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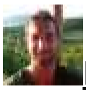
What Are the Different Types of Solar Batteries?



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There are various types of solar batteries. Each of them has pros and cons when it comes to storing your solar energy production. Solar batteries are specially designed for solar systems and are different from your regular car battery. You might then wonder what the different types of solar batteries are.

There are currently 4 types of batteries fitted for solar energy storage:

- **Lead-Acid batteries**
- **Lithium batteries**
- **Red-ox flow batteries**
- **Hydrogen batteries**

In this article, we will review each type of battery and its technological variations.

First, we will list the qualities we could expect from a good solar battery.

Then, we will describe the different types of solar batteries. After that, we will outline their advantages and disadvantages in a short guide for you to pick the best solar battery type.

Finally, we will talk about their prices.

Why Do We Need Good Solar Batteries?

Our sun provides huge quantities of energy to the surface of the earth. We estimate that in one hour of sunlight, our planet receives more energy than what the world is consuming in one year.
Calculations show that a solar panel field the size of Texas would be enough to cover 100% of humanity's energy needs for one year.

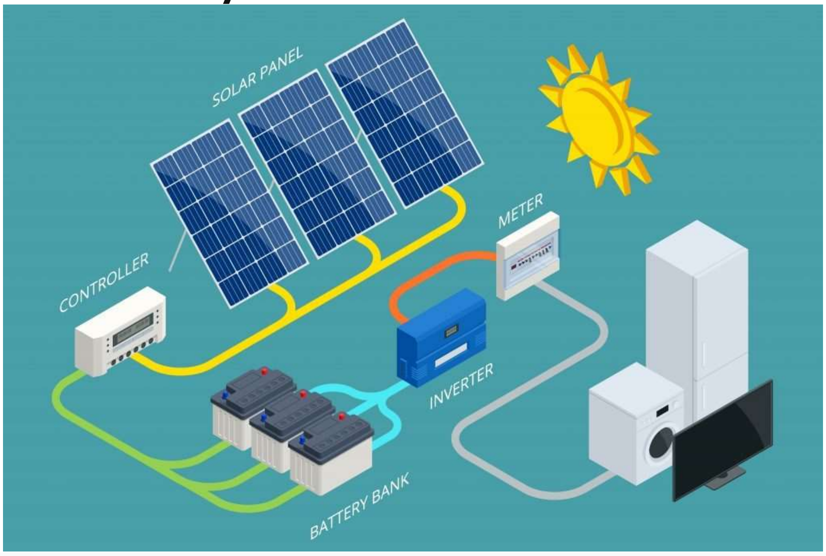
In addition, solar energy is now the cheapest source of electricity in most countries around the world.
Those figures are impressive, and you might wonder why we aren't moving faster to adopt solar energy?

At this stage, only 3% of worldwide electricity is produced with solar panels.
The main reason is that solar energy is intermittent, meaning that our sun doesn't shine the same at all times (weather conditions, seasonal variations), especially at night.

Therefore, solar energy, like most renewable energy sources, must be stored so it can be used on-demand.

Currently, the most versatile way to store solar energy is in a solar battery.
Let's take a look at what makes a good solar battery.

What Is a Good Solar Battery?



Solar batteries are specially designed to be charged by solar energy through a solar charge controller. A good solar battery should be the best combination of the above characteristics:

- **Tolerant to intermittent solar charging**
- **Durable (high number of cycles charge/discharge, long life duration)**
- **Powerful**
- **Accept quick charging/discharging**
- **Safe**
- **Robust**
- **Compact**
- **Lightweight**
- **And ultimately, cheap**

You can see the huge technical challenge that scientists and engineers are tackling to bring the best product to the market.

Now, let's have a closer look at the technologies they were able to develop (and still improving) as solar batteries.

What Are the Different Types of Solar Batteries?

In this section we will describe the 4 types of solar batteries commercially available:

- **lead-acid,**
- **lithium batteries,**
- **red-ox flow and**
- **hydrogen technologies**

Lead-Acid Batteries

Lead-acid is the oldest rechargeable battery tech, created in 1857 by Gaston Planté. Their main active material is lead. Often compared to lithium batteries, we could divide them into three types that are well designed to store solar energy:

Solar Battery – GEL

The GEL-type battery is sealed and maintenance-free. It was invented 70 years ago by a German company. Its main feature is the gel electrolyte. Therefore, this solar battery is safe. No gas outburst and leakage of electrolytes can occur under normal usage conditions.

