Information pack on improving the energy efficiency of boating for boaters and sailors

---

EUROPEAN UNION
European Regional Development Fund

Interreg
Central Baltic

CB SMALL PORTS

Table of contents

Introduction

This information pack contains tips and recommendations for boaters on best practices for resource efficient and energy efficient boating. The information pack is divided into two main sections. The first part consists of some good tips on how to change our habits while boating without major investments and the second part describes different technical solutions that can be used to produce electrical energy while boating.

The information pack provides information on energy efficient solutions and options for motorboats and sailing boats, such as electric motors, wind generators and hydro generators, and Off-grid photovoltaic systems. In addition, this information pack includes calculation examples, a comparison table of traditional boat panels, and information about boat batteries.

Change your boating habits

This section provides tips for changing boating habits, as well as ways to increase energy efficiency while boating. Even small changes can affect the overall energy efficiency of boating, electricity and fuel consumption and safety. The boating habits can be changed without major investments.

Tips for increasing energy efficiency in boats and boating

- The boat's electricity consumption can be reduced by changing your habits
    - Turn off extra lights and close the refrigerator door properly
    - Use a heater only for the time required
        - → The refrigerator and the heater are one of the biggest energy consumers of the boat
        - → The heater usually takes the required fuel from the same tank as the engine
    - Turn off extra electrical devices that are not in use
    - Maintain boat's electrical devices regularly

- The energy efficiency of the refrigerator is important, especially on longer boating trips
    - Check the refrigerator and the feezer temperatures and the door gaskets (seals)
    - The optimal temperature for the refrigerator is +2–6°C and in the freezer -18°C
        - → Too low temperatures in the refrigerator and freezer increase electricity consumption as the compressor runs more
        - → The door gaskets that are worn out and old increase electricity consumption, as warm air can leak into the refrigerator, which, in turns, increase the use of the compressor
    - The energy consumption of a gas refrigerator is higher than a compressor refrigerator
    - The compressor refrigerator is safer than the gas refrigerator because it uses only electricity connections 12V/24V
        - → The gas refrigerator connections are 12V, 230V or gas (Liquefied petroleum gas)

- One good way to increase boat's energy efficiency is to replace in stages old incandescent bulbs with LED lights
    - The LED lights consume significantly less power than the incandescent bulbs and have a longer service life
    - The exchange of LED lights can be started, for example, from mast-head lights and nautical lights, if boating takes place in the night-time
    - Replace light bulb with the LED light when the old light bulb is burned out

Sailing responsibly and sustainable boating

- Do not litter the nature or the waterways
    - Collect waste and sort them in ports according to possibilities
    - Collect greywaters such as washing and dishwater in their own container
    - Use eco-friendly dish soap and wash the dishes on shore if possible
    - Empty the toilet waste container responsibly in ports
    - Do not burn waste in a campfire

- On a boat, all the energy comes from the fuel. Examples of how to reduce the boat's fuel consumption
    - Reduce the use of electrical devices and turn off extra equipment
    - Adjust the boat's driving position so that water resistance and friction are kept to a minimum
    - Drive the boat at cost-effective speeds
        → The boat's driving style and speed affect the fuel consumption of the boat
    - Leave unnecessary items out of the boat
        → The heavier the boat is, the more energy is needed to move it
    - Use sails as much as possible instead of the engine when sailing
        → Wind energy is free and almost always available
    - Utilize solar or wind energy to charge the boat's batteries
        → The boat's batteries will charge while boating and the batteries will not run out

- Make sure the gas is used safely on the boat
    - Maintain liquefied petroleum gas (LPG) cylinders and equipment regularly and use them properly
        → Effectively prevents gas accidents
    - Check the condition of the LPG cylinders and equipment as well as gas hoses and connectors before the start of the boating season
        → To prevent gas leak, fire hazard and risk of explosion
        → From an energy efficiency perspective, it is also important that gas does not leak
    - A gas alarm is a good accessory on the boat. It detects gas leaks
    - Equipment with flame protection must always be used on the boat
    - The refrigerator and the heater must be in accordance with a closed loop system
        → The combustion air is taken from the outside and the combustion fumes escape directly out

