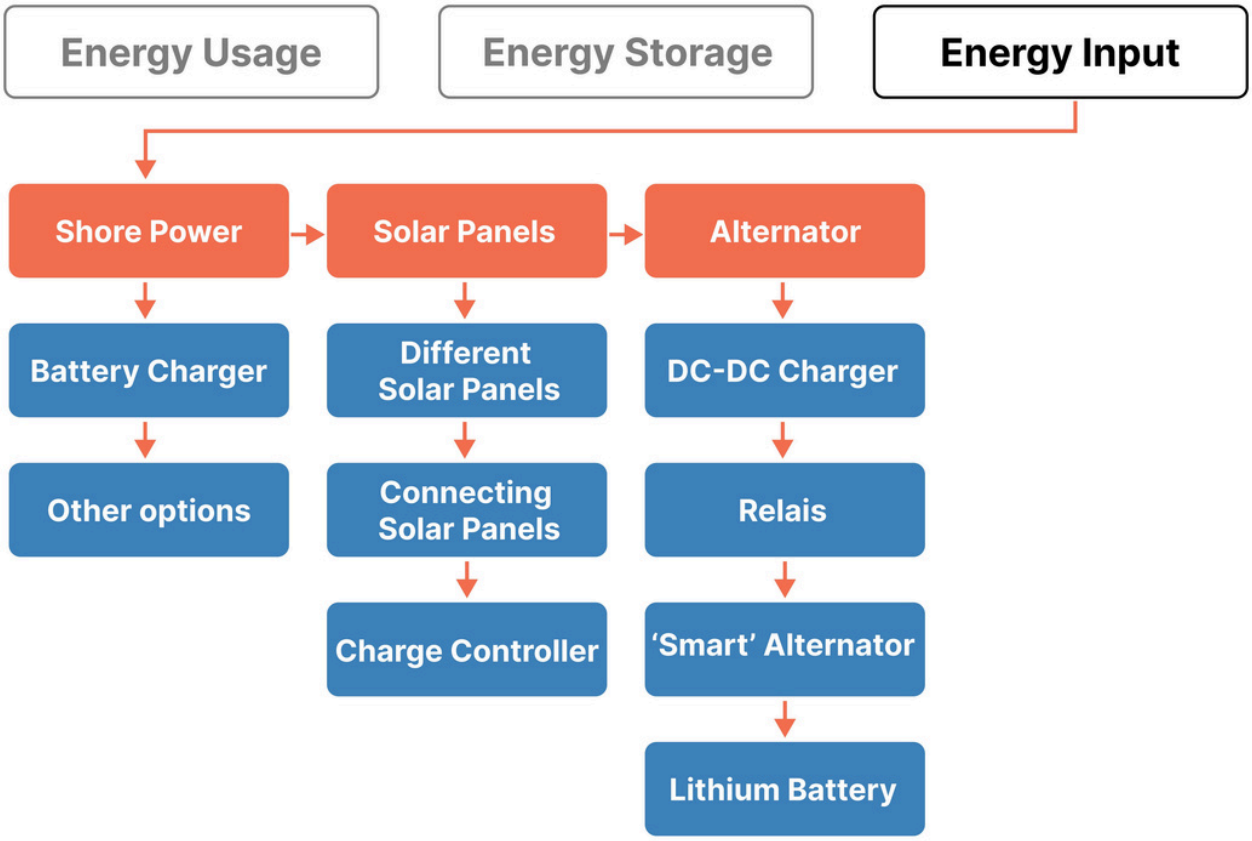


By now, we've already discussed how your house/leisure battery works and the different ways it can be discharged.

Of course, your battery can't magically store an unlimited amount of power — so eventually, it needs to be recharged. Luckily, there are several ways to do that:

- **Via shore power** (using a battery charger)
- **Via solar panels**
- **Via your vehicle's alternator**

In this chapter, we'll walk you through each of these charging methods, starting with charging from shore power.



Charging via shore power

You've already read the term **shore power** earlier in this guide — external electricity that you can plug your camper into. Now it's time to take a closer look at how shore power can be used to charge your house/leisure battery.

Let's start with a fun fact:
Did you know the term s*hore power* originally comes from the **boating world**?

When a ship docks at a harbor, it connects to a power source on land — the "shore" — to get electricity. Pretty different from a camper, right? But actually, the principle is exactly the same.

When your camper "**docks**" at a campsite, your driveway, or anywhere else with a power outlet, you can plug into the grid and charge your house battery.

This is done using a battery charger that's connected to your shore power inlet. It converts the 230V (or 120V in North America) AC power from the grid into 12V or 24V DC — the kind your battery needs.
So:

- You plug your camper into a **regular power outlet**
- That electricity goes to your **battery charge**r
- The charger fills up your h**ouse battery,** just like charging your phone or laptop

Simple, reliable, and super useful — especially if you're staying somewhere for a longer time.

Shore power inlet

To charge your house battery via shore power, your camper needs to have a **shore power inlet** — a dedicated socket mounted on the outside of your vehicle. There are a few different types of inlets to choose from.

The most common option in **Europe** is the **CEE inlet**, also known as the "blue plug." You've probably seen one before: a large, blue, 3-pin connector.
This CEE inlet is the standard for outdoor power connections at campsites across Europe, and it's what most camper builders recommend.

In North America, however, shore power connections look a bit different. Most RVs and campers there use either:

- NEMA TT-30 (30 amp, 120V — common in smaller RVs)
- NEMA 14-50 (50 amp, 240V split phase — used in larger RVs)

So depending on where you are in the world, the inlet and power standard may vary, and your camper's electrical system should be built accordingly.

Back to inlets: there are also alternatives to the CEE, like:

- **DEFA inlet**
- **PowerCon connector**

Just like the CEE, both DEFA and PowerCon are designed for outdoor use.
Their big advantage? They're much **more compact** and can be mounted in a more discreet way — for example, in the bumper or a body panel.

The downside? These smaller connectors are usually less robust than a CEE plug.
So if you plan to plug into shore power often, CEE (or the North American equivalents) is typically the more durable choice.

CEE Inlet

★★★★☆

More information at:

Amazon.com

Charging your house/leisure battery

So, now you know about the different types of power inlets — but how exactly do you charge your house battery using shore power?

You'll need a **battery charger.**
A battery charger is a device that takes external AC power — like from a wall outlet (230V in Europe or 120V in North America) or a generator — and converts it into DC power to charge your 12V or 24V house battery.

How Fast Can It Charge?
Battery chargers come in different sizes, each with its own charging speed.
The more amps a charger can provide, the faster it will charge your battery.
But faster isn't always better — especially with lead-acid batteries (AGM or gel).
Most manufacturers recommend charging them at **no more than 20%** of their capacity.

Example:
For a 100Ah lead-acid battery → use a 20A charger
Charging faster than this can shorten the battery's lifespan.

Lithium batteries, on the other hand, can usually handle much higher charge currents. Always check your battery's manual for the recommended charge rate — or contact the manufacturer if you're unsure.

Types of battery chargers

Battery chargers come in a few different forms, depending on how you want to set up your electrical system:

1. A traditional battery charger
2. An inverter/charger combo
3. An inverter/charger with solar input

Let's break these down one by one.

The traditional battery charger

We'll start with the simplest option: the traditional battery charger.
There are two ways to use it:

- Permanently installed in your camper: it starts charging automatically when you're connected to shore power.
- Portable: you only plug it in during emergencies or when needed.

For emergencies, some chargers come with clamps so you can hook them directly to your battery terminals.

A solid option here is the Victron Blue Smart IP22 12/15(1) — portable and smart.

If you don't want to install a full CEE inlet, but still want the option to charge your battery from the grid occasionally, a traditional battery charger is a very practical backup.

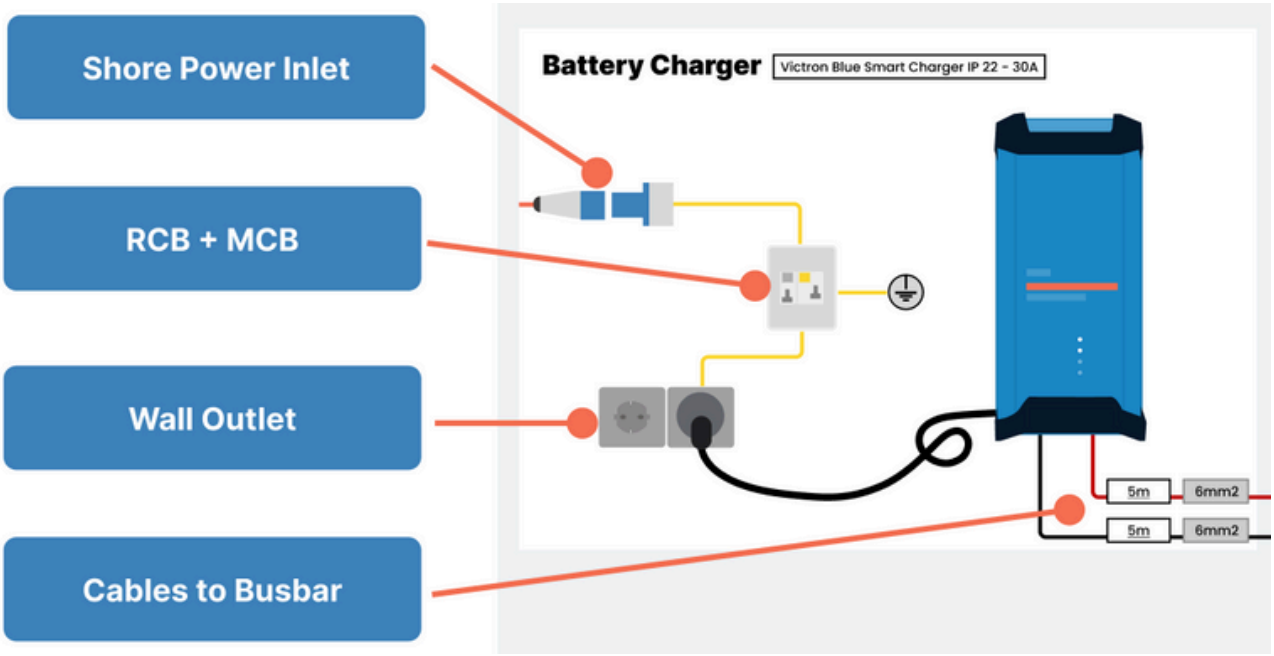


Illustration:
From the CEE shore power inlet, a cable runs through a circuit breaker to a wall outlet inside your camper.

You plug the battery charger into this outlet. From there, the positive (red) and negative (black) cables run to the distribution blocks, which are connected to your house battery.

Inverter/charger combo unit

Another type of battery charger setup is the **inverter/charger combo.**
You might remember we already touched on this earlier — for example, the **Victron MultiPlus**. To refresh your memory:

An inverter/charger combo like the Victron MultiPlus is a versatile device that combines two key functions:

- It charges your house battery when connected to an external AC power source
- It also inverts DC power to AC, allowing you to run standard appliances from your battery

How Does It Work?

When you plug your camper into **shore power**, the MultiPlus (or a similar inverter/charger) starts charging your battery automatically.

At the same time, it uses the incoming shore power to supply your onboard AC outlets — bypassing the battery altogether.

This switch happens through an automatic transfer switch inside the unit.
And if the shore power gets disconnected?

No problem — the unit automatically switches over to draw power from your house battery to keep your AC appliances running.

Why Choose an Inverter/Charger Combo?

Using a multi-functional device like the Victron MultiPlus can save you space, money, and installation time.

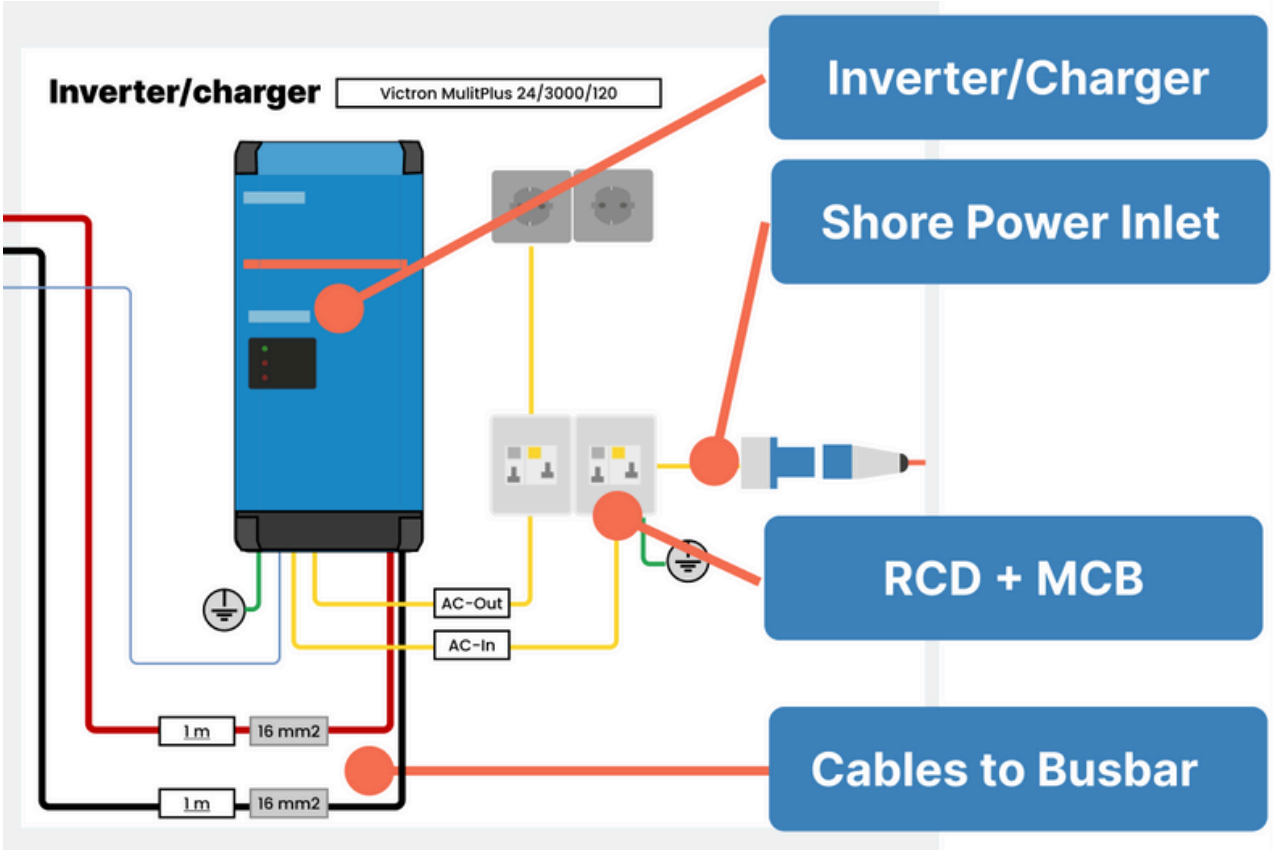


Illustration:
From the CEE shore power inlet, a cable runs through a circuit breaker to the AC-in of the inverter/charger.

From there, an AC-out cable runs (also protected by a breaker) to the interior outlets inside the camper.