Technically, a gel battery for solar energy contains:

- **Positive electrode: PbO_2 (lead oxide)**
- **Negative electrode: Pb (pure lead)**
- **Electrolyte: H_2SO_4 (sulfuric acid as a gel)**
- **Membrane separator**

The basic working principle of this battery involves the exchange of H^+ ions between the positive and negative electrodes through the electrolyte. This movement of ions creates a flow of electrons (electricity) outside the battery to power a load. The opposite reaction happens when the battery is charged with solar energy.

Solar Battery – AGM

The AGM solar battery is another type of lead-acid battery, invented in the '80s. AGM means Absorbed Glass Mat. In this battery, the acid electrolyte is absorbed on a glass matt. Therefore, the battery is safe and leakproof.

It shares the same components with the gel battery, except the electrolyte is absorbed on a fiberglass mat.

The working principle is exactly the same as the gel battery. A flow of H^+ ions between the two electrodes generates a current.

Tubular Lead-Acid Batteries –OPzV

One of the latest additions to the lead-acid solar battery, OPzV batteries from the German: O 'Ortsfest' (stationary), Pz 'PanZerplatte' (tubular plate), V Verschlossen (closed).

They are fitted for stationary applications, using tubes as electrodes. This specific design allows more contact with the acidic electrolyte compared to AGM and GEL batteries.

OPzV batteries are sealed and the electrolyte is of a gel type.

Technically, they share the exact same materials with GEL and AGM types. Therefore, their working principle is the same.

Let's now take a closer look at the latest lithium solar batteries.

Lithium Batteries

Lithium-ion batteries were invented in the '80s and reached the market in the late '90s. They take advantage of Lithium in the form of an ion: Li+ to generate or store electricity.

Let's have a look at the 2 main lithium-ion technologies for solar batteries:

LiFePo4 Solar Battery

LiFePo4 batteries are the most common type of Lithium solar batteries nowadays.

They are made of the following parts:

- **Positive electrode: Lithium oxide LiFePo4 (Lithium Iron Phosphate)**
- **Negative electrode: Carbon**
- **Electrolyte: lithium salt (Li+, gel type)**
- **Membrane separator**

Their working principle is based on the exchange of lithium ions (Li+) from one electrode to another, thanks to the electrolyte. This flow of ions generates a current outside the battery cell.

LTO Solar Battery

LTO is the third type of lithium-ion solar battery. It works similarly to LiFePo4 batteries. However, it features different electrode materials:

- **Negative electrode (anode): Li2TiO3 (LTO): Lithium Titanate Oxide**
- **Positive electrode (cathode): lithium manganese oxide**

LTO solar batteries are extremely robust (up to 30’000 cycles, 10 years) and powerful.

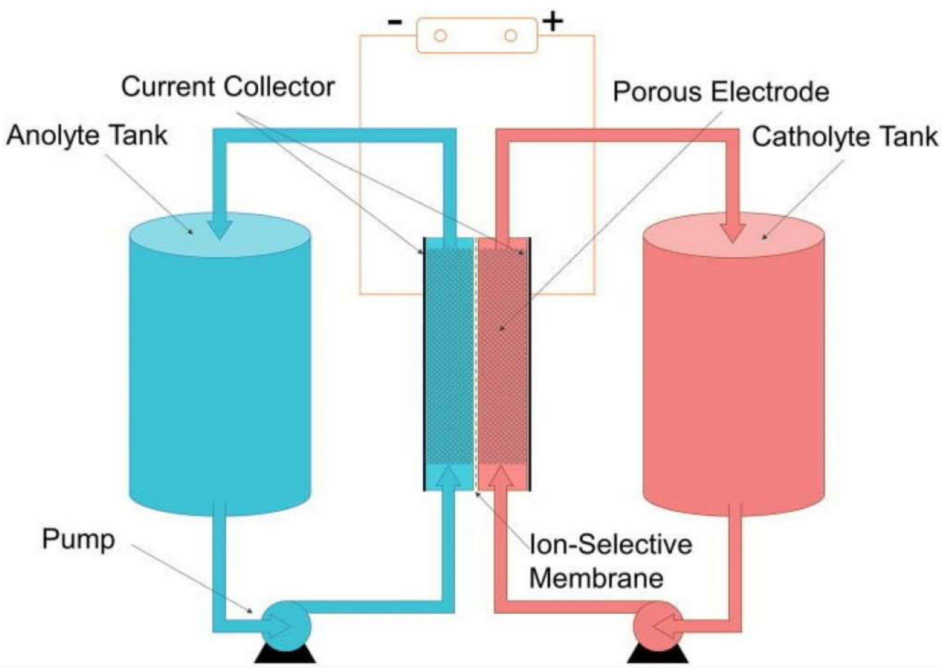
Vanadium Red-ox flow batteries (VRB)

Vanadium red-ox flow batteries were invented in the late ’80s in Australia. Like other solar batteries, they are electrochemical storage systems. However, their working principle and parts are slightly different. In a VRB, the electrolyte is flowing and is the main active component of the battery.