- Maintain the boat and clean the hull regularly, but do not harm the waterways
    - A maintained engine works better and is more environmentally friendly
    - During the boating season, fouling attaches to the hull of the boat
        → This increases water resistance and fuel consumption
    - Toxic paints or antifouling paints used on the hull of boats to prevent attachment of barnacles are dangerous for the environment, aquatic organisms, and human health
    - The toxic paints on the hull of the boat
        → Decreases the reproduction of fish and other aquatic organisms
        → Causes long-lasting adverse effects in the environment
        → It is not allowed to use in lake waters

- Instead of using the toxic paints to prevent the bottom of boat from fouling
    - Clean the barnacles on the bottom of boat, such as mussels and fouling organisms, with a brush or a pressure washer 1–3 times during the boating season
    - It is recommended to wash the hull of the boat between July-August, when the barnacle's larvae attach to the hull of the boat
    - Use covers and mats to protect the hull of the boat
        → These are well suited for motorboats
    - Keep the boat dry on a trailer or a boat lift

- Plan your boating route
    - The greatest energy savings are achieved through sensible route selection
    - Plan your refuelling and find out about the ports along your route and their services
    - Keep the spare fuel tank full
    - Check the weather conditions before boating and prepare for them

See more tips for the sustainable boating:
https://www.pidasaaristosiistina.fi/en/enviromental_information

Technical solutions for boats

This section includes various technical solutions for motorboats and sailing boats that increase energy efficiency and energy savings while boating. For example, wind, hydro, or solar energy can be used to charge boat batteries and keep them well charged while boating. The section covers electric motors, boat batteries, Off-grid photovoltaic systems, wind generators and hydro generators.

Advantages of electric motor vs. diesel and gasoline engine

New electric boats sold on the market are still very expensive. As a solution to this problem, an electric motor can be installed in place of an old engine. The electric motor is lighter than a diesel or a gasoline engine. When the old engine is removed from the boat, the old fuel system can be removed at the same time. This increases the space and allows more batteries to be installed in the boat. The electric motor is a quiet and a pollution-free option for outboard motorboat. This makes the boat environmentally friendly and easy to manage. In addition, the smell of diesel or gasoline is removed.

The electric motor requires little maintenance and does not need annual service in the same way as a diesel or gasoline engine, which changes the engine and transmission oils as well as the fuel and oil filters. This cause costs and service operations for the users.

Pleasure boats with displacement hulls are planned to travel at a slow speed and they are well suited for boats electrification. For example, traditional wooden boats, most sailing boats, fishing boats, rowing boats, tugboats are displacement hull boats. Pod electric motors, that are suitable for the electrification of sailing boats and small watercrafts, are sold on the market. For example, a POD 2.2 and 4.3 electric motors can be installed in place of sail-drive device and a POD 4 is suitable for fixed installation on the hull of the boat. The size and power requirements of the boat affects the selection of the electric motor.

Some electric motors also have feature that turns the electric motor into a generator at the push of a button. This feature suits well for sailing boats that makes longer sailing trips. When the generator mode is switched on while sailing, the motor propeller starts to rotate freely due to boats movement and produces electrical energy. This solution allows the batteries to be charged while sailing with wind energy.

Marine batteries for boats

On a boat, there are usually both a starter and a leisure battery. The starter battery is used for a short time to start the engine that takes a larger current at a time. The leisure battery is used continuously for a long time and provides current for a long time, but its amount is small. The sufficient capacity (Ah) and current consumption (A) of the starter battery should be checked on the engine nameplate. When selecting the starter battery, the values of the starter battery should not be less than specified on the engine.