The house battery is connected via positive (red) and negative (black) cables to the distribution blocks.

Inverter/charger with solar charge controller

Back in the chapter on power consumption, we already introduced you to an inverter/charger with built-in solar input— the Ective SSI, which we personally used in our very first camper build.

This type of device combines three functions in one unit:

- An **inverter** to convert DC battery power into AC (for regular appliances)
- A **battery charger** to charge your house battery from an external AC power source (like shore power)
- And a **solar charge controller** to manage power from your solar panels

How Does It Work?

When you connect the device to shore power, y**ou first need to turn on the inverter.** Once it's on, the built-in battery charger kicks in and starts charging your house battery. At the same time, the device automatically powers your AC appliances directly from the shore power — bypassing your battery.

The Ective SSI has **two operating modes**:

- **UPS mode**: The battery charger is always active when shore power is available.
- **Eco mode:** The system prioritizes solar power to charge your battery. If your solar input isn't strong enough (for example, during cloudy days), it will fall back on shore power to top off the battery.

When you **disconnect shore power**, the inverter automatically switches to using your house battery to run your AC devices. This transition is seamless and fully automatic — no buttons or switches required.

Even when the inverter itself is turned off, the built-in solar charge controller keeps working. That means your battery will continue to charge from the sun, whether or not you're plugged in or using AC appliances.

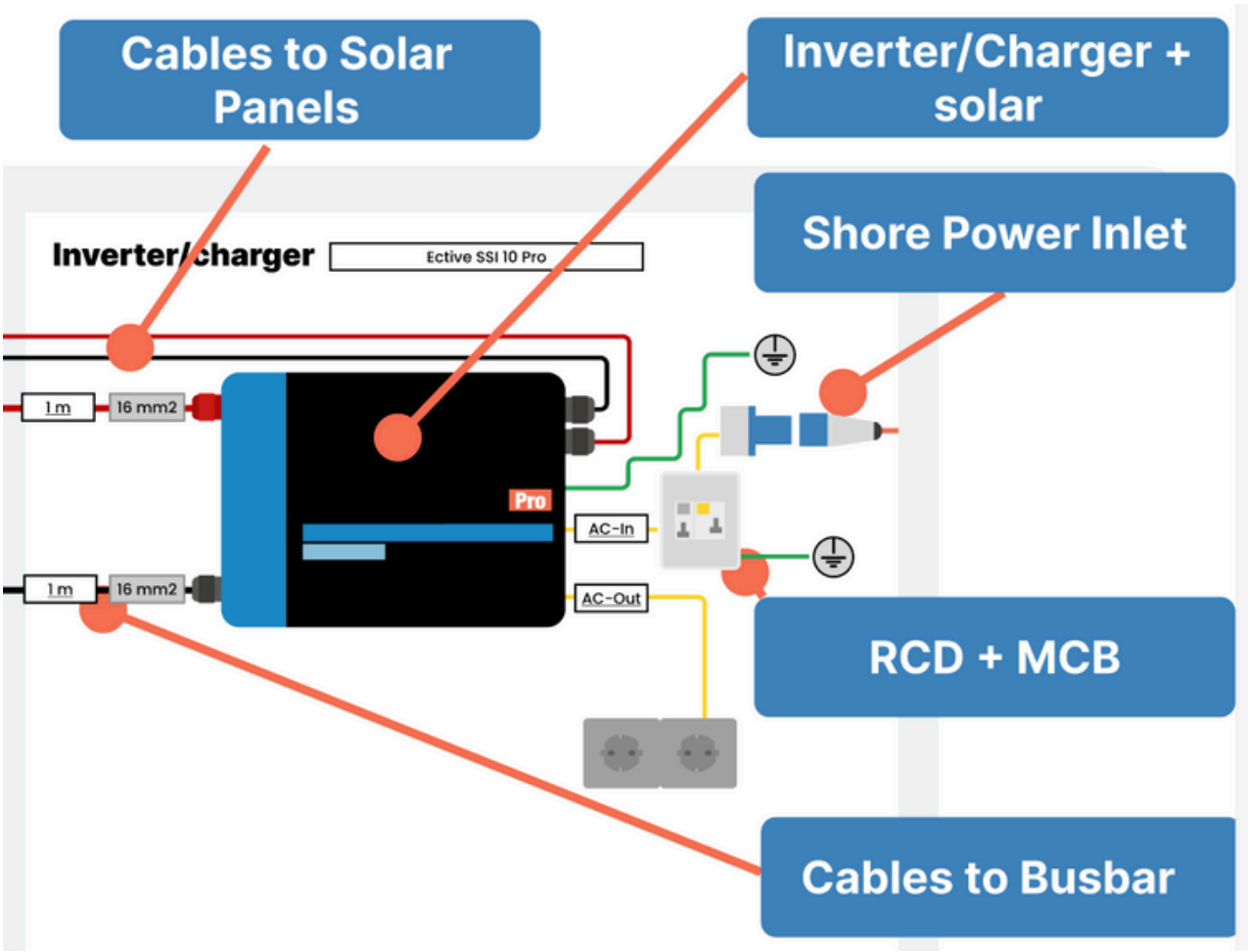


Illustration:
From the CEE shore power inlet, a cable runs through a circuit breaker to the AC-in of the inverter/charger.

From there, an AC-out cable runs to the interior outlets inside the camper.

The house battery is connected via positive (red) and negative (black) cables to the distribution blocks. The solar panels are also connected directly to the Ective SSI.

You can make your own wiring diagram by using our software. Check out:
www.gridless-solutions.com

Charging via solar panels

Is there anything better than your battery charging while the sun is shining?
That's why you'll see **solar panels on almost every camper or RV** — and for good reason.

And here's something you might not know:
Solar panels can still generate power even when it's cloudy.

As soon as **sunlight hits your solar panel**, it begins to generate electricity.
The output voltage can range anywhere from 16 volts up to several hundred volts, depending on the size and configuration of your solar setup.

But here's the catch:
You can't connect your solar panel directly to your battery — that would damage the system.

Instead, the solar power flows into a special device called an **MPPT charge controller**.
This controller regulates the voltage and current to safely and efficiently charge your 12V or 24V house battery.

So whether you're parked off-grid or just soaking up the sun on a quiet day, your solar panels keep your battery topped up — quietly, automatically, and without using a single drop of fuel.

Type of solar panels

There are tons of solar panels on the market, but we can roughly divide them into **three main categories**:

1. Rigid (glass) solar panels
2. Flexible solar panels
3. Foldable solar panels

Let's take a closer look at the pros and cons of each type. We'll start with the most common one: **rigid panels.**

Rigid (glass) solar panels

Rigid solar panels — often framed and covered in glass — are by far the most commonly used panels in camper setups.

They're the same type you'll see installed on rooftops of houses. Why are they so popular?

Because they offer the **highest efficiency and best overall performance** compared to other panel types. They're also durable, reliable, and often the most cost-effective choice for long-term use.

Flixible solar panels

Flexible solar panels were originally developed for the **marine industry**, but they're sometimes used on campers and vans too.

High-quality flexible panels can be a good solution — but they're also expensive. Cheaper flexible panels are often lower quality and tend to have a shorter lifespan. Why?

- They're prone to thermal expansion and contraction, which can cause internal damage over time
- Many low-end panels have a top layer that's vulnerable to UV radiation, turning dull and yellowish after a few years — significantly reducing output

The better flexible panels solve these problems.

They typically have:

- An aluminum backing plate for stability
- A durable EFTE coating to resist UV damage

The downside? They're more expensive than other panel types.

Foldable solar panels

Foldable solar panels are a great alternative if you:

- Don't have space on your roof
- Want to park your camper in the shade
- Need a **portable and temporary** solar solution

These panels aren't mounted permanently. Instead, you unfold them and place them in the sun wherever you like — perfect for off-grid flexibility.

But keep in mind:
If your foldable panels are stored away while driving or when you're parked in the shade, they're not generating any power.

So, unlike rooftop panels, they only work when you actively set them up.

Connecting multiple solar panels

Maybe one solar panel is enough for your setup — or maybe you've got room for a large, high-output panel.

But in many cases, you might want to install **multiple solar panels.**
In that case, you'll need to connect them together — and just like with house batteries, there are two main ways to do that:

- **Series** connection
- **Parallel** connection

Solar panels wired in series

Let's use a simple analogy to help you understand how solar panels connected in series work. Imagine a string of old-fashioned **Christmas lights**, where each bulb is connected one after the other along a single wire.

If one bulb breaks, the entire string goes dark. Why? Because in a series connection, **the electrical current has to flow through each component** in the chain to complete the circuit.

Wiring your solar panels in series follows the same principle — they're connected end to end, forming one continuous loop. This setup is easy to install and can work very efficiently, especially with an MPPT charge controller.

But there's a catch:
If one panel is shaded or not performing well, it affects the entire system. The output of the series is limited by the weakest panel.

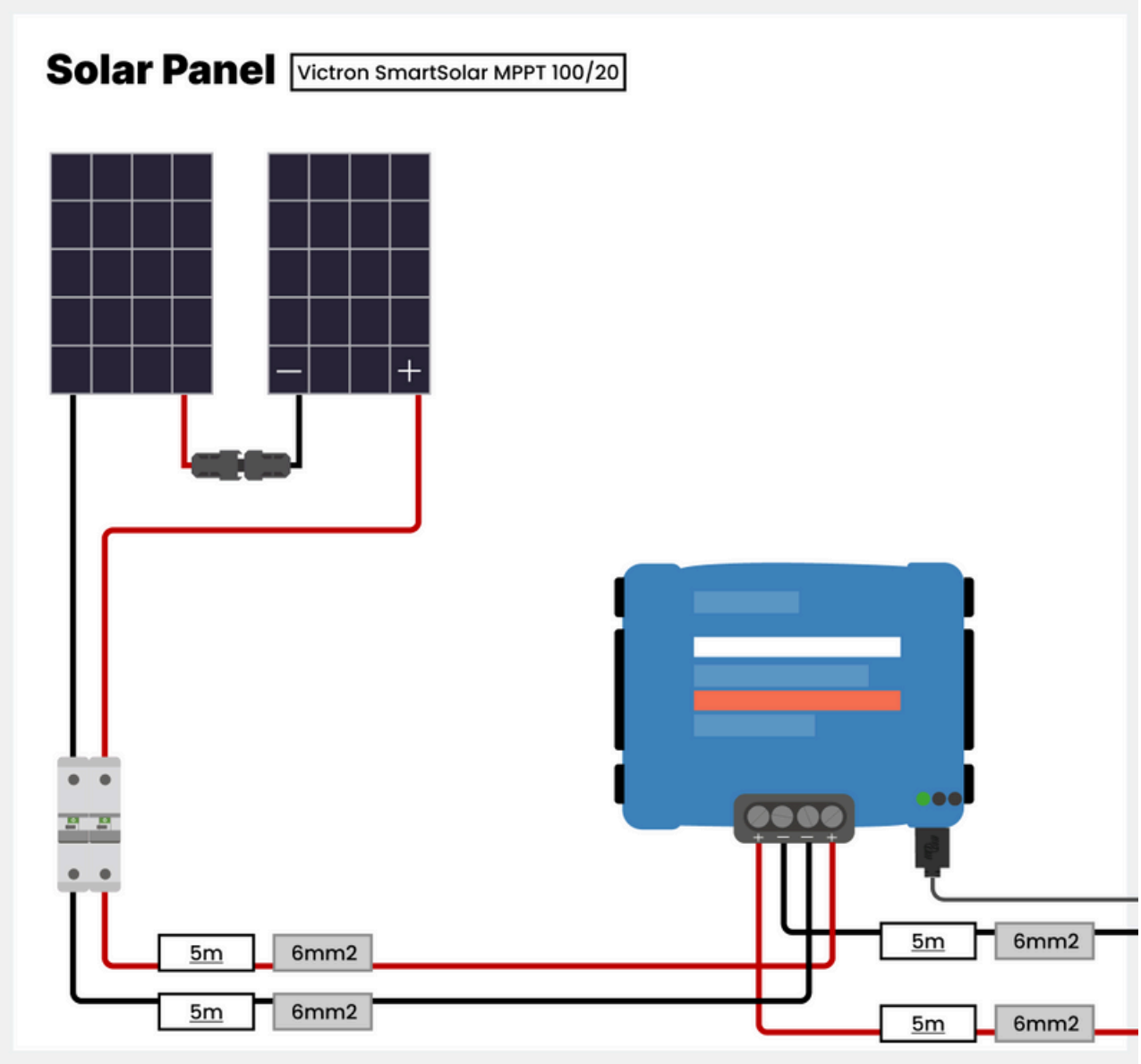


Illustration:
In a series connection, the solar panels are installed in one continuous loop.
This means that if one panel doesn't receive sunlight, the performance of the entire system is reduced — or it may even stop working altogether.

Solar panels wired in parallel

To understand how solar panels connected in parallel work, let's use another everyday example. **Imagine you want to charge several smartphones at the same** time. You plug them all into a power strip, which connects each device to the same power source — but along separate paths. Each phone charges independently, regardless of what the others are doing.

That's how a parallel connection works:
Each solar panel has its own direct path to the system. So if one panel is shaded or underperforming, the other panels keep producing power normally.