A VRB consists of:

- **Two tanks of liquid acid electrolytes containing Vanadium ions (V2+)**
- **Two carbon electrodes**
- **An Ion exchange membrane**

Unlike other batteries, the storage capacity in a VRB is determined by the volume of each electrolyte. When the electrolytes are flowing, an electrochemical reaction occurs at the electrodes with the vanadium ions, thus generating current outside the battery.



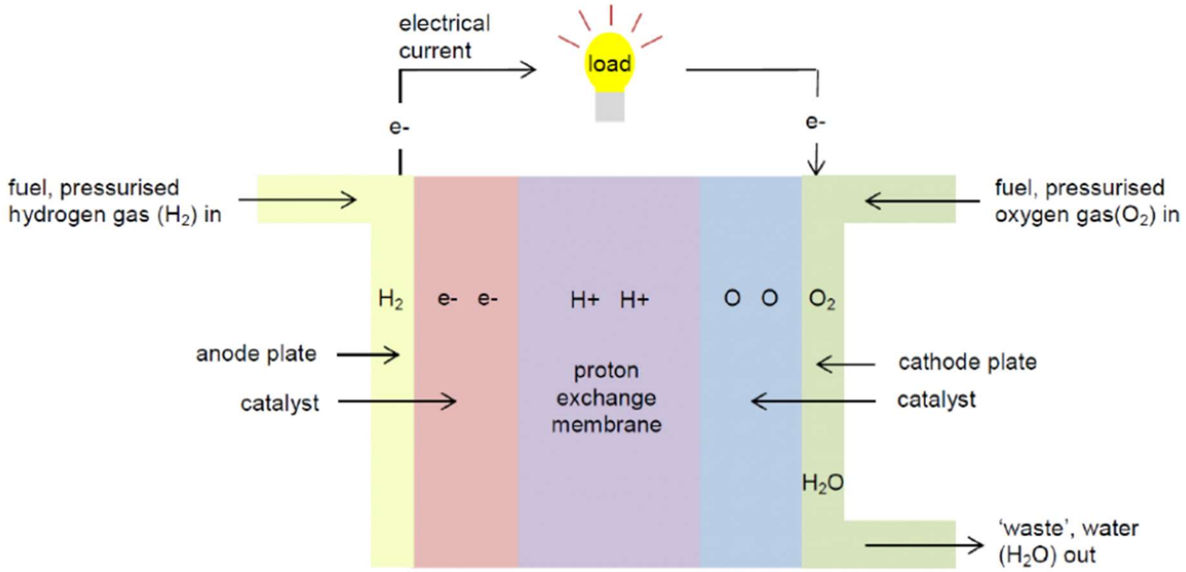
Hydrogen Batteries

Hydrogen batteries are better known as hydrogen fuel cells. This type of energy storage system takes advantage of the properties of hydrogen and oxygen.

It consists of a:

- **Hydrogen storage tank**
- **Positive electrode (cathode, graphite)**
- **Negative electrode (anode, platinum)**
- **Proton exchange membrane (PEM)**

Hydrogen enters the system as a gas at the negative electrode (anode). There, a platinum catalyst helps to split hydrogen into positive ions (H+) and negative electrons (e-). Then, the PEM membrane lets the H+ through and the electrons flow outside the system creating an electric current. In the meantime, the H+ at the cathode (positive electrode) combines with oxygen (O2) from the air to create water (H2O) as a byproduct.



Now that you know all the different types of solar batteries, you might wonder what would be the best for your system. Let's have a closer look at their main *advantages* and *disadvantages.*

Which Type Of Solar Battery Is Best For Me?

In this section, we will describe the pros and cons of each technology and summarize all of our findings in a comparative chart that will help with your decision.

