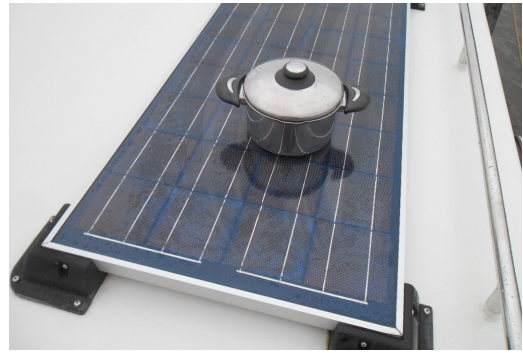


12 Volt Cooking

This 6 page article describes the transition to electric cooking and the use of an electric kettle and coffee maker on board. It provides insight into the **energy consumption**, **calculation examples** and the **schematics** of a battery setup.

It concerns cooking on a simple induction plate with one cooking zone that can be placed, for example, on a counter top or closed gas appliance.



Why cooking electrically

The main reasons for electric cooking are that **no combustion gases**, **fine dust** and **water vapor** are produced. In addition, there is no open fire involved, which reduces the chance of fire or explosions. During induction cooking, the heat is produced directly in the bottom of the cooking pot. As a result, less heat is lost and your handles and environment remain cooler. It also saves carrying gas cylinders.

The only water vapor which is produced comes from your cooking pot.

What does it take to cook electrically on board?

Electric cooking requires a **good understanding** – and **consciously monitoring** – of energy consumption. A battery has a very limited storage capacity compared to a gas cylinder and when cooking, a high discharge current, similar with starting your engine, is quickly achieved. You will probably need to increase your **battery capacity** and make additional provisions to charge the batteries.

To indicate the charge of 12V batteries, Ampere-hour (Ah) is usually used.

1Ah means that the battery can supply a current of 1 Ampere over a period of 1 hour(hour).

(kW and kWh are explained at the end of this article.)

In addition to the capacity of the battery bank, **the consumption by the individual** users is important. This is called the power and is usually indicated in Watts at the bottom or back of a device. These values are usually on the safe side. They normally indicate the maximum power and not the power for individual cooking settings. In this article the actual measured values for each setting are indicated.

We use induction but a ceramic hob is also possible. I would prefer a plate with fixed positions to a plate that is thermally controlled and is switching. The disadvantage compared to induction is the loss of heat that is inserted into the plate itself. In addition there is a delay when you change the setting (Induction cooking reacts, like with gas, almost immediately.)

The 220 Volt AC required for cooking is produced with an inverter from the 12 Volt batteries. Usually the voltage is a somewhat higher, for example 230 Volts. Our first inverter could handle consumers up to a power of 1500 Watts. Compared to a home installation, this is low. For example, I can't use our 1.5 liter, 2000 Watt kettle from home, via the inverter on board. So on board I use a smaller, 955 Watt kettle.

I placed our combined inverter / battery charger in the fore ship. This is a relatively cool area. The inverter/ charger is, cooled with a fan from the bottom.

With a switch next to the counter, I switch the inverter on/off. Just like batteries, it is better not to place the inverter in a motor compartment.

Because of the high currents, it is wise to keep the cable length to the batteries short.

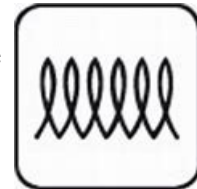


One 230 Ah deep-cycle battery is close to the inverter (next to the bow thrust-er) and a second 120Ah domestic one is placed next to the starter battery. The bowthruster has its own 120Ah battery which can be coupled if needed.

While using the combined Victron inverter/charger as an inverter, I switch off the "charging of the starter battery" mode to prevent the starter battery from being charged from the domestic batteries. The jumper that you have to place for this in the device I have replaced by a switch on the outside.

In addition to the inverter/charger shown, there are plenty of other brands and types with newer technology and different powers and prices. The prices of some inverters (without a charger) start around 200 Euro. We recently bought one with a capacity of 2500 W and efficiency of 94%

Another point with induction cooking is that the cooking pots must be suitable for it. An magnet should stick to the bottom of the suitable pans and/ or the pans should have a pictogram with a spiral.



The placement of the users

If the 220 V installation is already present on board, the placement of the hob is simple. We place the hob on the closed stove, somewhat higher with some thick cork (stuck with sealant). This improves the ventilation (There is a mechanical ventilation at the bottom of the hob that cools the electronics in the appliance at a certain temperature)



Users and consumption:

Kettle 955 W

If our kettle is "on", the Victron inverter uses approx. **116 A** from the batteries.

Bringing half a liter of water to a boil takes **3 minutes and 10 seconds** (3.16'). In Ampere-hour (Ah) expressed: **$3.16 \times 116 / 60 = 6.11 \text{ Ah}$**

If the solar panels can charge with 6.5 A in the meantime or afterwards, the battery is replenished after 1 hour. (You actually have to charge a little more because of your losses)



Filter coffee machine 600 W

This device uses less (**56A**) than the kettle but over a longer period of time. It's occasionally turned off/on automatically to give the coffee a longer brewing opportunity.