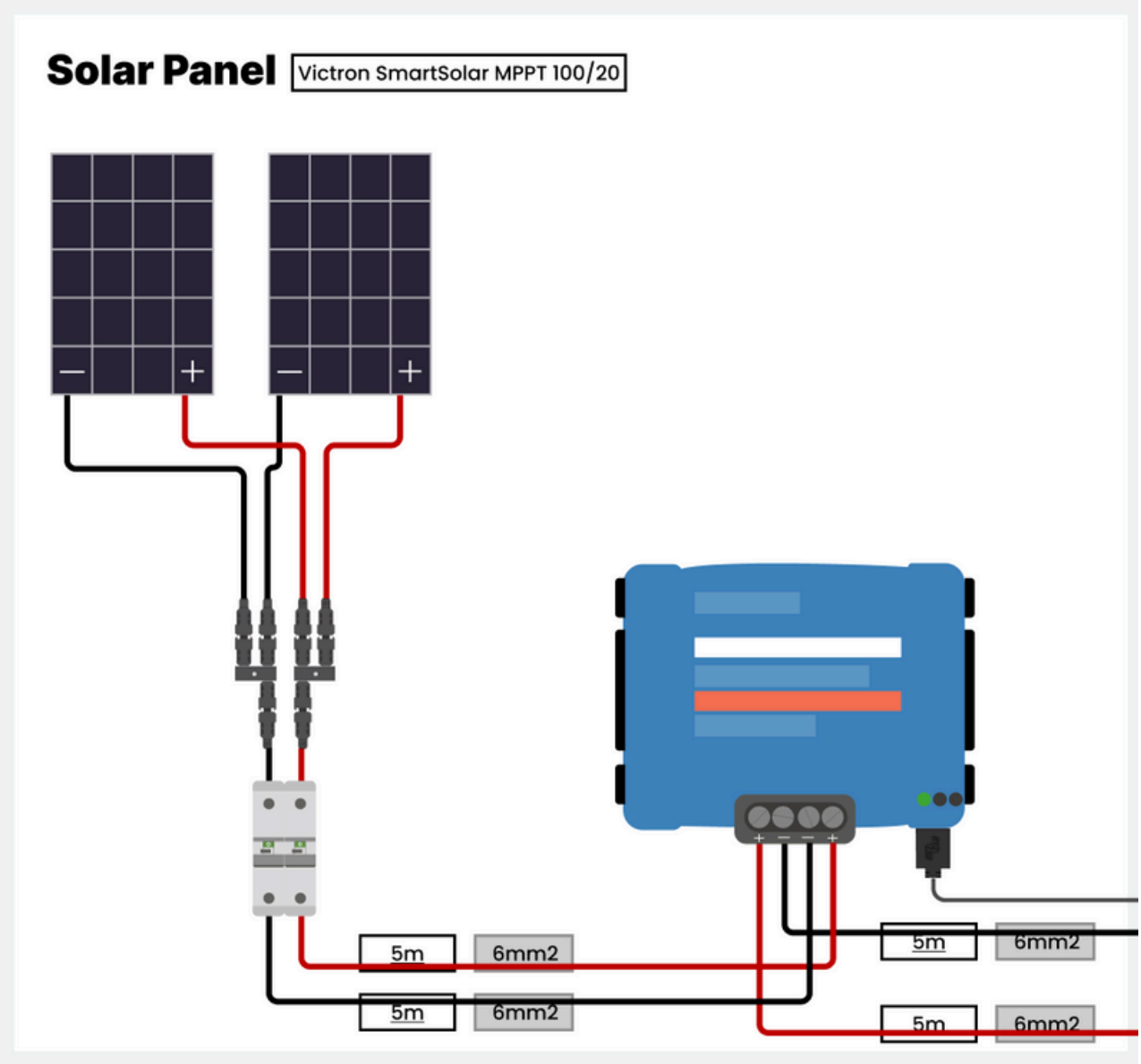


Illustration:
In a parallel connection, the solar panels are wired independently, so the system is less affected if one panel doesn't receive sunlight.

Each panel has its own connection, making the setup more shade-resistant overall. However, this setup requires separate connectors, and if you're wiring together several large panels, you'll need a thicker cable to handle the higher current.

Our Wiring Diagram Software takes this into account in its design.

Installation preference: series or parallel?

Solar panels connected in series tend to perform better during times of low sun, like early morning or late afternoon. (Or during the winter when the sun is lower)

That's because a series setup produces a **higher voltage**, which allows your MPPT charge controller to more efficiently convert sunlight into usable power. So, if your roof is mostly free from shade, a series connection is usually the better choice.

But what if you do have issues with shade?

In that case, you have two main options:

1. Connect your panels in **parallel**
2. **Use a separate charge controller for each panel**

If you choose a parallel setup, keep this in mind:
On **cloudy days** or **during low sun seasons**, your panels may not generate enough voltage for the MPPT controller to even start charging. (Don't worry — we'll explain this in more detail in just a bit!)

If you want the highest efficiency, you can install one MPPT charge controller per panel. And if you go with multiple Victron MPPT controllers, you can even link them together so they work as a team.

Solar charge controllers

Once you've chosen your solar panels and how you want to wire them — in series or parallel — it's time for the next step: Charging your house battery using solar power.

But here's the thing:
You **can't connect solar panels directly to your battery** — doing so could damage the system. That's why you need a solar charge controller.

We've mentioned this term before, but now it's time to take a closer look.

There are two main types of charge controllers:

- **MPPT (Maximum Power Point Tracking)**
- **PWM (Pulse Width Modulation)**

MPPT charge controller

MPPT stands for **Maximum Power Point Tracking.**
It's a smart technology that continuously adjusts the input from your solar panel to extract the maximum possible energy, even as sunlight and temperature change.

With an MPPT controller, you get the **highest efficiency and performance** from your solar setup. That's why MPPT is the most commonly used type in modern camper builds.

PWM charge controller

PWM stands for **Pulse Width Modulation**.
It's a simpler and older technology that works by "chopping" the voltage to match your battery.

PWM controllers are less efficient and are **rarely used** in camper systems nowadays — mostly in small-scale or budget setups.

How does a solar charge controller work?

As promised, it's time to take a closer look at solar charge controllers, and explain why parallel wiring of solar panels is **not always the best option**.

In later chapters, we'll show you how to calculate the size of your solar setup. But first, let's break down how an MPPT charge controller actually works.

On every MPPT controller, you'll see two key numbers — for example: **100|20.**

- **The first number** (100) represents the maximum input voltage (in volts)
- **The second number** (20) is the maximum output current (in amps)

Let's illustrate this with an example.

Suppose you want a total of **300 watts** of solar power, and you're considering **two 150W panels**. Now you need to decide whether to connect them in series or in parallel. In most cases, series wiring is the better choice — and here's why.

Before you choose a charge controller, you'll first need to decide which solar panels you'll be using and how you plan to wire them.

Each panel comes with a **spec sheet** that includes key technical values. One of the most important numbers is the **open-circuit voltage**, often shown as **Voc**.
This number is **crucial** when determining what type of MPPT controller you need.

An MPPT charge controller starts charging your battery once the panel voltage is at least **5V higher than the battery's voltage.**

For example:
To charge a **12.5V battery**, your solar panel setup must deliver at least **17.5V** (12.5V + 5V).

Let's return to the earlier example:
You have **two 150W** panels, each with a **Voc** of **22.8V.**

- In **series**: total voltage = 45.6V
- In **parallel**: total voltage = 22.8V

With series wiring, you have plenty of voltage to activate the MPPT — even on cloudy days or when the sun is low in the sky. With parallel wiring, however, you're right on the edge — and the system might fail to start charging in low-light conditions.

If you use panels that individually produce enough voltage, you could also choose to install a separate MPPT charge controller for each panel.

The benefit?
If one panel is shaded or underperforming, the others can still charge independently without being affected.

Victron SmartSolar charge controllers are ideal for this kind of setup.
They can be **linked together** in the same **Bluetooth network**, allowing them to work as a single, unified charger.

But note:
This setup only works well with **high-voltage panels**.
It's not recommended for standard 36-cell panels, which typically produce 18–22V, because they won't provide enough voltage individually for an MPPT to start reliably.

Too complicated?
Victron has developed a free online tool to help calculate the right MPPT charge controller.

Our software program also includes a built-in calculator that automatically selects the correct MPPT controller for your setup.

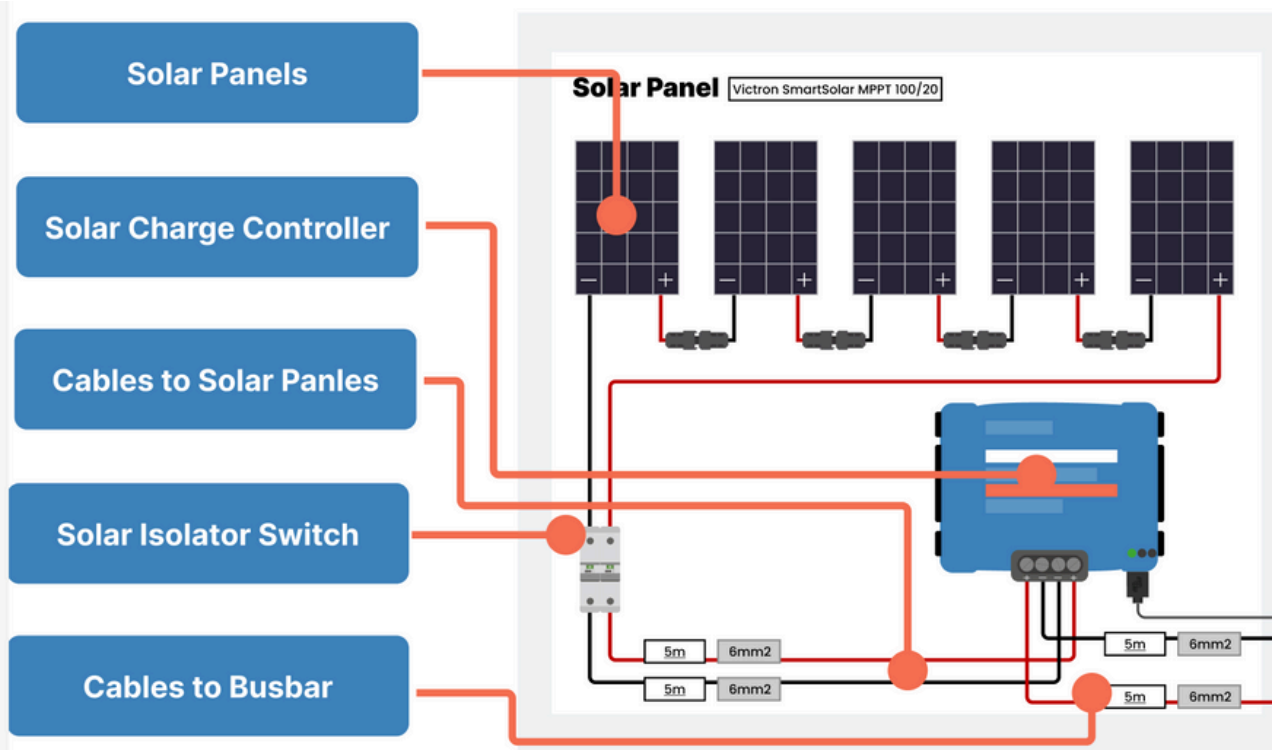


Illustration:
The solar panels are connected to the MPPT charge controller.
From there, two cables run to the distribution blocks, which connect to the house battery and allow it to be charged.

Charging via the alternator

So far in this chapter, we've covered **two ways** to charge your house battery:

- From **shore power** using a battery charger
- And via **solar panels**

But there's a third option you should know about:

Charging your battery while driving, using your vehicle's alternator.
There are two main devices that allow you to do this:

1. A **DC-DC charger**
2. A **battery isolator (relay)**

Both systems use the **electrical current produced by your vehicle's alternator** to charge your house battery.

However, not every method is suitable for every setup — and choosing the right one depends on your vehicle type, battery chemistry, and charging needs.

DC-DC charger

A DC-DC charger — also known as a **buck booster** or simply a battery-to-battery charger — converts the power generated by your vehicle's alternator into the correct charging voltage for your house battery.

When you start the engine, the DC-DC charger receives a signal and begins charging the house battery. When you turn the engine off, it receives another signal and automatically stops charging.

With some brands, you'll need to manually wire in a signal cable (often called a **D+** connection) to tell the charger when the engine is running. However, with brands like Victron, this isn't necessary — their DC-DC chargers automatically activate when they detect engine vibrations.

DC-DC chargers come in various sizes: 10A, 20A, 30A, 40A, and more.
They're compatible with almost any vehicle and suitable for all types of house batteries, because you can usually set the charging voltage to match your battery chemistry (AGM, Gel, or Lithium).

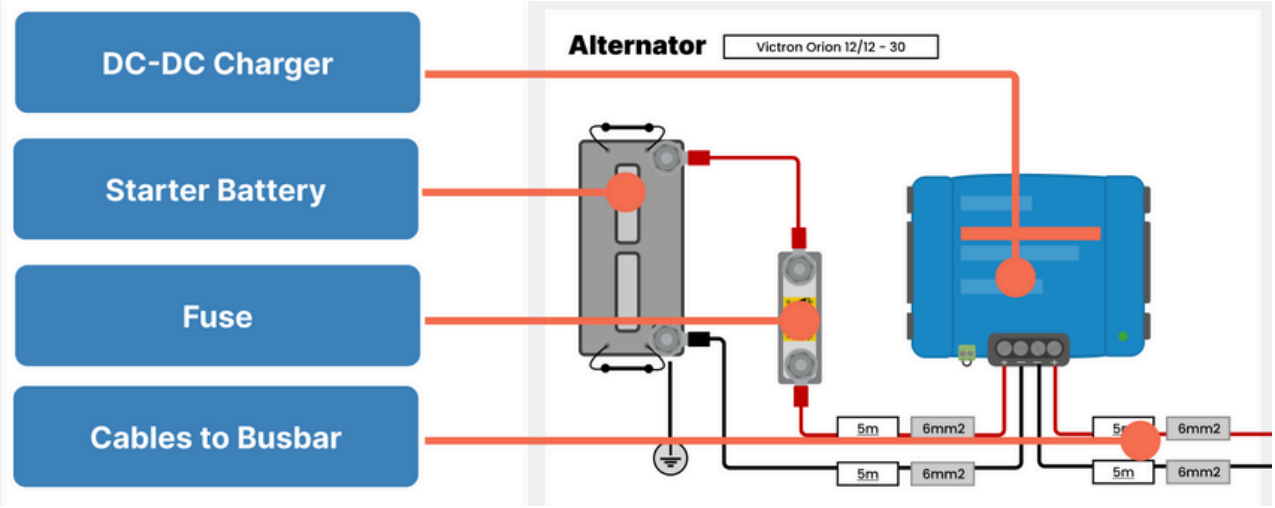
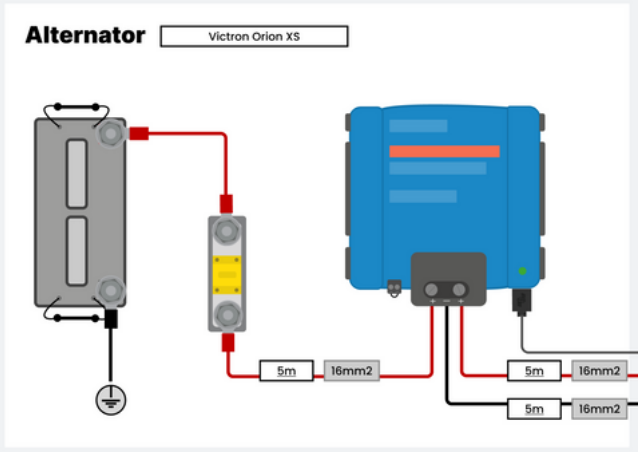


Illustration (isolated version):
The starter battery is connected to the DC-DC charger. When the engine starts, the charger receives a signal (depending on the type of charger) and begins operating. From the DC-DC charger, two positive (red) and two negative (black) cables run to the busbar.

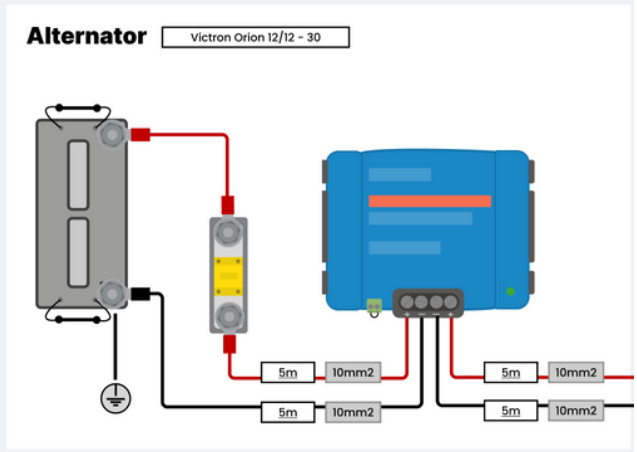
Isolated and non-isolated DC-DC chargers

There are two types of DC-DC chargers: **isolated** and **non-isolated**. In an isolated DC-DC charger, the input (from the starter battery) and the output (to the house/leisure battery) are electrically separated. This means there's no direct connection between the grounds of both systems. Isolated chargers are often used in boats, older vehicles, or systems where electrical interference or ground loops could be an issue — for example, when the house battery and starter battery are mounted on different grounding points or metal frames.