The basic battery types for boats are lead-acid batteries, AGM batteries and lithium batteries. The battery voltage is typically 12VDC and it works on direct current (DC) just like a car's electrical system. Because of this, there are many 12 VDC components and electrical devices available for the boats. The operating voltage of the boat's electrical system is 12, 24 or 48 VDC. Serial and parallel connection of the batteries increases battery voltage (V) or battery capacity (Ah). It is important to choose a battery with sufficient capacity (Ah) and the correct voltage (V) for the boat.

When buying a boat battery (or batteries), consider the electricity consuming devices and the amount of current (A) or power (W) they require, as well as the operating time of the electrical devices in hours (h). The required battery capacity in ampere-hours (Ah) can be calculated from the currents or powers and estimated operating hours of the electrical devices. The total number of ampere-hours of electrical devices corresponds to the required battery capacity.

Electrical device current (A) x using time (h) = ampere-hour (Ah)

Electrical device power in hour (Wh) / Battery voltage 12 V = ampere-hour (Ah)

However, the actual value of the boat's battery capacity (Ah) must also consider the battery type discharge depth %. The lead-acid and AGM batteries maximum level of discharge is 50–80 % of full capacity and the lithium batteries maximum level of discharge is 90–95 % of full capacity.

$$\frac{\text{Sum of daily battery capacity (Ah) x 100}}{\text{Battery discharge depth \%}} = \text{The actual value of battery capacity (Ah)}$$

In calculation

- The acid-lead and AGM battery discharge level is 50 %
- The lithium battery discharge level is 90 %

On the boat, the batteries energy is used for running different electrical devices like

- Lights: indoor lights, deck lights, boat lights, anchor lights
  Kitchen appliances: refrigerator, freezer
- Entertainment electronics: mobile phones, tablet PC, travel TV, radios, stereo set
- Electric water pumps: shower, tap
- Ventilation and heating: air conditioner, heater, cooling air fan
- Other electrical devices: starter motor, instrument panel, engine controls, autopilot, navigation devices, windscreen wipers, winch, anchor, bilge pumps

Example:

How much energy a 4 x 10W lamp consumes in ampere-hours? Voltage is 12V and using time is 6 hours.

Power W = Voltage U x Current I → Current I = Power W / Voltage U

Calculation method 1

$$\frac{(4 \text{ x } 10 \text{ W})}{12 \text{ V}} = 3.33 \text{ Ah}$$

$$3.33 \text{ A x } 6\text{h} = 20 \text{ Ah}$$

→ The answer is 20 Ah

Calculation method 2

$$(4 \text{ x } 10 \text{ W}) \text{ x } 6\text{h} = 240 \text{ Ah}$$

$$\frac{240 \text{ Wh}}{12 \text{ V}} = 20 \text{ Ah}$$

See more information of boat battery capacity sizing (in Finnish only):
https://stek.fi/veneilijalle/sahko-ja-vene-opas/

Counter for boat power consumption and battery capacity sizing (in Finnish only):
https://gravasoftdemo.azurewebsites.net/laskuri/etusivu.html

Comparison of boat battery types

Lead-acid battery

Pros

+ Relatively cheap
+ Almost maintenance-free
+ Provides options for boat starter and leisure batteries
+ The quality lead-acid batteries can provide 600–700 charge and discharge cycles

  → Corresponds to a service life of 6–8 years

Cons

- Maximum level of discharge (percentage of discharged battery) is around 50 % of the total battery capacity
- Larger and heavier than a lithium battery of the same capacity
- The lead-acid batteries tolerate poorly being too empty (deep discharge)

  → Shortens service life

AGM battery (Absorbent Glass Mat)

Pros

+ Relatively cheap
+ Maintenance-free and can be installed variously to different positions
+ AGM is a lead-acid deep-cycle and a sealed battery
    → No acid leaks
+ Provides options for boat starter and leisure batteries
+ The quality AGM batteries can provide 500–1000 charge and discharge cycles
    → Corresponds to a service life of 6–10 years
+ Maximum level of discharge is 50–80 % of the total battery capacity