For the consumption I have charged **7 minutes** of the approx. 8.5 min that making the coffee takes. Also filled with half a liter of water, I came to **$7 \times 56 / 60 = 6.53 \text{ Ah}$**

Silvercrest induction plate with one cooking zone

Positions 5 and 6 were also tested with a cooking pot filled with half a liter of water. Bringing it to the boil took 4.45 and 3.7 minutes respectively and used **108** and **136A**.

Position 5 930 W **4.45 * 108 / 60 = 8.01Ah**

6 1170 W **3.7 * 136 / 60 = 8.39Ah** (is slightly faster but with a **26% higher current**.)

Position 1-4 500-930 W These modes switch on and off (unsettled for the inverter)

7 1379 W too much for continuous use for the Victron inverter

8 1550 W too much for this inverter

9 1685 W too much for this inverter

Overview when bringing half a liter of water to a boil. (Victron Phoenix Multi 12 1300 70)

	Power watt	T °C	Time min	Current A	Charge Ah
Kettle	955	11°	3.16	116	6.11
Coffee machine max.	600	11°	8.4/7 *	56	6.5
Induction mode 5	930	11°	4.45	108	8.01
Induction mode 6	1170	11°	3.7	136	8.39
Gas, burner diameter 62 mm		11°	4.66	ca.400gram	Propane

T Ambient temperature and starting temperature of the water 11° C

* Coffee machine stops occasionally, 7 minutes charged for the Ah value

Gas consumption is measured with a luggage hand weigh-er

(Weight bottle before – weight after cooking 15.95 – 15.54 kg).

Recently I installed another inverter and took some other measurements at approx. 25°

	Shore power kWh time	RoHS/Vevor 2500W kWh time	Amps from batteries	Victron Multi 12 1300 70 kWh time Amps
Kettle	0.041 2:37	0.046 2:49	95-97.5 A	0.045 2:48 118 A
Coffee-maker	0.046 10:49	0.041 10:49	50-51 A	0.046 11:12 54-55.5 A
Induction #5	0.057 3:57	0.053 3:22	89 A	0.054 3:42 103A(+15%)
Induction #6		0.057 3:01	111-114.5 A	

So the newer RoHS/ Vevor inverter is significant more efficient for cooking. However for smaller charges like a DVD player combined with a monitor, the Victron uses less. (**1.86** in stead of **2.1 A**)
Unfortunately the cooling of the Vevor inverter doesn't work as advertised. We added an extra external fan which starts cooling at a lower temperature.

When I **prepare a meal**, I bring the content to a boil and switch the hub off. Every few minutes I bring the content to the boil again until the meal is finished. This takes around 11 minutes from the first time of boiling. When having a meal with two pots I switch them at times. Cooking this way with 0.8 liter of water takes around **0.161 kWh** measured on the 220V side

Together with the preparation of 3 times thee and 3 times coffee, my **daily consumption** adds up to 0.422 kWh. At 12 V this equals to 35.2 Ah. I assume this covered by a **charge of 4 hours of 10 A**. (Dependent on losses and efficiency of the inverter).

This applies to the cooking only, other consumption by fridge, radio etc. has to be added.