A **non-isolated DC-DC charger**, on the other hand, uses a shared ground between the starter battery and the house battery. This makes the design simpler and slightly more compact. **Non-isolated chargers are commonly used in campervans** and van conversions, where both battery systems are grounded to the same vehicle chassis. They're practical and efficient for most modern van builds, especially when everything is mounted within the same electrical environment.



Non isolated DC-DC Charger



Isolated DC-DC Charger

Charging via a relais

In some setups, you can also use a **charging relay**.
This device acts as a switch between your starter battery and your house battery. The relay monitors the voltage of the starter battery, and once it rises above a certain level — typically when the engine is running — the relay closes the circuit, allowing current to flow from the starter battery to the house battery so it can be charged.

When the engine is turned off and the voltage drops below a certain threshold, the charging relay disconnects the two batteries. This prevents your starter battery from being drained when you're using power from your house battery while parked.

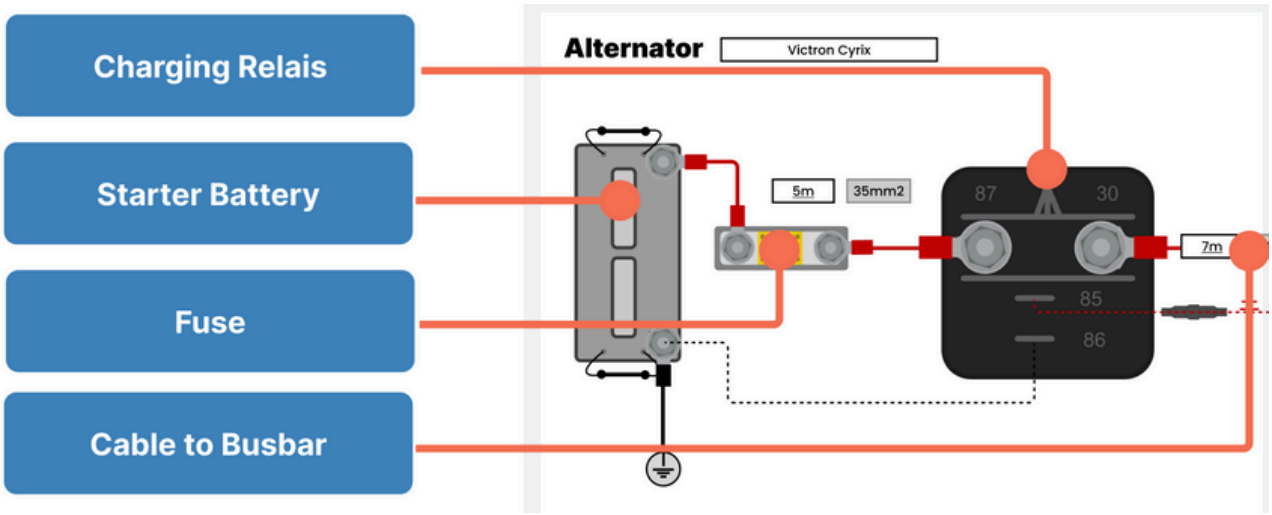


Illustration:
The starter battery is connected to the charging relay. When the engine starts, the alternator begins charging the starter battery. The voltage slowly rises to around 14.4V.

Once the voltage reaches approximately **13.5V**, the charging relay detects this and closes the circuit, allowing current to flow to the busbars, which are connected to the house battery.

Note: There are two situations where a charging relay is not suitable — when your vehicle has a smart alternator, or if you're using a lithium battery. We'll explain that next.

"Smart" alternators

Charging relays aren't suitable for every vehicle or battery type — and that's mostly because **newer vehicles are equipped with so-called "smart" alternators**. These alternators are designed to reduce emissions, and they do this by not charging the starter battery continuously.

Instead, they only charge when needed and often use regenerative braking — meaning the energy generated when slowing down is used to top up the battery. Because the starter battery's voltage isn't consistently high, the **charging relay may assume the engine is off and disconnect the house battery**, even while you're driving.

So how can you tell if your vehicle has a smart alternator?

In the Netherlands and most of Europe, you can check the emissions standard (Euro norm) listed on your vehicle registration.
Vehicles that meet Euro 5 or Euro 6 standards are very likely to have a smart alternator.

In North America, emissions standards are different and smart alternators are not directly linked to a "Euro" classification. However, most vehicles built from 2015 onward — especially fuel-efficient or start/stop-enabled models— are equipped with some form of smart alternator technology.

Still unsure? The easiest way to find out is to ask your local mechanic or dealer — they'll know whether your specific make and model uses one.

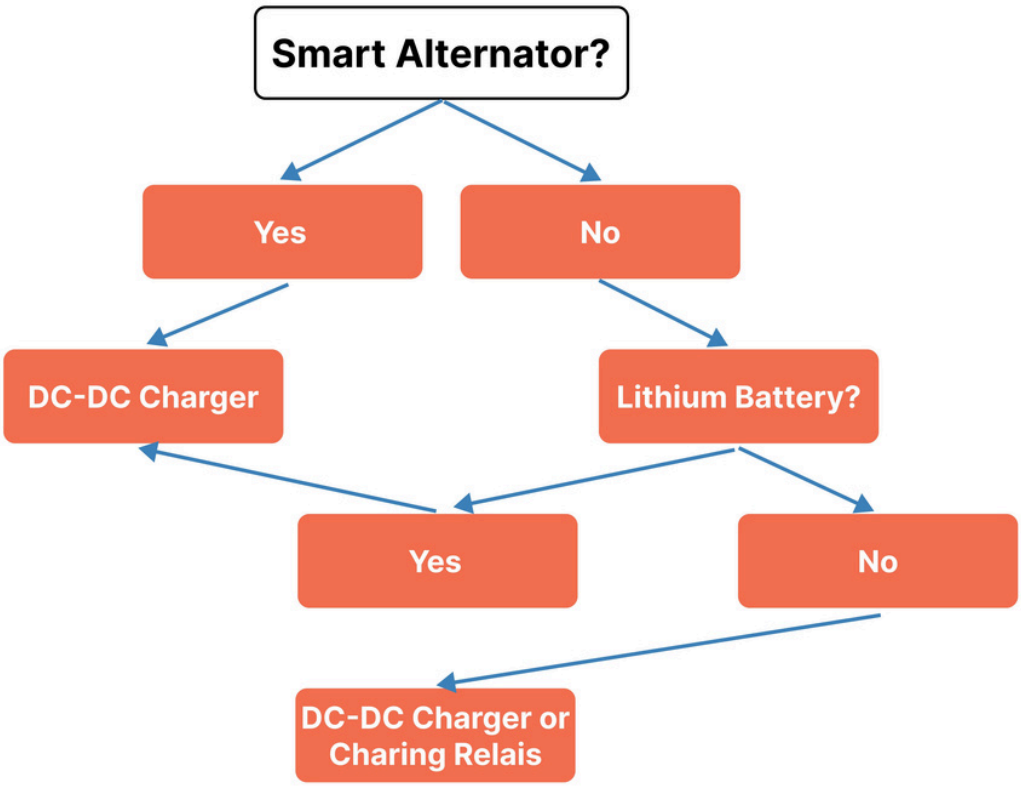
Lithium batteries

Before we wrap up this topic, let's briefly talk about **lithium batteries** — because they **cannot be charged using a charging relay**. (Well they can but we don't recommend it)

The charging relay is an older design, originally **intended for lead-acid batteries.** Without going too deep into the technical details, lithium batteries have a very **low internal resistance**, which allows them to accept high charging currents. A charging relay isn't designed for this kind of current flow, and using one with a lithium battery can even **overload** your vehicle's alternator.

In contrast, a DC-DC charger is compatible with all types of vehicles — no matter the emissions standard, alternator type, or battery chemistry. A charging relay is only suitable in systems that use a **traditional alternator** and a **lead-acid battery** (see diagram below).

That's why, for modern camper setups, the DC-DC charger has become the most commonly used and reliable solution.



Calculating your energy needs

You've already made some serious progress on your journey to building your dream camper — and planning your dream trip along with it! **You're doing great.**

By now, you should have a solid understanding of the basics of camper electrics: how your house battery, inverter, battery charger, solar panels, and charging while driving all work together.

But before you can truly hit the road and start living your campervan dream, there's one more key concept you need to understand — and it might just be the most important one of all: Creating your **energy balance/need.**

Living your dream trip

Maybe you already own a van and you're planning to convert it.
Or maybe you've been on camper trips before, and now you're dreaming of building your own van from scratch.

Either way: traveling in a **van you built yourself** gives you the ultimate freedom. You can wake up at breathtaking spots, follow the road wherever it takes you, and always have everything you need with you.

That's why the very first step in designing your camper should be to imagine the actual trip you want to take.

Why?
Because this helps you decide which **devices**, **features**, and **comforts** you'll truly need in your van. When you start with the **trip in mind**, you'll be able to choose the right setup — and focus on what actually matters to you.

So let's dive in and start building that vision — your ideal travel scenario — so we can build the perfect electrical system to match it.

Imagining your dream trip

Thinking about your dream camper trip shouldn't be hard — it's probably the very reason you're considering building a van in the first place.
But it's still important to take a step back and really reflect on what matters most to you when it comes to your travel setup.

When you imagine your ideal road trip, ask yourself:
Where would you go?
Where would you camp?
And how long would it take to get there?

Camping with some friends in Scotland @stravanaig

There are also practical factors to consider, like the season you're planning to travel in. Are you heading to **Scandinavia in winter** to catch the northern lights?

Exploring **sunny southern Europe** in the middle of summer?
Or maybe you're planning a road trip through the **Scottish Highlands**, the coastal roads of **California**, or the **Canadian Rockies**?

Whether you're planning a multi-month journey through Europe, a cross-country adventure in North America, or weekend getaways across the UK, the kind of trip you envision will directly shape your electrical setup.

Some other questions to guide your planning:

- **How long** do you want to stay in one spot? A night? A few days? A whole week? Maybe even longer?
- Will you be staying at **campsites** with **hookups**, or do you want your camper to be fully equipped for **off-grid travel**, so you can park and live in the wild — completely self-sufficient?

The clearer your vision is, the better you'll be able to design an electrical system that truly supports the way you want to travel — wherever in the world that may be.

Capacity for your dream trip

Wasn't that nice?
Letting your imagination wander through beautiful, unforgettable trips — or sitting down with your travel partner to talk about all the places you still want to see.
For us, **there's almost nothing better than dreaming about the road ahead.**

But aside from being fun, this exercise is actually **really useful** when it comes to designing your electrical system.

Why? Because your ability to **store and generate enough power** on the road depends entirely on the kind of trip you're planning. That means the capacity your camper needs — both battery size and charging options — depends on your travel style, your locations, and how long you want to be self-sufficient.

To get a better idea, try listing all the **electrical devices** you'll want to use while you're parked at your dream location, for as long as you plan to stay there.
Think of obvious essentials like a fridge, lights, and phone chargers, but don't forget the ones you might easily overlook, like a **water pump**, **roof fan**, electric bike charger, or even an **air fryer**.

To give you an idea, here's a list of the devices **we use in our own camper**:

- Fridge
- Roof fan
- LED lighting
- Water pump
- Diesel heater
- Mobile phone
- 2 x Laptops

Take your time here.
Sit down, think it through, and make a list that reflects your personal needs, comfort level, and budget.

Once you've figured out which devices you want to use in your camper, we can move on to the next step:

Estimating how much power they use in a 24-hour period.
And don't worry — we'll guide you through it!

Estimating your power consumption

By now, you've hopefully spent some time thinking about which **electrical devices** you want to use in your camper.

To get an accurate picture of your energy needs, it's important to know the **technical details** of those devices. Now that you've made a list, the next step is to look at the specific type of each device — for example:
What kind of **fridge**, **lighting**, or **charger** are you planning to install?

Important values to consider

Why is this so important? A fridge is just a fridge, right?
Not quite. There are different types of fridges — and other devices — that have different features and therefore consume different amounts of energy.

The key value you want to find is the **power rating** of each device, measured in **watts** (**W**).
You'll also want to estimate:

- How many **hours per day** each device will run
- Which **230V appliances** you plan to use — especially if you'll run multiple devices at the same time

To summarize, here's what you need to gather to calculate your total energy use:

- The **power consumption (W)** of each device
- Which **AC (230V) devices** you'll use (and whether they'll be used simultaneously)
- The **daily usage time** for each device (in hours)

Calculating your daily consumption

Once you've collected all the info above, you can calculate your **daily energy usage** (in watt-hours per 24 hours).

You can do this the old-fashioned way — with a pen and paper or a spreadsheet — or use our free calculator to make things easier.

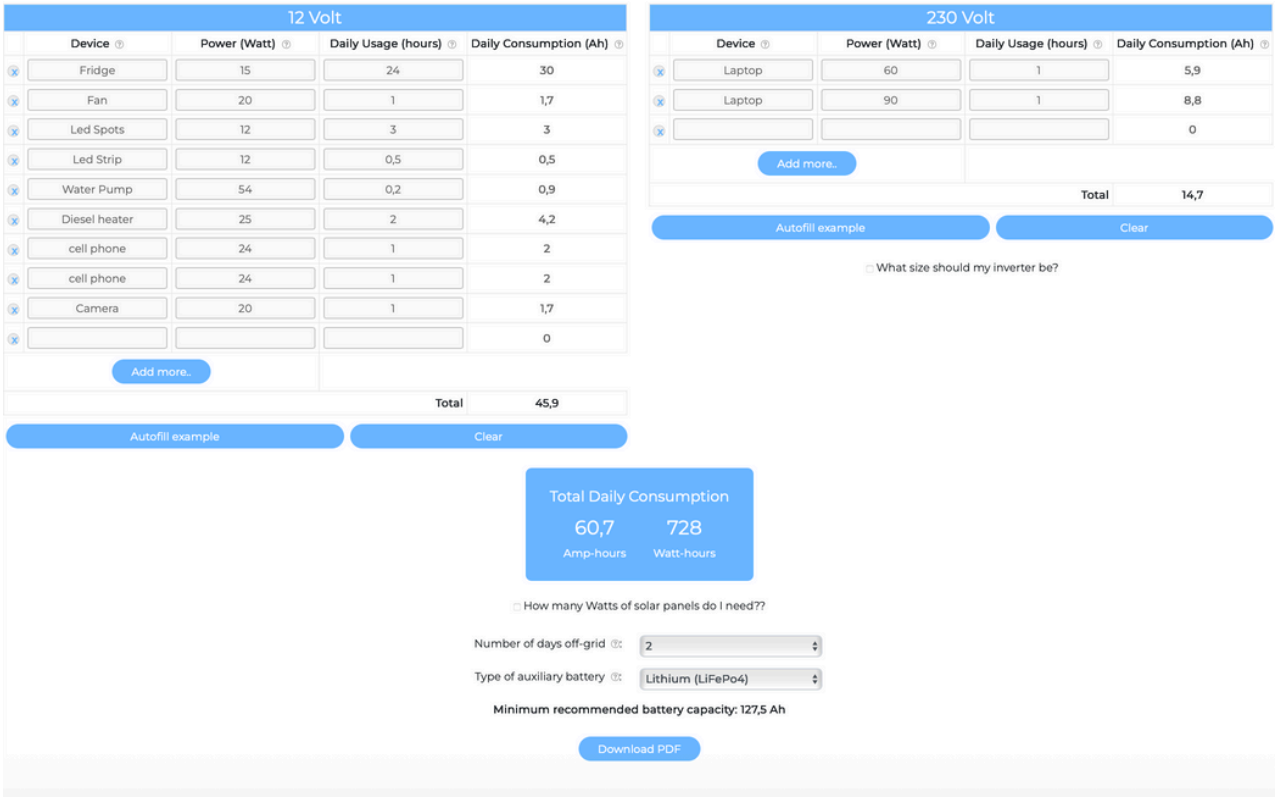
Prefer to do it manually? That works too:
Just create a list of all the devices you'll use, and multiply each one's power (W) by the number of hours per day it will be running.