Cons

- Larger and heavier than a lithium battery of the same capacity
- The AGM battery cannot be stored empty

Lithium battery, Li-ion

Pros

+ More technically advanced than the lead-acid battery
+ Maintenance-free and lighter than the lead-acid battery
+ Provides options for boat starter and leisure batteries
    → $LiFePO_4$ (LFP) Li-ion batteries are suitable for marine and solar panel use
+ The quality lithium batteries can provide even 3000 charge and discharge cycles
    → Corresponds to a service life of 8–15 years
+ Maximum level of discharge is 90–95 % of the total battery capacity

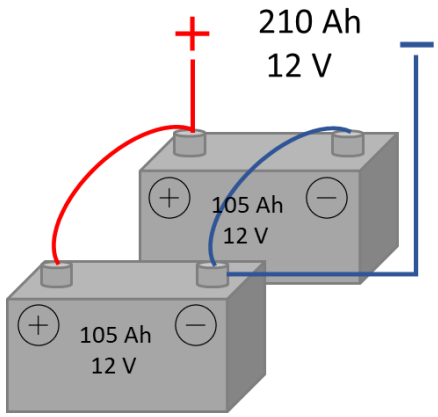
Cons

- Includes battery management system (BMS) that requires maintenance skills from the user
    → The BMS is an essential part of battery safety
    → The BMS prevents overcharging and excessive discharge of batteries
- The lithium batteries must be installed in accordance with instructions
    → Can cause a fire hazard, if the batteries are installed incorrectly
- Four times more expensive than a lead-acid battery of the same capacity

Boat battery connection examples

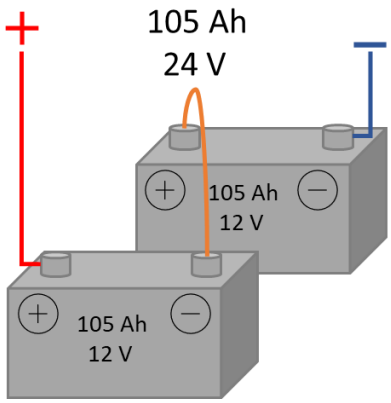
By connecting the batteries in series or in parallel, the number of voltage or ampere-hours can be increased. However, most boats have 12VDC electrical systems and there are a lot of electrical devices on the market that are suitable for a 12VDC systems. Some larger boats have a 24/48VDC system. Connecting the batteries to 24VDC configuration requires that all the boat's electrical devices use 24VDC, otherwise this connection may damage the boat’s electrical system. In addition, it is important to remember that when connecting the batteries that they must be of the same type and size in terms of voltage and capacity and preferably also the same age.