The big picture

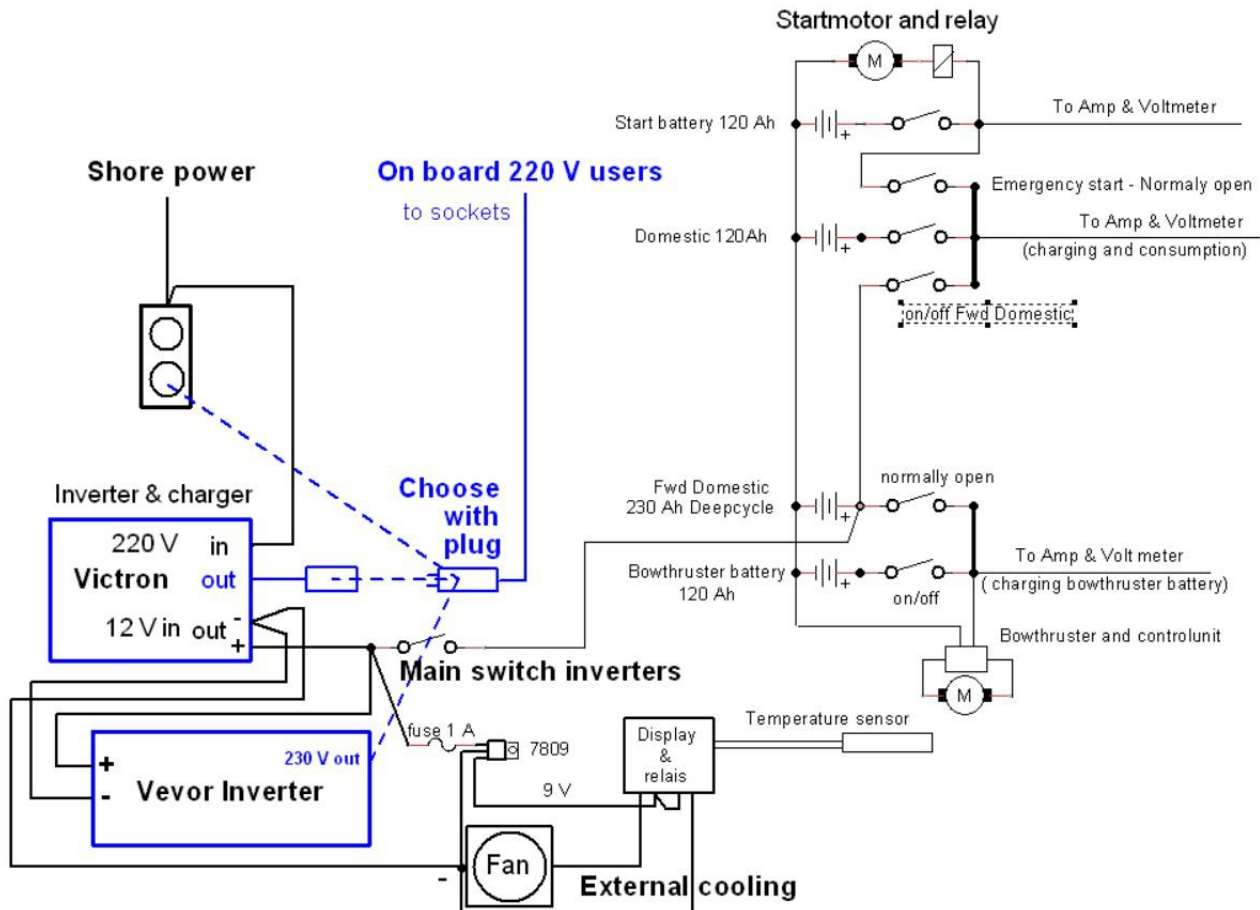
The total energy requirement will be different for everyone and will depend on cooking habits, sailing schedules, seasons and the degree of flexibility one has. One will have to adjust the use and / or installation as needed.

The batteries

A large battery bank is important because of the **high discharge currents**. You can not, based on the "low" Ah values of just cooking for a few minutes, suffice with a small battery.

The battery must **be able** to supply the high discharge current also when it is discharged for a large part. If a deeply discharged battery is overloaded, this will usually result in the irreparable failure of one or more cells.

The bowthruster uses around 280 A when running. These are short periods. The inverters use less but over a longer period. We had to replace some of our older 120Ah batteries and replaced two for one 230Ah deep-cycle battery for inverter use and use one 120Ah battery for the bowthruster and another 120 Ah as a second domestic and backup for the starter battery.



In the morning, before the sun can start charging and after an evening with the use of TV and possibly the stove, the battery voltage is usually at its lowest. Especially after a few days with little sun, the voltage can have dropped quite a bit. If one sails away at such times, it is wise to avoid the use of the bow thrust-er, windlass or other large users, if possible.

Charging

We used to charge with two **solar panels** that can charge together with about 6-10 A. Because our consumption increased due to the electric cooking we recently installed an extra 175 Watt (peak) panel.



While running the engine, the batteries can be charged with approx. 50A from the **alternator** on the main engine. This requires energy and this can be heard at the load on the engine. Sometimes it can be practical to sail somewhat slower to the next destination, to allow for a longer period of charging.



My measuring instruments

To measure the power (watts) of the consumers, I used this meter



The current that runs between the inverter and the battery (the discharge current) is measured with an ampere meter that is clamped around one of the cables



The new situation with two inverters

The switch with the red key connects the inverters to the batteries. It is normally switched off to prevent stealth consumption. When the switch is on, there is also voltage on the temperature-controlled relay that can turn on the fan. The Vevor inverter is slightly raised to allow good airflow along the underside.

With the plug, the 220 V source is chosen for the users. In the photo, the consumers are connected to the shore power socket.



Kilowatt hour(kWh) versus ampere-hour(Ah)

*With electric propulsion kilowatt hours (kWh) and not ampere-hour (Ah) are commonly used
This makes comparing devices such as motors, **when using different voltages**, clearer.*

Watt (W) is the electrical power:

When at a voltage difference of 1 Volt a current flows of 1 Ampere, you use 1 Watt

$$1W = 1V \times 1A$$

For example: You can drive your sloop with a 3000 Watt (3kW) motor

When used at full power, a current runs:

$$\text{At } 12 \text{ V} : 3000 / 12 = 250 \text{ A}$$

To sail 1 hour 250 Ah is needed

$$\text{At } 48 \text{ V (more common)} : 3000 / 48 = 62.5 \text{ A}$$

To sail at 1 hour sailing 62.5 Ah is needed

In both cases you need 3000 Watts per hour = 3kWh

In addition, the motor can run at various voltages.

*By using kWh and kW, the comparison between batteries and users is **independent of the voltage** at which you use them.*

This also applies to electrically powered cars where different voltages are used.

The capacity of the 12V 120Ah batteries mentioned earlier equals to 1440 Wh or 1.44kWh