To help you get started, we've included an example calculation below.

To calculate your daily energy consumption using this example, it helps to organize your data into a simple table.

Start by listing each **device** in the left column. Next to that, note the device's **power consumption** in **watts** (**W**). In the next column, write down how many hours per day you expect to use it. Finally, calculate the amp-hours (Ah) required and list those in the rightmost column.

By adding up all the values in the last column, you'll get a good estimate of your total daily power usage.



Use the (free) Calculator

Once you've filled out the calculator — or created your own list and done the math — you'll have the key information we need: Your estimated daily energy consumption.

With this number in hand, we can move on to the next step:
Determining the right battery capacity, the number of solar panels you may need, and the best way to charge your battery while driving.
Let's take a closer look at each of these.

Note: It's nearly impossible to make a perfectly accurate prediction, because many real-world factors affect power usage. Actual consumption is often lower than the estimate — but planning for a bit more is always a good idea.

Batteries and solar panels

When you visualised your dream trip, you likely considered a few important factors — like which devices you'll use, what kind of climates you'll be traveling through, and how many days you'd like to spend **off-grid** or at **campsites**. Based on that, you now have a good idea of your **daily energy consumption.**

With this in mind, it's time for the next step:
Figuring out how you'll supply your camper with the energy it needs.
We'll start by looking at one of the most essential parts of your system: the **house/leisure battery.**

What size should the battery be?

During your dream trip planning, you may have decided how many days you want to be able to **camp without shore power.** Using your daily power consumption (in amp-hours or Ah), we can now calculate the total battery capacity you'll need.

Let's go through an example:

You've determined the following:

- Your **daily energy usage is 60 Ah**
- You want to be **off-grid for 3 days**

That means **you'll need a total usable capacity of 180 Ah** (60 Ah × 3 days).
But — as you may remember from the chapter on batteries — you can't use 100% of a battery's capacity:

- For **AGM** or **gel batteries** (lead-acid), only about **50%** is usable
- For **lithium batteries**, you can typically use up to **90%**

Based on this, you'd need:

- **360 Ah** of lead-acid battery capacity (180 Ah ÷ 0.5)
- **200 Ah** of lithium battery capacity (180 Ah ÷ 0.9)

This example assumes no energy is being generated during your trip.

In reality, you'll likely produce some power — especially if you have solar panels on your roof. Still, there are a few things to consider:

If you plan to travel during winter months or in low-sunlight regions, it's wise to stick to this full-capacity calculation.

But if you mainly travel in summer and install solar panels, you might get away with a slightly smaller battery, since the panels will top up your system throughout the day.

Roaming through Spain (Yes our van has a different color here)

How many solar panels do you need?

Before we dive into the numbers — here's a simple rule of thumb:
If you're planning to travel a lot with your camper, just install as many solar panels as your roof can fit.

Seriously. More panels mean more flexibility, more comfort, and less worry about running out of power when you're off-grid. But if you want to calculate exactly how many watts of solar you'll need based on your setup — let's walk through a full example.

In the earlier chapter on solar, we discussed the different types of panels, how to connect them, what a charge controller does, and how to wire everything properly.

Now that you've estimated your daily energy consumption, it's time to figure out how much solar power you'll need to cover that usage.

Each day, you consume a certain amount of energy — for things like lights, your fridge, phone chargers, and more.

To offset that usage, you can install solar panels. But how **much wattage** should you install?
That depends on several factors:

- Your daily consumption
- The season you travel in
- The tilt and placement of your panels
- Other details like cable losses, panel type, and charge controller efficiency

We'll keep things simple here and focus on the basics.

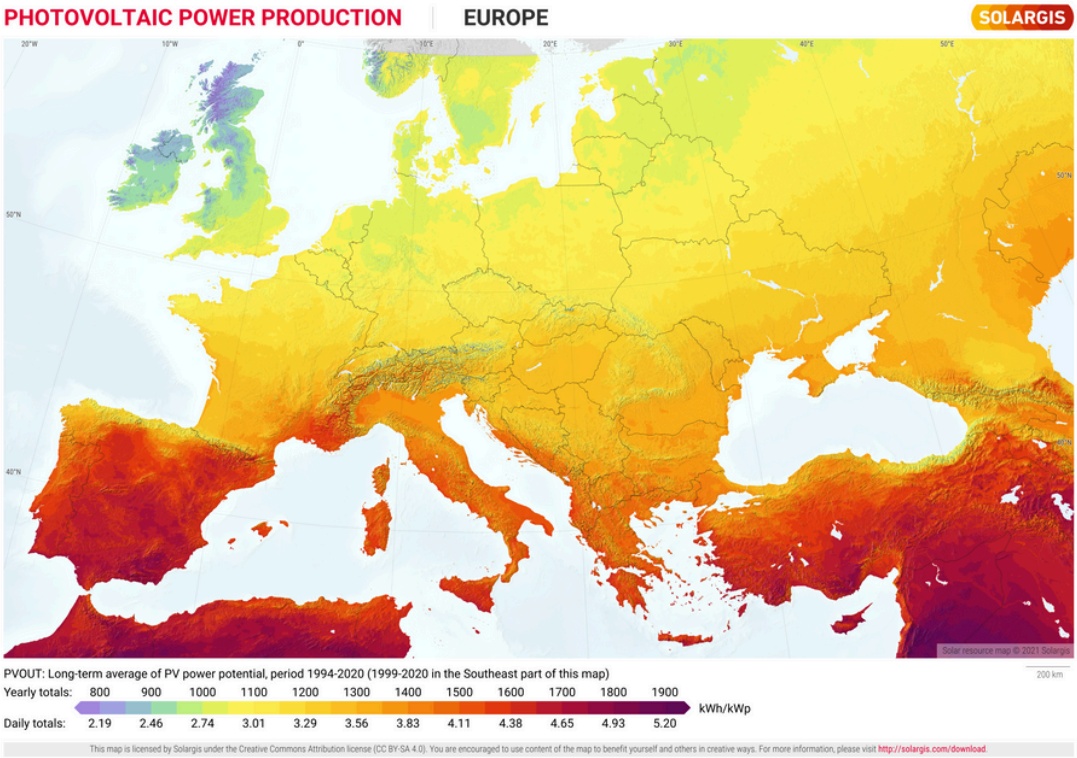
You can either use our free calculator, or make the calculation manually:
Here's how it works:

1. Take your **total daily energy consumption in watt-hours (Wh)**
2. Divide it by the **average number of sun hours per day** (in the Netherlands, we use 4 hours as a reference)
3. **Add a 23% efficiency loss** to account for flat-mounted panels

Let's go back to the example we used when calculating battery size:
You use **60 Ah per day**, and you have a **12V** battery system.
To convert this to watt-hours:
60 Ah × 12 V = **720 Wh**

Now apply the formula:
720 Wh / 4 sun hours × 1.23 (for 23% loss) = 221 W

So, to cover your daily consumption of 720 Wh, you'll need about 221 watts of solar — and rounding up, that's a **250W solar panel**.



Charging while driving

Sometimes you might hit a stretch of **cloudy weather** where your solar panels don't produce enough power. That's when it's incredibly useful to have a way to charge your house battery while driving.

For this reason, we always recommend installing a **DC-DC charger**.
You don't really need to make any complex calculations for this part — after all, you're simply topping up your batteries you drive.

And since we want to keep this eBook as simple and practical as possible, we won't go into detailed math here.

If you'd like to dive deeper into the difference between a DC-DC charger and a charging relay, feel free to revisit the chapter where we explain both options in more detail.

Electrical Wiring Diagram

You're doing an incredible job!

By now, you have a solid understanding of your **power consumption**, the **right battery capacity,** and how to choose your **inverter**, **battery charger**, **solar panels**, and **charging methods** while driving. Most importantly, you now know how to build an accurate energy balance. **Well done!**

With all this knowledge, you're ready to move on to the next step:
Creating the electrical wiring diagram for your camper.

This diagram shows all of your components, and maps out how everything should be connected.

But first — why is creating an electrical schematic so important?

To start, it helps you **visualize and plan** your full setup in detail, so you can confirm that everything will actually work the way you want it to. If you just rely on gut feeling and connect things as you go, there's a big risk you'll hit a (literal or figurative) dead end — only realising it once everything is already installed.

By creating a wiring diagram, you'll also know exactly what you need when it comes to wiring and protection. Think of:

- Wire sizes
- Correct fuse ratings
- Safe and clear connections

Our software helps you with:

- Laying out all your devices and components
- Calculating the correct cable thicknesses
- Choosing the right fuses
- Creating a clear, organized overview
- And offering personal support if you have questions

Bernard van der Laan
NL • 1 review

★★★★★

Camper Elektra is an ext useful site for your camper elekta

Camper Elektra is a very useful site with clear YouTube video's. Most helpful however is the PDF sheet (costs **€97**) in which you can import your devices and than the PDF algorithm shows you the cable thickness and which fuses to install, great experience!!
And above all, when you have got a specific question than you can email at info@ and Gijs will get back to you within short notice.

Matthias M
DE • 1 review

★★★★★

Gutes Programm für den Vanausbau..

Gutes Programm für den Vanausbau... zu dem schnelle und konstruktive Hilfe über WhatsApp.

Dick de Fluiter
NL • 4 reviews

★★★★★

Prima elektra-schema geleverd

Het gekochte schema werkt perfect en maakt duidelijk hoe jouw elektriciteit in jouw camper eruit kan zien. Op vragen wordt door Gijs snel geantwoord

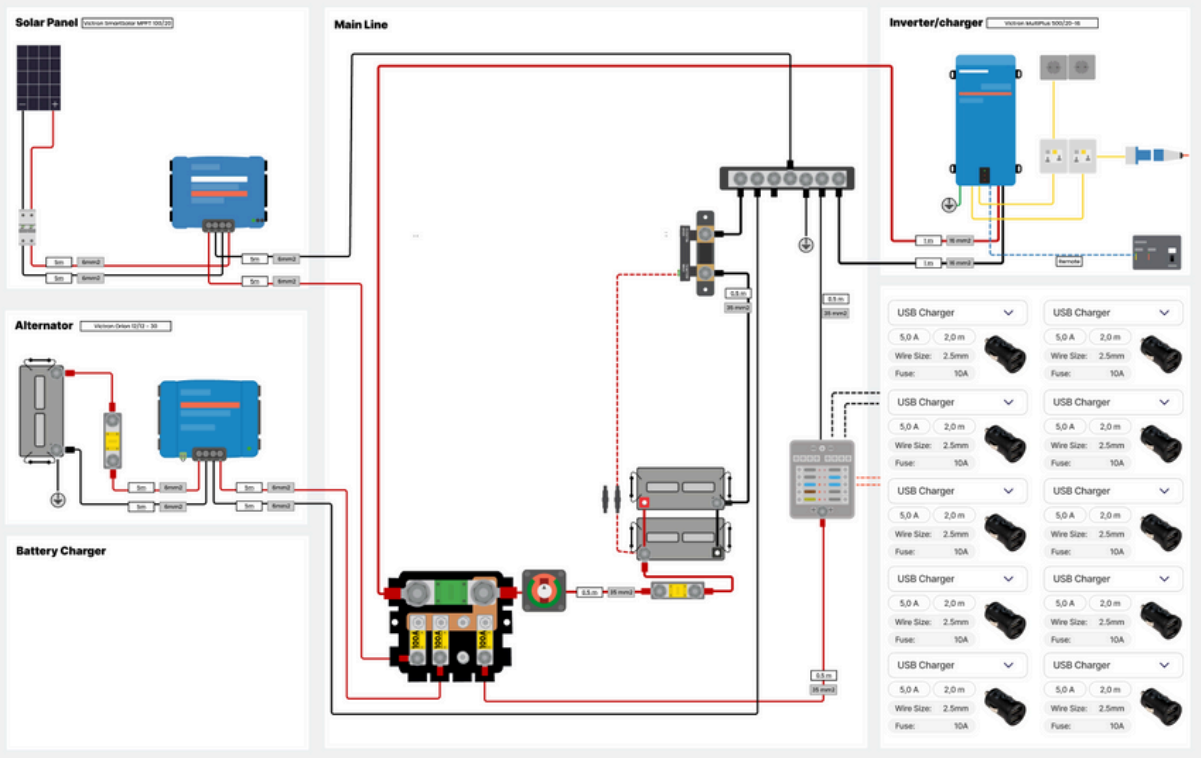
Pieter Janssen
NL • 3 reviews

★★★★★

Incredibly helpful electrical wiring diagram

Made the DIY process a lot less daunting, the wiring diagram was a great help, exactly wat I needed. And he kindly helped me out with the few questions that remained. Right now enjoying the luxury of the off-grid nespresso ;)

Try out our software today!



Our personal Wiring Diagram

Preparations

As we mentioned earlier, the goal of creating an electrical wiring diagram is to clearly and simply visualize how everything in your camper should be connected — and to easily determine the correct wire thicknesses and fuse ratings for each connection.

But before you can start drawing up that schematic, a few important preparations need to be made.

First, you'll need to decide exactly where all your electrical devices will be located inside your camper. The easiest way to figure this out is by asking yourself the following questions:

- Which devices will I install?
- Where in the camper will I install my electrical system?
- What is the maximum power draw (in watts) of each device?
- What is the distance between each device and the battery or distribution point?

Once you've answered these questions, you'll have the key information needed to move on to the next step: **calculating the correct cable sizes.**

Type of cable

In a moving vehicle, **stranded copper wire is always used.** This type of wire is flexible and far more resistant to vibrations than the solid copper wire typically used in homes. **Solid wire**, as the name suggests, consists of a single, rigid copper core and is simply **not suited for mobile applications.**

Never use solid copper wire in your camper. The constant movement and vibrations can eventually cause it to break — and locating a break in a solid wire hidden somewhere in your system is no fun, we promise.