Connecting batteries in parallel

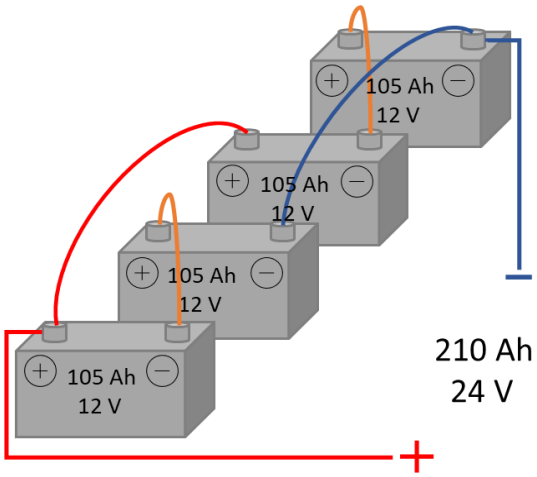


Parallel connection → more ampere-hours
12V, 210 Ah

Connecting batteries in series



Series connection → more volts
24V, 105 Ah



A 24V system is usually a combination of parallel and series connections

Combination = 24V, 210 Ah

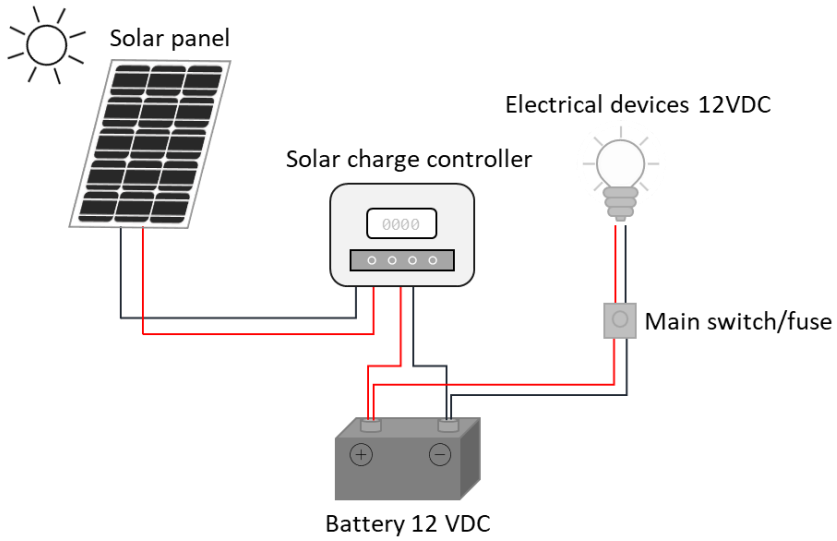
Advantages of solar panels for boats

Solar energy is an environmentally friendly and a renewable energy source. It is easy to utilize and there are various solutions on the market for motorboats and sailing boats. Solar panels are sustainable alternative to electricity production because sunlight is free, so only the purchase and installation of the system present costs. The solar panels are silent and easy to use. In addition, the system has a long service life that requires very little maintenance.

An Off-grid photovoltaic (PV) system is a good solution for boats because the boating season usually lasts from spring to late fall and most of the electricity produced by the solar panels is in between March and September. This means that the production and consumption of solar energy meet. In addition, the Off-grid PV system can be used to charge the boat's batteries while boating. This creates safety for boating as the batteries will not run out. The energy stored in the boat's batteries can be used for all the suitable electrical devices on board.

Off-grid PV system

An Off-grid photovoltaic (PV) system means a solution that is not connected to the public electricity grid. The Off-grid PV system produces electrical energy with solar panels during the day, just like an On-grid PV system, but the produced electrical energy is stored in the boat's batteries for later use. On-grid PV systems may also have batteries, although this is less common while in for the Off-grid PV system, batteries are essential. One difference is also that in the Off-grid PV system the excess energy that is not used or cannot be stored into batteries when they are full goes to waste. The Off-grid PV system is suitable for example, for caravan, boats, and cottages in the archipelago. In addition, the Off-grid PV system is a good solution for locations where energy use and consumption do not meet. The basic components of an Off-grid PV system consist of solar panels, a solar charge controller, batteries, mounting accessories and basic electrical components such as wires, fuses, and a circuit breaker. The Off-grid PV system can be connected to boat's existing battery system.



Picture 1. The Off-grid PV system

The solar panels converts the solar radiation into direct current (DC) electricity, which is directed via the solar charge controller to the batteries and from there to all electrical devices used on board. The rated power of the solar panel is expressed in watt-peak (Wp), and it describe the maximum power produced by the solar panel in Standard Test Conditions (STC) when the solar radiation perpendicular to the panel is 1000 W/m² and the solar cell temperature is 25 °C.

Example:

How much one a 100 W solar panel produce battery charging current (Ah) in one day and what is its maximum power voltage and efficiency?