Pros and Cons Of Lead-Acid Solar Batteries

AGM Batteries Pros and Cons

Pros

- Cheap
- Support high power load
- Resistant to cold weather
- Maintenance-free
- Safe

Cons

- Degrade if overcharged
- Heavy
- Low life duration (3 years at 50% depth of discharge)
- Does not support quick charging
- Low tolerance to intermittent charging

GEL Batteries Pros And Cons

Pros

- Cheap
- Maintenance-free
- Safe to use
- Tolerate high temperatures
- Higher life cycle than AGM

Cons

- Heavy
- Sensitive to overcharge and deep discharge
- Low output power
- High self-discharge rates
- Low life duration (500 cycles, 3 years)

OPZv Batteries Pros And Cons

Positive

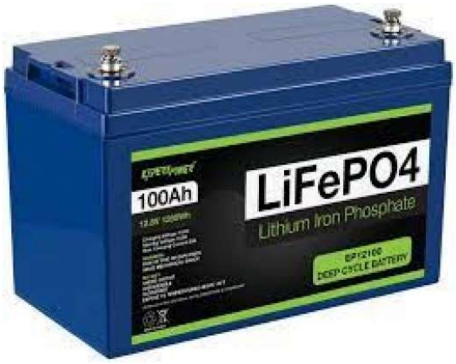
- Cheap
- Very large storage capacity (several kWh per battery)
- Long lifespan (2000 cycles, up to 15 years)
- Support deep discharge
- Maintenance-free
- Safe
- Fast power response

Negatives

- Extremely heavy and bulky
- No quick charging abilities
- Low tolerance to intermittent charging

Pros And Cons Lithium-Lon Solar Batteries

LiFePo4 Solar Batteries Pros And Cons



Pros

- High storage capacity
- Fitted for intermittent charging
- High power output
- Very durable (5000 cycles, 10 years)
- Accept quick charge
- Lightweight
- Tolerate high temperatures

Cons

- Expensive to buy
- Safety is average
- Reduced performances under cold temperatures

LTO Solar Batteries Pros And Cons

Pros

- Super-fast charging
- Highly powerful
- Extremely durable (30’000 cycles, 10 years)
- Resistant to low and high temperatures (-22°F to 150°F)
- Safe

Cons

- Expensive
- A bit heavy

Pros And Cons Vanadium Red-Ox Flow Solar Batteries

Pros

- Unlimited storage capacity (depends on the volume of the tanks)
- Long lifespan (6000 cycles, up to 20 years)
- Powerful
- Tolerant to intermittent charging

Cons

- Bulky
- Noisy (pumps)
- Needs maintenance
- High upfront costs

Pros And Cons Hydrogen Batteries

Pros

- Extremely durable (20’000 cycles)
- High capacity
- Quick charge
- Powerful
- Clean

Cons

- High upfront costs
- Heavy

Solar Batteries Comparative Chart

	Life cycle	Price	Weight	Power	Capacity	Quick charge	Safety
Lead-acid AGM	+	+++	+	+	+	+	+++
Lead-acid GEL	+	+++	+	+	+	+	+++
Lead-acid OPzV	++	+++	+	+++	++	+	+++
LiFePO4	+++	++	+++	+++	++	+++	++
LTO	+++	++	+++	+++	++	+++	++
Vanadium RedOx Flow	+++	++	+	+++	+++	+++	+++
Hydrogen	+++	+	++	+++	+++	+++	++

Which Type Of Solar Battery Is The Most Expensive?

The average buying price of each solar battery goes as follow:

AGM	250 USD
GEL	200 USD
OPzV	500 USD
LiFePO4	2000 USD
LTO	2500 USD
Vanadium Red-ox flow	+10000 USD
Hydrogen	+10000 USD

It is well known that lithium batteries are the most expensive. But as we demonstrated recently, the buying price of a battery does not reflect its real price. Batteries have different life duration, storage capacities, and abilities.

The *Levelized cost of storage (LCOS)* is the best way to compare the cost of various battery technologies. It is expressed in USD/kWh and takes into account the total life cycle of each battery.

Now let's compare the average LCOS of each solar battery:

AGM	0.82 USD/kWh
GEL	0.34 USD/kWh
OPzV	0.25 USD/kWh
LiFePO4	0.13 USD/kWh
LTO	0.04 USD/kWh
Vanadium Red-ox flow	0.04 USD/kWh
Hydrogen battery	0.13 USD/kWh

In the end, over their lifetime, lithium technologies, red-ox flow, and hydrogen are much cheaper than lead-acid batteries.

Final Thoughts

The price of lithium batteries is going down and is expected to continue its decrease in the coming years. Therefore, there is no doubt that this technology will dominate the solar battery market, and lead-acid technologies will be phased out. LTO is predicted to be the main lithium solar battery technology in a few years, thanks to its extreme durability, and super-fast charging/discharging abilities.

In the future, hydrogen technologies might also get a share of the domestic energy storage market, whereas Red-ox flow batteries will be for industrial applications only.