DC wiring (12/24V systems)

For wiring 12V devices and circuits, it's best to use **flexible**, **stranded copper wire** with appropriate insulation. One commonly used option is **2-conductor sheathed cable** (for example, 2 x 2.5 mm² or 2 x 14 AWG), which includes an outer plastic jacket to protect and hold the two inner wires together.

Typical color codes for 12V DC wiring:

- Brown or Red – positive wire (+)
- Blue or Black – negative wire (–)

You can also use speaker cable with a stranded copper core. These often come in red and black, which makes polarity easier to identify.

Important: Try to avoid CCA wire (Copper-Clad Aluminum). It has significantly higher resistance and poorer conductivity than 100% copper wire. Always opt for pure stranded copper, especially in automotive and camper applications.

For high-current components like inverters, DC-DC chargers, or solar charge controllers, use battery cable or welding cable. These cables are available in thicker gauges (from 6 mm² / ~10 AWG to 95 mm² / ~3/0 AWG), and typically come in red (positive) and black (negative).

I**f you're using our software program, it will tell you exactly how many meters/feet of each cable size you'll need for your setup.**

Stranded copper wire

★★★★★

More information at:

Amazon.com

AC wiring (120/230V systems)

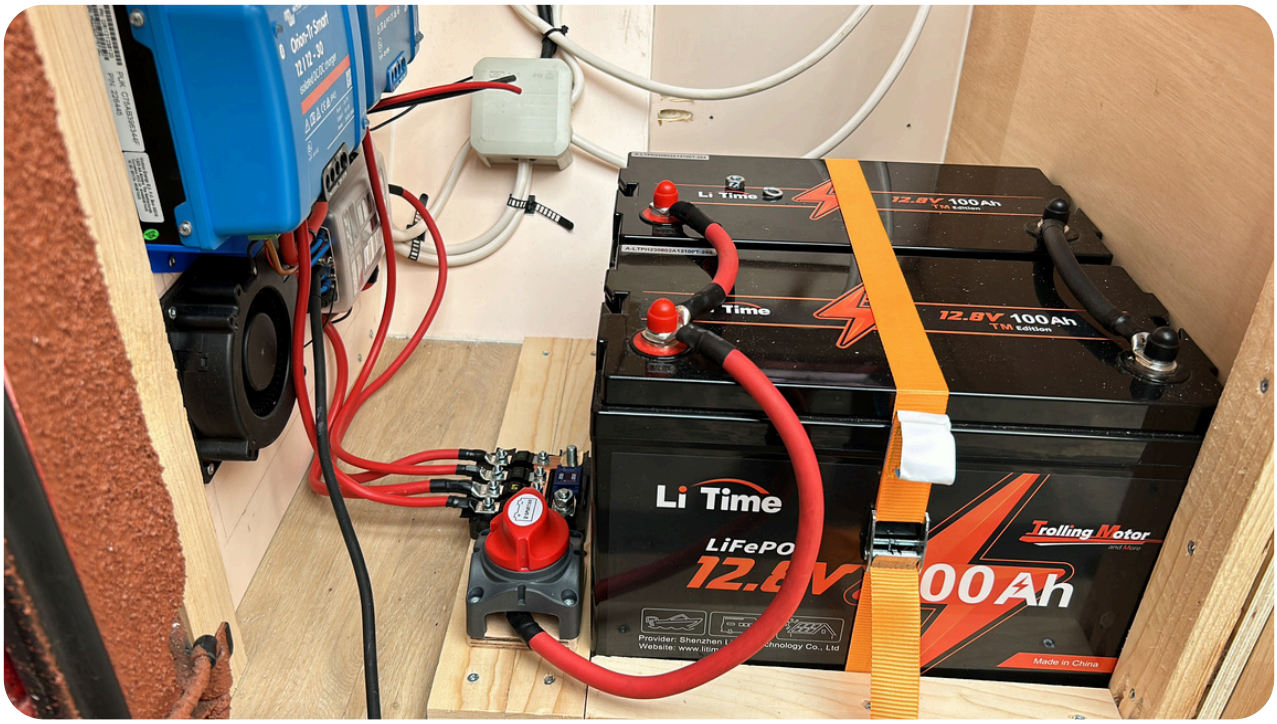
For your shore power (mains AC) system — whether you're using 230V in Europe or 120V in North America — it's standard to use **3-conductor sheathed cable** with a cross-section of 2.5 mm² (Europe) or 10 AWG (North America). Choose cable types with an extra protective outer layer, such as H07RN-F, SJTW, or PUR cable, depending on local standards.

Typical color codes for AC wiring:

- Brown (EU) / Black (US) – live wire (L)
- Blue (EU) / White (US) – neutral wire (N)
- Green/yellow (EU) / Green or bare (US) – ground wire (PE or earth)

These cables are used to power 230V or 120V sockets, appliances, and shore power inlets safely. Always follow regional electrical standards and safety regulations when installing AC wiring in your camper.

Tip: Always order at least 10% more cable than your calculated needs. Even the most experienced builders make mistakes from time to time — and when that happens, it's great to have some extra cable on hand to avoid delays or messy workarounds.



Our electrical set-up (not finished (second van build))

Protecting your cables

To keep your cables safe from wear, heat, and movement, it's best to run them through a corrugated conduit. We recommend using the **black** version, it's more flexible and far less likely to stiffen or crack in colder temperatures.

Cable size

Campervans require thicker electrical cables than typical household wiring — and here's why: Camper systems operate at lower voltages (12V or 24V) compared to homes (typically 230V or 120V). To deliver the same amount of power at a lower voltage, more current must flow through the cables. Thicker cables are essential to carry this higher current safely without overheating.

While cable runs in a camper are usually shorter than in a house, thicker cables also help reduce voltage drop — making your system more efficient and ensuring your devices get the power they need.

That's why choosing the correct cable gauge is so important in any camper electrical setup. Luckily, you can calculate the ideal cable size yourself — we'll show you how.

To calculate the correct cable size, you need two key pieces of information:

- The maximum power consumption (in **Watts**) of each device
- The **cable length**, meaning the distance between the device and either the fuse distribution block or the house battery

The maximum power of each device

You can usually find the maximum power rating of a device in its manual, on a label directly on the product, or by searching online. To calculate the correct cable size, we need to convert the power (in Watts) into current (in Amps).

This is done using the following formula:
Watts ÷ Volts = Amps

Distance device to busbar/leisure battery

Every electrical device is connected using two wires: a positive and a negative one. When calculating cable length, you always add both lengths together.

Let's look at an example:
If your inverter is placed 50 cm away from your house battery, the total cable length for the calculation is 100 cm — 50 cm for the positive wire and 50 cm for the negative one.

Once you know the current draw (Amps) and the cable length, you have two options: You can either calculate the wire gauge and fuse size manually, or let our **software** tool do the work for you.

Designing a full campervan electrical system — including proper wire gauges and fuse ratings — can be complex and time-consuming, especially if you're not an expert.

That's why we created **our software tool**, which includes a built-in calculator that automatically determines the correct wire sizes and fuses based on your setup.
It also generates a clear wiring diagram of your system, giving you a complete parts list and making installation much easier.

Calculating the cable size manually

Victron has developed a helpful reference table to determine the correct wire gauge for your setup. This table shows you which wire diameter is suitable based on the current (in Amps) and the total length of the positive and negative wires between your electrical device and your power source.

Note: Always consult the user manual of your device first for the recommended wire size. If the manual doesn't specify it, this method is a good guideline.

Cable diameter (mm)	Cable cross-section (mm^2)	Maximum current (A) for a total cable length up to 5 meters	Maximum current (A) for a total cable length up to 10 meters	Maximum current (A) for a total cable length up to 15 meters	Maximum current (A) for a total cable length up to 20 meters
0.98	0.75	2.3	1.1	0.8	0.6
1.38	1.5	4.5	2.3	1.5	1.1
1.78	2.5	7.5	3.8	2.5	1.9
2.26	4	12	6	4	3
2.76	6	18	9	6	5
3.57	10	30	15	10	8
4.51	16	48	24	16	12
5.64	25	75	38	25	19
6.68	35	105	53	35	26
7.98	50	150	75	50	38
9.44	70	210	105	70	53
11.00	95	285	143	95	71
12.36	120	360	180	120	90

Let's walk through an example:

You have a device that draws a maximum of 40 Amps, and it's installed 2 meters (6.5 feet) away from your battery. Since current flows through both a positive and negative cable, your total cable length is 4 meters (13 feet).

Now go to the column in the Victron chart titled "Maximum current for a total cable length up to 5 meters". Look up your required current—in this case, **40 Amps**. Then, round up to the nearest value in the table, which would be 48 Amps.

According to the chart, for 48 Amps over a 5-meter cable length, you'll need a wire size of **16 mm^2** (which is roughly equivalent to **5 AWG** in the U.S.). This is commonly referred to as a "16-square" cable in Europe.

Tip:
Your system must always meet the minimum cable size to avoid overheating and fire hazards. However, there's generally no issue with using a larger cable than required. For example, if your calculation says you need 0.75 mm^2 wire (about 18 AWG), but you have a leftover piece of 2.5 mm^2 (about 14 AWG) wire—that's perfectly fine to use and can even reduce voltage drop. Plus, it saves you money and waste.

Fuses

Aside from cables, there's another essential component you need to include in your electrical system: fuses. Fuses are designed to protect your wiring and devices from short circuits, overloads, and fire hazards. If something goes wrong and too much current flows through a wire, the fuse will "blow" (i.e., it burns out and breaks the circuit).

Now, blowing a fuse might sound like a hassle—but in reality, that's exactly what you want to happen in the event of a short circuit. Without a fuse, excessive current would continue to flow through your wire unchecked, overheating the cable and eventually causing it to catch fire.

Think of the fuse as your first line of defense. It breaks the circuit before the wires can overheat and ignite. Without it, the current might stay high for too long—melting the insulation, burning the wire, and potentially setting your camper on fire. Not ideal.

So, as you can see: **installing the right fuses is critical** for any safe and reliable camper electrical system. Always fuse your circuits properly to prevent serious damage—or worse.

Choosing the right fuse size

To determine the correct fuse size—and the appropriate wire gauge—**you need to know the maximum current** that will run through the wire. Let's walk through a detailed example together.

Note: Always check the product manual for fuse size recommendations first. If the manual doesn't specify this, you can use the method outlined below.

Let's use the same example we used earlier when calculating wire thickness: a device with a peak current draw of **40 amps**. Previously, we determined that this device requires **4 meters** (13 feet) of cable with a wire gauge of **16 mm²** (roughly AWG 5) to handle the load safely. We'll use these numbers to choose the right fuse.

To do this, we again refer to Victron's cable size table, which shows the maximum current capacity for different cable sizes over various distances. According to the table, 16 mm² wire can handle up to 48 amps over 5 meters (both directions combined). To protect the cable, your fuse must never exceed this maximum.

If you were to install a **50A** or **60A** fuse, the fuse might not blow fast enough in case of a short circuit—and the wire could overheat and burn before the fuse reacts.

That's exactly what we want to avoid.

So how do you choose the right fuse? Use this general rule:
Fuse Size = Peak Current x 1.2

For a 40A device:
40A x 1.2 = 48A

However, **48A fuses don't exist**—you'd likely round up to a standard **50A** fuse. But here's the issue: a 50A fuse exceeds the safe capacity of your 16 mm² cable (which is only rated for 48A). This is where an earlier tip comes in handy: it's perfectly fine to upgrade your cable size.

So in this case, to safely use a 50A fuse, you need to upgrade your wire from 16 mm² to 25 mm² (roughly AWG 3).

Final conclusion from this example:
For a device with a peak load of 40A located 2 meters (6.5 feet) from the battery, use a 25 mm² (AWG 3) cable and a 50A fuse.

As you can see, figuring out the right wire gauge and fuse size for every part of your system can get complex. It takes time, care, and a solid understanding of electrical safety. That's exactly why we created our **Software tool** that automatically calculates your wire sizes and fuses for you, giving you a clear wiring plan and shopping list.

Fuse size for your ac system

Selecting the right fuse size for your AC (Alternating Current) system is different from your DC system. Fuse ratings for AC circuits depend on the total power (Wattage) drawn by all devices that may be running at the same time.

Here are some general guidelines based on standard household voltages:

- In 230V systems (common in Europe):
- – A 10A fuse allows up to 2300W of simultaneous load (10A × 230V)
- – A 16A fuse allows up to 3680W of simultaneous load (16A × 230V)

In 120V systems (common in North America):

- – A 15A fuse allows up to 1800W of load (15A × 120V)
- – A 20A fuse allows up to 2400W of load (20A × 120V)

⚠️ Important: These values are based on purely resistive loads (like heaters, lights, or kettles). Inductive loads, such as refrigerators, fans or AC units, often require higher current at startup. Always leave enough headroom to prevent nuisance tripping or overheating.

If you're unsure which fuse size is appropriate for your system, please consult a local certified installer or electrician. This ensures safety, efficiency, and compliance with local electrical codes.

Fuse placement

Now that you know which fuse to use, the next question is:
Where exactly should you install the fuse?

The answer is simple:
As close to the power source as possible.

In a camper electrical system, the power source is usually your house battery. So, install the fuse directly on to your battery (with an MRBF fuse - more on that later-) or the busbar/distribution block that is connected to it.

Why does this matter?
If there's a short circuit somewhere in your wiring, the fuse needs to cut the power immediately to prevent damage or fire. But if the fuse is too far away, part of the wire between the battery and the fuse is left unprotected. That wire can overheat very quickly.

This is why the fuse should be placed as close as possible to where the power begins —at the battery. That way, the entire cable is protected from the very start.

A good rule to remember:
A fuse belongs at the start of the cable, not halfway or at the end.

If you are unsure which fuse to use or where exactly to place it, always consult a qualified local installer or professional. When it comes to electrical systems, safety comes first.

Different kind of fuses

Fuses are essential for protecting your electrical system, but they need to be installed in the right place — and attached to the right components. This means you'll need solid, reliable hardware to hold and connect them. Two common and practical solutions used in camper electrical systems are fuse holders and modular distribution blocks. Below, we'll explain two popular options that we also integrate into our software: the **midi/mega fuse holder** and the **Victron Lynx Distributor.**

MIDI/MEGA Fuse Holder
The midi/mega fuse holder is a compact and convenient way to install fuses in your campervan. It combines one MEGA fuse slot and four MIDI fuse slots in a single unit. This makes it ideal for organizing your power system — especially for connecting your main positive cables. The MEGA fuse slot is often used for large power consumers like inverters, while the four MIDI slots are perfect for medium-sized loads such as DC-DC chargers or MPPT solar charge controllers. The holder also helps to keep your installation neat, and allows for safe and easy access if a fuse ever needs replacing.

Midi/Mega Fuse Holder

More information at:

Amazon.com

Victron Lynx Distributor
The Victron Lynx Distributor is a more advanced and modular solution for distributing DC power in your system. It provides a central connection point for multiple DC circuits and includes built-in fuse monitoring. Each output is fused and the system shows you if a fuse has blown — either via LEDs or through Victron's GX devices. This is especially useful in larger or more complex setups, where you want both safety and detailed monitoring. The Lynx Distributor is designed to work seamlessly with other Victron components and is ideal for high-end camper or off-grid systems.