In the example, is assumed that

- The number of charging current of the solar panel is 5.89 A → Maximum Power Current (Imp)
- The solar panel uses the STC conditions mentioned earlier (1000 W/m² and 25 °C)
- The solar panel size is 1060 mm x 540 mm x 3 mm ~ 0.57 m^2

Power W = Voltage U x Current I → Current I = Power W / Voltage U

Solar panel Maximum Power Voltage (Vmp)

Maximum Power Voltage (Vmp): $\frac{100\ \mathrm{W}}{5.89\ \mathrm{A}} = 16.977\ \mathrm{V} \approx 17\ \mathrm{V}$

Battery charging current (Ah)

- The number of hours of sunshine varies, depending on the season, month, and weather conditions
- If the number of sun hours is 6h or 8h, then the battery charging current is

  5.89 A x 6h = 35.34 Ah

  5.89 A x 8h = 47.12 Ah

Solar panel efficiency under the STC conditions

Efficiency: $\frac{100\ \mathrm{W}}{(0.57\ \mathrm{m^2\ x\ 1000\ W/m^2})} = 0.1754 \approx 17.5\ \%$

Solar charge controller

The solar charge controller regulates the voltage from the solar panels and the current to suit the batteries. In addition, it prevents batteries from overcharging and leaking current from returning to the solar panels. The solar charge controller should be dimensioned according to the voltages of the batteries and the maximum current of the solar panels. There are two types of solar charge controllers: a Maximum Power Point Tracking (MPPT) and a Pulse Width Modulation (PWM). The MPPT controller charging efficiency is around 95–98% and the PWM is around 50–60%.

The Off-grid PV system solar charge controller, boat battery voltage 12V

Solar charge controller	Solar panel (Max power)
5 A	60 W
10 A	120 W
15 A	180 W
20 A	240 W
30 A	260 W
40 A	480 W

Example:

If the solar charge controller is 5A and the boat battery voltage is 12V, a 60W solar panel can be connected to it. On the other hand, if the boat battery voltage is 24V, a 120W solar panel can be connected to it.

Solar panels for boats and their installation solutions

On a boat, it is important to install the solar panels in a sunny place with no shading. Usually the solar panels are directed to the south, in which case the solar panel system producing the best electrical energy in the northern hemisphere. However, the challenge in boating is that the boat moves and changes direction, so that the solar panels are not always facing south. As a solution to this problem, the solar panels can be installed horizontally on cabin roof, in which case sunlight is collected from all directions. The solar panels should be installed horizontally on the cabin roof without tilting angles, as the solar panels are always at the mercy of the weather: for example strong wind could damage them.

Another solution is installing the solar panels on the deck, or on the side or back rail of the boat. The solar panel can be installed on a railing rack, which allows the solar panel to be repositioned and rotated to follow the sun all day. Some of the solar panel models on sale are removable, in which case they can be stored under the boat deck and used as needed. There are also semi-flexible solar panels on the market, which can be installed on bimini covers, sprayhoods and canvas surfaces for motorboats and sailing boats.

Picture 2. Semi-flexible solar panel installed on the cabin roof

Picture 3. Solar panel installed on the back pole of the boat

Picture 4. Solar panels installed on the deck of the boat

Off-grid PV system planning and purchase

The number and size of solar panels in watts is affected by how much energy is used during boating. In addition, the available installation space affects the size of the system. During the design phase, it is also a good idea to consider the location of the solar panels, the batteries type, number and their location, and finally the position of the solar charge controller on the boat.

The solar panels for boats are divided into four typical groups: monocrystalline panels, polycrystalline panels, semi-flexible panels, and flexible thin-film panels. The Off-grid PV system with solar panels between 65W and 130W is a suitable option for motorboats, yachts and sailing boats that use charging power for lights, refrigeration equipment, and other electrical devices. The solar panels of boats with a power of 40W and less are suitable for keeping 12V boat's batteries charged and for weekend cruises. The semi-flexible and thin-film solar panels are suitable for curved surfaces. The Off-grid PV system components are sold separately on the market, as well as turnkey packages that include all the necessary components for the system.