Victron Lynx Distributor

More information at:

Amazon.com

MRBF Fuse (Marine Rated Battery Fuse)
The MRBF fuse is compact, highly reliable, and mounts directly to a battery post or busbar. We use this type by default in our software tool because it can safely interrupt very high short-circuit currents—especially important when working with lithium batteries, which can discharge very high currents very suddenly. MRBF fuses are available up to **350 amps**, which covers most camper setups using lithium or AGM batteries. They're ideal for protecting the main feed from your house battery to your distribution system. **Make sure to use Bluesea or Bussmann and do buy cheap knockoffs.**

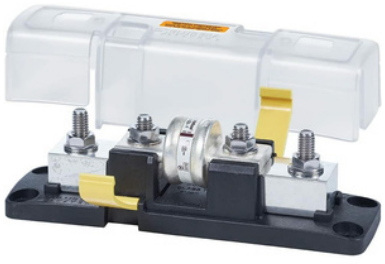
MRBF Fuse

★★★★★

More information at:

Amazon.com

T-Class Fuse
If your system requires more than 350 amps of protection, the T-Class fuse is the next step up. It's physically larger and can handle even higher continuous and short-circuit currents. This makes it suitable for advanced or high-power setups, such as large inverters or combined inverter/charger units drawing very high currents. Because of its industrial-level capacity and slow-blow characteristics, the T-Class is commonly used in marine and RV systems with high-demand components.



T-Class Fuse

★★★★★

More information at:

Amazon.com

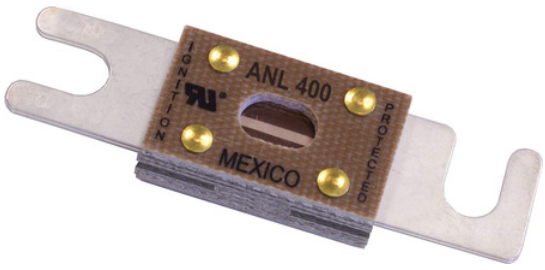
MEGA Fuse
The MEGA fuse is one of the most widely used heavy-duty fuses in camper systems. It's designed to protect high-current circuits and is commonly installed between the inverter, DC-DC charger, or solar charge controller and the busbar or battery. Available in ratings from 40A up to 500A, MEGA fuses are a solid choice when you need robust overcurrent protection but don't need the compactness of MRBF or the higher limits of T-Class.

Mega Fuse

More information at:

Amazon.com

ANL Fuse
The ANL fuse is a heavy-duty fuse also often used in RV and marine setups. It's suitable for high-current applications like inverters, battery links, or large DC chargers. ANL fuses cover a wide range (typically 35A–750A) and can handle brief power surges better than MEGA fuses. While they offer great flexibility, ANL fuses are bulkier and need more space. Compared to MEGA fuses, they're better for higher currents, but less ideal if space is limited.



ANL Fuse

More information at:

Amazon.com

MIDI Fuse
MIDI fuses are smaller than MEGA fuses but still capable of handling significant loads —typically up to 200A (we recommend a maximum of 120A). They are used for medium-sized components such as DC-DC chargers, MPPT solar controllers or battery chargers. Their compact size makes them ideal when space is limited, and they offer reliable protection for circuits that are too powerful for mini fuses but don't require a MEGA fuse.

Midi Fuse

More information at:

Amazon.com

Automatic Reset Breakers
Although automatic circuit breakers are sometimes found online and appear attractive, they can be unreliable and are usually more expensive than traditional fuses. We generally **don't recommend** using these in critical circuits, especially where reliability and long-term safety are a priority. **If you want to use them, for whatever reason. Use Bluesea breakers.**

Automatic Reset Breakers

More information at:

Amazon.com

Blade Fuse Holder
A blade fuse holder, also called a blade fuse block, is used to connect and protect low-current 12V circuits like USB ports, LED lights, and small fans. It provides a central place to install multiple mini blade fuses, keeping your setup organized and easy to maintain. Many blade fuse holders include labels for each circuit and sometimes built-in LED indicators that light up when a fuse blows—making troubleshooting quick and simple.

Blade Fuse Holder

More information at:

Amazon.com

Now that you know which fuses to use, here's a quick recap. For the **main fuse**—the one between your battery and the busbar—we recommend using an **MRBF** or **T-Class fuse** when working with lithium batteries, as most other types are not rated to safely handle the higher fault currents lithium systems can produce.

If you're using a **lead-acid battery,** a **MEGA** or **ANL fuse** is generally sufficient for this main connection.

Finally, always aim to use **high-quality components** from trusted brands like **Victron, Hella, Blue Sea Systems, or Bussmann.** While these may cost more upfront, they offer better safety, longer lifespan, and fewer problems down the road.

AC circuit protection (technical but essential)

In a campervan, using 230V electricity requires extra attention to safety. That's because you'll typically be switching between two types of systems: one when you're connected to shore power, and one when you're off-grid using your inverter. These systems—**called TN** and **IT systems**—have different electrical grounding methods and require different protection strategies. In this chapter, we'll break it down in a simple and accessible way, suitable for both Europe and North America.

Shore Power (TN System – Like at Home)
When connected to a regular outlet at a campsite or house, **you're using a TN system**. In this setup, the **neutral wire is bonded to ground**, just like in household installations. This allows the use of standard protection devices like RCDs (Residual Current Devices), also called GFCIs in North America. These devices measure the current going in and out of the circuit and disconnect power if any leakage is detected, preventing electric shock.

In this setup, you are protected both inside and outside the camper—assuming the external power source is correctly installed and grounded. Many campsites in Europe have proper RCD protection built into their power pedestals. Still, it's a good idea to install your own RCD or RCBO (a combined breaker and RCD) inside the camper, especially if you plan to travel internationally or use less regulated power sources.

Off-Grid Power (IT System – Floating Neutral)
When **you're not connected to shore power** and instead rely on your inverter, your camper operates in an IT system, also known as a **floating system**. In this case, the neutral wire is not connected to earth, which means **a standard RCD will not work** correctly. That's because RCDs rely on a reference to ground to detect faults, and in a floating system, there is no such reference.

Some inverters, like the **Victron MultiPlus**, create an **internal connection between neutral and ground**. This makes it possible for an **RCD to work**, but only **within the camper's internal wiring**. Any 230V outlet used **outside the camper would remain unprotected.**

Cheaper inverter chargers (Renogy) do not have an internal neutral ground connection, so an RCD does not work.

Using 230V Outside the Camper While Off-Grid
To use 230V safely outside the camper in an off-grid setup, you need to install an **Insulation Monitoring Device (IMD).** This device continuously checks the insulation between live conductors and ground. If it detects a current leakage—meaning that electricity is escaping the intended circuit—it will immediately disconnect the power supply.

IMDs are a legal requirement in some countries for IT systems, especially when power is made accessible to users outside of protected enclosures. They provide early fault detection and add a critical layer of safety. If you install an IMD, you must also disable the automatic ground relay in inverters like the MultiPlus. This is done using Victron's VEConfigure3 software and an MK3-USB interface.

Protective Devices for 230V Systems
For any AC setup in your camper, a combination of protective devices is needed to ensure safety:

- **Miniature Circuit Breakers (MCBs)** protect against overloads and short circuits. Common sizes are 6 A, 10 A, and 16 A.
- **RCDs (Type A)** detect leakage currents and protect against electric shock. These are suitable for most camper systems.
- **RCBOs** combine both overload and leakage protection into one unit.
- **Type B RCDs** are required when using inverters, chargers, or other equipment that may generate DC leakage.

Typical current ratings and corresponding power limits:

- 6 A = 1380 W
- 10 A = 2300 W
- 16 A = 3680 W

Personal Setup Example
In our own camper, we use an Insulation Monitoring Device (IMD) to ensure safe use of 230 V power outside the vehicle when off-grid. This is especially important when loaning the camper to others, as it protects against electric faults even without a shore connection. We've chosen not to install an RCD or RCBO after the inverter, since the IMD handles fault detection and disconnection in a floating system. We also don't use a separate RCD on the shore power side, because most European campsites already have proper protection. Plus we rarely use shore power. However, if you're planning to travel in regions where shore power is less reliable, installing a dedicated RCD between the shore plug and your inverter is a smart safety upgrade.

Summary and Safety Guidelines
If you only use 230V inside your camper, installing a standard RCD or RCBO will be sufficient. If you also want to use 230V outside the vehicle while off-grid, you should install an Insulation Monitoring Device. Always verify that your inverter's ground settings match your setup, and disable any automatic bonding if needed.

Before finalizing your electrical system, it's essential to follow local regulations and safety guidelines. In the UK, for example, all vehicle installations must follow BS 7671 standards. In the EU, harmonized IEC standards apply. In North America, refer to the National Electrical Code (NEC) and ensure your setup complies with UL or CSA standards.

If you're ever unsure, consult a qualified local electrician or professional campervan installer. Electricity is safe—when done right.

Drawing your wiring diagram

Now that you understand what needs to be included in your camper's electrical system, you're probably eager to get started on your own wiring diagram. While no two campers are the same — and every system is unique — we can still give you some helpful guidance before you dive in.

We can't draw your exact system for you step by step, but we can help you make smart choices and avoid common mistakes.

What can I use to create my electrical diagram?
You can design your electrical layout on paper, using tools like Canva, or with (surprise surprise) our **software program** designed specifically for camper electrical systems.

What do I need to use your software?
Our software runs directly in your web browser, so there's no need to install any programs. To use it, you simply need a computer or laptop with an internet connection. It does work on smartphones and tablets, but it's not optimised for it, best use an pc or laptop..

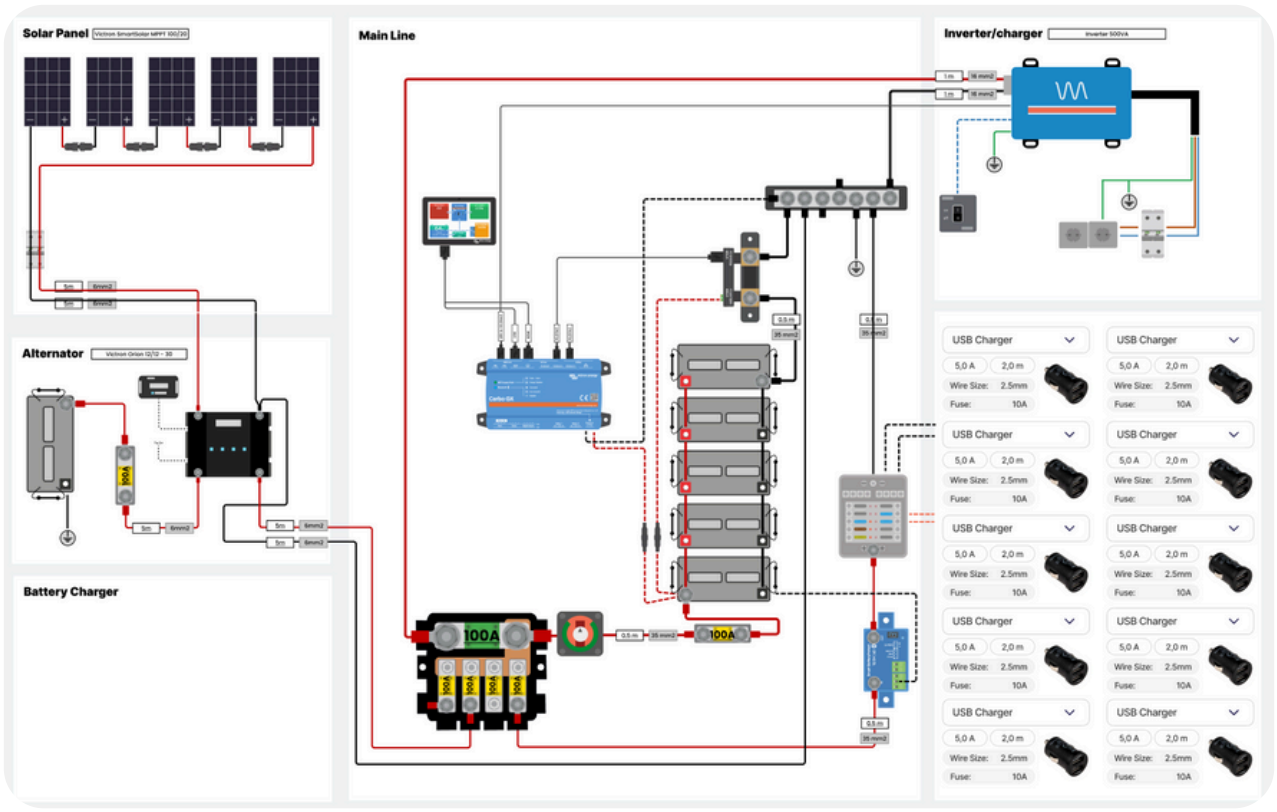
How long can I use your software?
When you purchase a license, you get 365 days of full access to the software. After that period, you can renew annually if you'd like to keep using it or create a new project.

What are the benefits of using your software?
One of the main advantages is the built-in smart calculator. It automatically calculates wire sizes, fuse ratings, and recommends suitable components based on your setup.

You'll also receive a **detailed component list and a clean, organised wiring diagram** tailored to your specific build. This makes designing and installing your camper electrical system much easier — even if you're not an expert.

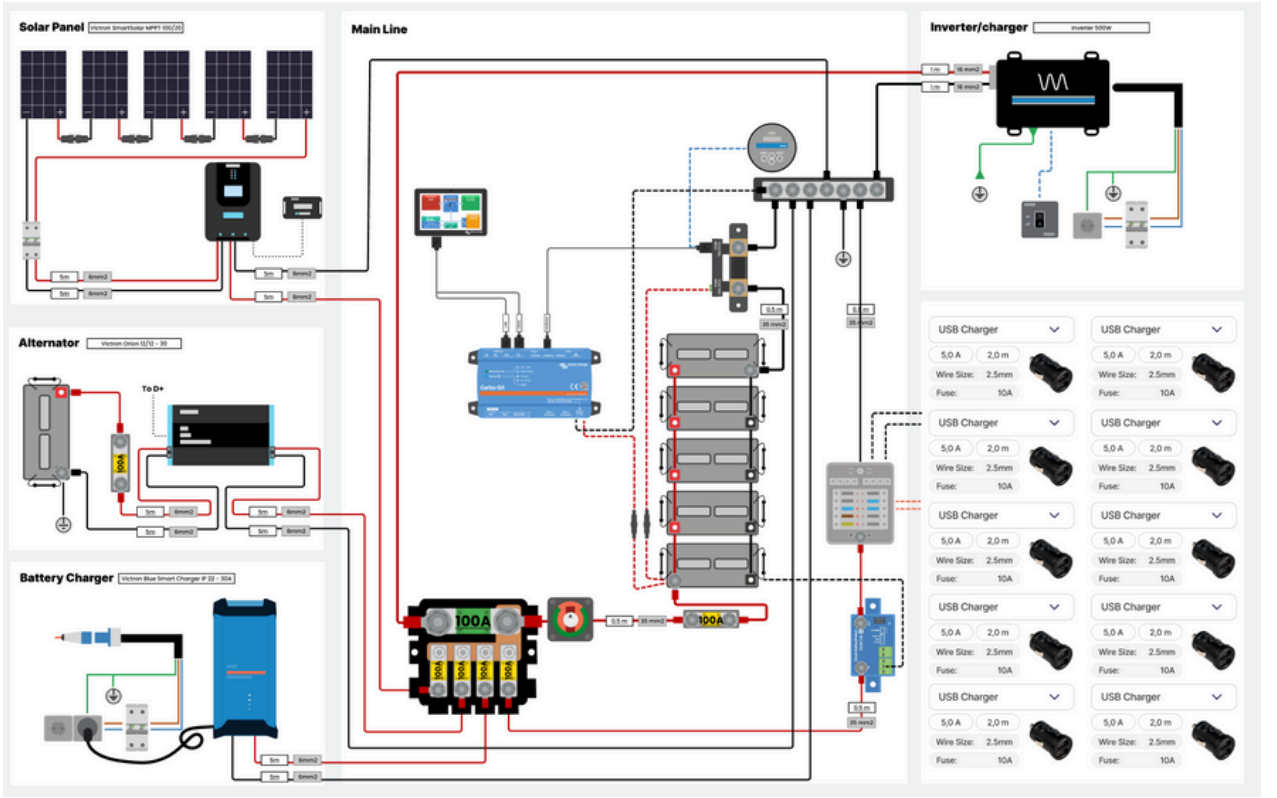
Where can I find the software?
You can access our program directly through our website: **www.gridless-solutions.com** or press the button below

Try out our software today!



Beta set-up with a Renogy 50A DC-DC/MPPT Charger

Try out our software today!



Beta set-up with a Renogy DC-DC Charger and MPPT

Connecting your System

Now that you've covered the theory, it's time to roll up your sleeves and get to work on the practical side—the actual **installation** of your camper's electrical system. Feeling excited already? Great! There's a lot to do, but with a solid plan, it becomes a smooth process.

Before you start connecting wires or mounting components, there are a few **important preparation** steps to take. Good preparation is more than half the work—and when it comes to electricity, it's also essential for a safe and reliable setup.

Decide on kay electrical features

Before insulating your camper, it's smart to plan where certain electrical components will go—especially those that require holes in the bodywork. Consider whether you want to install any of the following:

- Shore power inlet
- Rear-view camera
- Roof fan

If so, determine their locations early and **cut the necessary holes** before adding insulation and wall panels. Make sure the cutouts are the correct size to avoid water ingress or poor fitting later.

Placing the house/leisure battery

After planning the above, the next step is to choose a suitable location for your house (leisure) battery. Not sure where to put it? A common and convenient spot is **next to one of the rear wheel wells**. There's usually enough space here, and it helps balance the weight of the battery in the van.

Running your cables

Once the battery position is set, you can **begin running cables** to the areas where you plan to install electrical devices. These cables will deliver power to your lights, chargers, appliances, etc.

We recommend using **cable conduits or protective sleeves**, especially for cables that run behind walls or under flooring. These help protect the wires from dust, moisture, and mechanical damage. Be sure to secure the conduits properly with clips or fasteners.

There are different opinions on the **best timing** to run your cables. Some people do it before insulation and wall paneling, while others prefer to wait until the structure is fully built. Each approach has pros and cons. Choose the method that best fits your workflow—and don't hesitate to ask for help if you're unsure.

Tools you'll need

To install the electrical system yourself, you'll need the right tools. It's not a long list, but each item is essential for doing the job safely and properly. Here's what we recommend:

- (Hydraulic) Cable Crimping Tool (4–70 mm²)
  - For crimping large lugs on your battery and inverter cables.
- Cable Crimping Tool (0.5–6 mm²)
  - Used for smaller wires and terminals.
- Cable Shears
  - For cleanly cutting thick battery cables to length.
- Wire Stripper
  - To remove insulation from copper wires without damaging the strands.

(Hydraulic) Cable Crimping Tool (4–70 mm²)

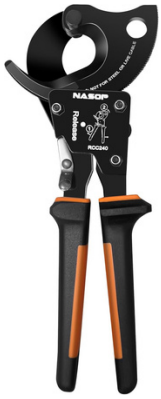
More information at:

Amazon.com

Wire Crimping Tool (0.5–6 mm²)

More information at:

Amazon.com



Cable cutter

More information at:

Amazon.com

Wire Strippers

More information at:

Amazon.com

Got all the tools and materials on your checklist? Great—then it's finally time to get started on the real deal: installing your camper's electrical system.

So, put on your work gloves and get ready—because you're about to bring your power setup to life, step by step. Let's make this a project you'll be proud of.
Are you ready? Let's go!

Installing your system: step by step

This is it—the moment you've been working toward! After all the reading, planning, and prep, you're ready to tackle the part most people look forward to: **wiring your camper's electrical system.**

You've gathered your tools, decided which components you want, and created your electrical layout. In short, everything is in place to get started.

If you have little or no experience working with electrical systems, we understand this can feel a bit overwhelming. In that case, **we strongly recommend** working alongside someone with experience—or at least having a professional supervise your work. Don't know anyone with expertise? It's always a good idea to hire a certified electrician or qualified installer.

Still with us? **Great—then it's time to begin!**
Please read through the following steps carefully—ideally two or three times—before you start the actual installation. Being well-prepared is key.

Note: Electrical work can be complex, and doing it wrong can have serious consequences. Always prioritize safety. If you're unsure at any point, stop and consult an expert.

Blade fuse holder: before you start

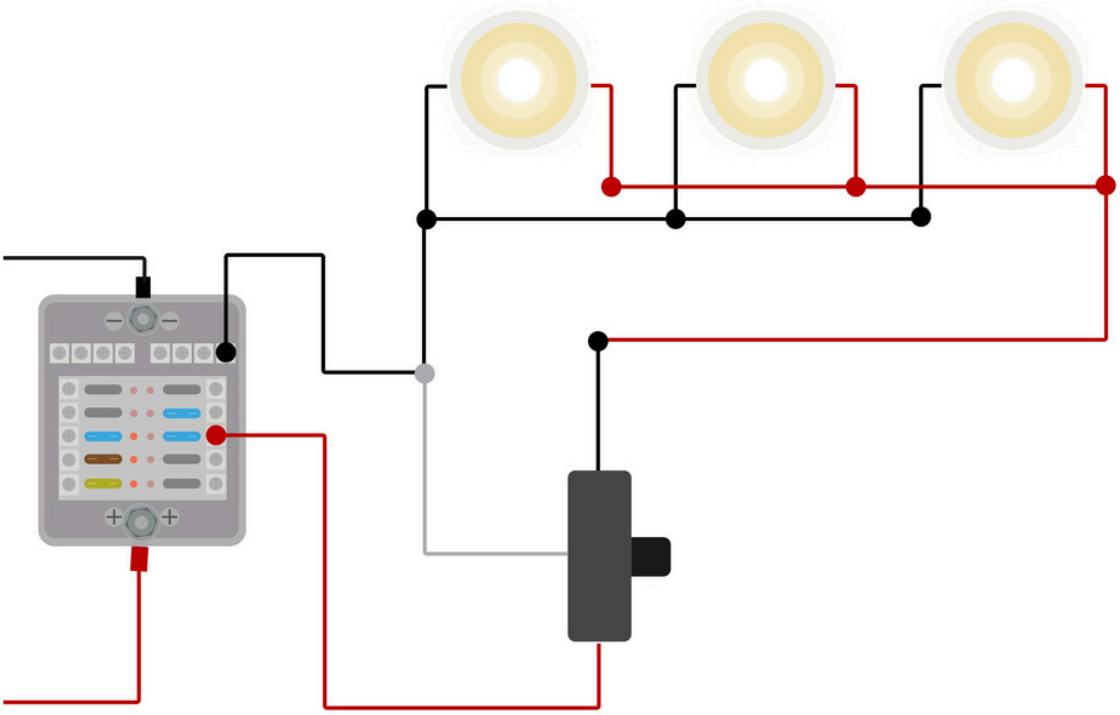
Before jumping into the full step-by-step wiring plan, let's take a moment to focus on something essential: **the blade fuse holder.**

When designing your camper, you probably already planned out which 12V devices you want to install—such as lights, USB chargers, a fridge, or a diesel heater. Now that it's time to actually connect these devices, it's important to know how to do it safely and efficiently.

Fortunately, the basic setup is quite straightforward. In most cases, it's just a matter of connecting the **positive** and **negative** wires to the correct terminals. But there are a few practical details to keep in mind.

One thing we want to highlight is the setup for LED lighting, especially if you're adding a dimmer. In this case, your LED lights should be wired in parallel. That means you bring all the positive wires together at one connection point, and all the negative wires together at another. This ensures that each light receives the same voltage and functions properly with the dimmer.

Wiring in parallel is the most common and reliable method for 12V lighting in camper setups, and it's the method we recommend for consistent performance.



From that **junction point,** you'll run a single cable to the dimmer. The dimmer then connects to the **blade fuse holder**. This setup keeps your wiring clean and ensures proper control over your LED lights. Above is an illustration showing how this looks in practice. (*We use Wago connectors to connect multiple wires together.)*

As for your other 12V devices, the wiring is usually much simpler. Like we mentioned earlier, you just need to connect the positive and negative wires to the correct terminals. That means:

- All negative wires should be routed to the negative busbar or terminal.
- All positive wires should go to the fuse holder, each with its own fuse.

12V Dimmer

More information at:

Amazon.com

Dimmer used in example diagram (and we use in our own campervan)

Step by step installation guide

1. Mount Your Battery

Start by securely installing your house/leisure battery in its final position. A common spot is near one of the wheel arches, where there's usually enough space and minimal cable distance to key components.

2. Install Busbars and Fuse Holders

Place the positive and negative busbars (or fuse blocks) close to the battery. **Keep the positive and negative cable lengths equal** to maintain balanced electrical performance. Use proper fuse holders—typically a MIDI/MEGA holder on the positive busbar or a Lynx Distributor.

3. Position Your Electrical Components

Install all major components in their planned locations: MPPT solar charge controller, DC-DC charger, inverter, 12 V fuse block, Victron MultiPlus (if applicable), or any other electrical devices. Good layout planning improves both performance and future maintenance.

4. Connect the MPPT Solar Charger

Begin wiring with the MPPT controller. First, connect the cables from the controller to the busbars using appropriately sized cables and fuses. Only after this connection is complete should you connect the solar panels.

⚠️ **Important**: Solar panels generate voltage as soon as they're exposed to light. Cover the panels or delay this step to avoid unexpected current.

5. Measure and Prepare Your Cables

Use the correct wire gauge based on distance and current. Measure the length from each component to the busbar. To keep your installation neat and protected, use cable ducts or flexible conduit.

6. Cut and Terminate Cables

Once lengths are measured:

- Cut the cable to size
- Strip the ends
- Crimp ring terminals
- Finish with heat shrink tubing for insulation

Then connect each cable to its respective terminal or busbar.

7. Wire the 230 V Circuit (If Applicable)

Install your AC cabling and devices like the RCD, RCBO, or isolation monitor. This should be done carefully and only after completing the DC installation. Always keep the main switch turned off during this process.

8. Ensure Clean, Direct Connections

Make sure that all terminals on the busbars are clean and secure. Do not place insulation (like heat shrink) between the terminal and the busbar, as this can cause poor contact and heat buildup.

9. Add Your Main Fuse Block

Install the MIDI/MEGA fuse holder on the main positive cable between the battery and the main switch. Add the correct fuse rating here. Once secured, connect the other end of the fuse holder to the first terminal of your main disconnect switch.

10. Connect the Main Switch to Battery

Connect the output side of the main switch to a high-amperage fuse (e.g., MEGA fuse) and then to the positive terminal of the house battery. If you use an MRBF fuse, first connect the MRFB Fuse on your battery terminal, then connect the wire to the fus. **Ensure the switch is still off during this step.**

11. Set Up the Negative Connection

If using a battery monitor (like Victron SmartShunt or BMV):

- Place it between the negative busbar and the battery's negative terminal.
- If not using one:
- Connect the negative busbar directly to the battery's negative post.

12. Power-Up Procedure

If you're working with a large inverter (2000 W or more), it's important to safely pre-charge the internal capacitors before powering up the system. These capacitors can draw a massive inrush current when suddenly connected to a battery, potentially damaging components or blowing fuses. Here are several safe ways to pre-charge the capacitors—whether you're off-grid or using shore power:

1. Using Shore Power (If Available)

If you're using a shore power charger like a Victron MultiPlus, connect the vehicle to a 230 V power source while keeping the main switch off. This allows the internal capacitors to safely fill via the AC input. Wait around two minutes, then unplug the mains cable and turn on the main switch. This is the simplest and safest option if shore power is available.

2. Through the Solar Charge Controller

If your MPPT charge controller is connected and there's enough sunlight, it will begin charging the battery as soon as it's exposed to light. This indirect power path allows the capacitors in the inverter to fill gradually.
Important: Only turn on the inverter after 1–2 minutes, once the initial current spike has settled.

3. Via a DC-DC Charger from the Alternator
Another option is to start your vehicle's engine. If a DC-DC charger is installed, it will activate and start charging the system. Just like with solar, this slow build-up of voltage provides a safe way for the inverter's capacitors to charge.
Make sure your inverter remains off during this process.

4. Using a Pre-Charge Resistor (Advanced)
In more advanced or custom setups, you can temporarily use a resistor to safely pre-charge the inverter. A resistor of 100 Ω, 10 W placed between the inverter's positive input and the battery limits the current flow and allows the capacitors to charge slowly. After about 10–30 seconds, remove the resistor and make the full positive connection.

⚠️ **This method should only be used if you're technically confident. Always double-check polarity and ensure the main switch is off before starting.**

If you have done one of these things you can go and turn the main switch on.

13. Configure Your Devices

After powering up, configure your devices based on your battery type:

- AGM batteries typically work out-of-the-box with Victron gear.
- For lithium batteries, **update the charge profiles** via the **VictronConnect** app.
- If you use a MultiPlus, you'll need a **VEConfigure3** tool and **MK3 USB dongle** to make changes. Many suppliers will preconfigure this for you if requested at purchase.

14. Final System Check

Do a complete system check:

- Are all devices powering up correctly?
- Are the voltages as expected?
- Do fuses, switches, and monitors work?

If something isn't working as expected, carefully retrace the steps. Still stuck? Always consult a certified professional—especially when working with high-current DC or any AC components.

Thank you

You've Reached the End of This Guide — But Your Camper Electrics Journey Is Just Beginning! If you still have questions or could use some extra support, you can book a one-on-one session with us (a fee applies). We're happy to help you move forward with confidence.

We'd also love to see what you've built! Feel free to tag us on Instagram or send us a photo of your final setup by email — it always makes our day.

And finally, if you enjoyed this book, please consider leaving a review. Your feedback helps others decide whether this guide is right for them on their own camper electrics journey.

Thank you for letting us be a part of your adventure — and good luck with all your future projects and beautiful travels!

Cheers,

Lotte and Gijs (and Noor 🐶)