Comparison table of traditional boat panels, 12V system

Solar panel power	Charging current	Flexible ~20%	Price	Details of solar panel
35 W	2.1 A	✓	85 €	Curved surfaces, resistant to stepping
55 W	2.82 A	✓	259 €	Curved surfaces, resistant to stepping
60 W	3.6 A	✓	139 €	Curved surfaces, resistant to stepping
78 W	3.98 A	✓	349 €	Curved surfaces, resistant to stepping
80 W	4.44 A	✓	229 €	Curved surfaces, resistant to stepping
100 W	5.89 A	✓	275 €	Curved surfaces, resistant to stepping
160 W	8.9 A	✓	350 €	Curved surfaces, resistant to stepping
50 W	2.78 A	✓	165 €	Foldable and removable model
80 W	4.31 A	✓	270 €	Foldable and removable model
120 W	6.47 A	✓	375 €	Foldable and removable model
14 W	0.9 A	✓	399 €	Rollable solar panel, easy to store
21 W	1.35 A	✓	499 €	Rollable solar panel, easy to store
28 W	1.8 A	✓	599 €	Rollable solar panel, easy to store
22 W	1.7 A		209 €	Fixed installation, rigid solar panel
33 W	2.5 A		315 €	Fixed installation, rigid solar panel
46 W	3.4 A		379 €	Fixed installation, rigid solar panel

Sources: www.sunwind.fi, www.marinea.fi, www.jn-solar.fi, www.marinekauppa.com

Marine wind generator for motorboats and sailing boats

A wind generator, also known as a wind turbine or a wind charger, is an energy efficient solution for boats to utilize wind energy. In this systems, the wind rotates the blades of the wind generator that collects wind energy, which is converted into electrical energy. The produced electrical energy is stored in the boat's batteries. This is an effective way to keep the boat's batteries well charged as wind energy is free, renewable, and easy to utilize while boating and available also at night. The wind generator starts to produce charging energy at a wind speed of 3 m/s. The energy stored in the boat's batteries is ready to use, for example, for lights, coolers, navigation devices and other electrical devices of the boat.

The wind generator with a nominal voltage of 12V and a maximum power of 30-100W, corresponding to a current of 3-8A, is suitable for use in small and large boats as well as sailing boats. There are also the wind generator options for 24V systems on the market. The wind generator slightly shakes when operating and produces a smooth sound and it requires a charge controller that fits the wind generator. On the market, there are also wind generators with a hybrid controller that combines both the wind generator charge controller and a solar charge controller. This allows an Off-grid PV system to be connected to it. Combining the wind generator and the Off-grid PV system creates an efficient system that utilizes both wind and solar energy at the same time. For example, the wind generator with a power of 50W and 260W are sold on the market. The price of 50W, 12V wind generator is around 620 € and 260W, 12V is around 1200 €.

Picture 5. Wind generator with solar panels

Picture 6. Wind generator with solar panels

Marine hydro generator for sailing boats

A hydro generator, also known as a water generator or a water charger, is an energy efficient solution for sailing boats to charge the boat's batteries while sailing. In this systems, the water rotates the blades of the hydro generator that collects kinetic energy of water, which is converted into electrical energy. The produced electrical energy is stored in the boat's batteries and it can be used, for example, for lights, navigation devices, coolers and other electrical devices of the boat. The advantage of hydro generator is that it produces energy also at night. This affects the overall safety of the boat as the batteries will not run out. In addition to the hydro generator, the sailing boat can also utilize solar and wind energy. In this case, the self-sufficiency of the sailing boat, in terms of electrical energy, increases.

The hydro generator can be installed in the stern of the boat and is optimized for speeds of 2–10 knots. The hydro generator has a smooth operating sound and does not pollute the environment. There are also the hydro generator options on the market that works in both 12V and 24V systems. However, it is not recommended to operate the hydro generator at speeds above 15 knots or in bad weather, such as in high waves because the hydro generator can be damaged. The hydro generators with a power of 300W and 600W are sold on the market. The price of 300W, 12V hydro generator is around 2950–3600 € and 600W, 12V is around 4190–5090 €. The table show an example of how much charging amperes for the battery is produced by the hydro generator at different powers and speeds of knots. The system voltage is 12V.

The hydro generators for boats, 12V system

Max charging power of hydro generator	Knots speeds	Battery charging amperes
300 W	7	24 A
600 W	9	48 A
600 W	10	50 A

Source: https://www.marinea.fi/

Sources

AC-Sanafor. (2010, May 11). Muista kaasuturvallisuus veneilykauden alkaessa. Retrieved May 10, 2022, from https://news.cision.com/fi/ac-sanafor/r/muista-kaasuturvallisuus-veneilykauden-alkaessa,c489998

Alanen, R. (2010). Veneiden uudet energiajärjestelmät. VTT. Retrieved March 30, 2022, from http://www.finnboat.fi/linked/fi/Vene-Ene_VTT_W154.pdf

Almerini, A. (2022, February 11). Everything you need to know about installing solar panels on boats. SolarReviews. Retrieved March 28, 2022, from https://www.solarreviews.com/blog/solar-panels-for-boats

Aurinkosähkö.net. (n.d.). Aurinkosähköjärjestelmät 12V. Retrieved May 6, 2022, from https://www.aurinkosahko.net/page/7/aurinkosahkojarjestelma-12v

Dometic. (n.d.). Jääkaappien valintaopas. Retrieved May 29, 2022, from https://www.dometic.com/-/media/landing-pages/10-series/buyingguiderefrigerators2020fi.pdf?la=fi-fi&hash=179F2B8B32BF217CE5AB196371F6292B

Electric Marine. (n.d.). Sähköveneilyn ABC - Voiko minun veneeni sähköistää. Retrieved May 2, 2022, from https://www.electricmarine.fi/yleista-veneilysta/veneilyn-abc/#more-1556

EPIA. (2009). Photovoltaic Energy – Electricity from the Sun. Retrieved March 24, 2022, from https://www.motiva.fi/files/9179/Photovoltaic_Energy_Electricity_from_the_Sun_EPIA.pdf

Finnwind. (n.d.). FAQ aurinkopaneeli Usein kysyttyä. Retrieved March 21, 2022, from https://finnwind.fi/aurinkopaneeli-usein-kysyttya/

Independent Power Systems. (2021, January 25). Battery Storage 101: What Is Depth of Discharge. Retrieved June 20, 2022, from https://www.solarips.com/blog/2021/january/battery-storage-101-what-is-depth-of-discharge-/

JN-Solar. (n.d.). Aurinkopaneelit veneeseen. Retrieved April 25, 2022, from https://www.jn-solar.fi/fi/11-aurinkopaneelit-veneeseen

Kurki-Suonio, R. (n.d.). Sähkömoottoriveneeseen. Venemarket. Retrieved May 5, 2022, from https://venemarket.fi/sahkomoottori-veneeseen/

Marinea. (n.d.). Venepaneelit. Retrieved April 25, 2022, from https://www.marinea.fi/venepaneelit

Marinea. (n.d.). Vesigeneraattori. Retrieved May 10, 2022, from https://www.marinea.fi/vesigeneraattori

Marinea. (n.d.). Tuuligeneraattorit. Retrieved May 5, 2022, from https://www.marinea.fi/tuuligeneraattorit

Marinekauppa.com. (n.d.). Aurinkopaneelit ja tarvikkeet. Retrieved April 21, 2022, from https://www.marinekauppa.com/tuote-osasto/venesahkot/aurinkopaneelit/

Motiva. (2021, August 20. Aurinkosähköjärjestelmän teho. Retrieved June 12, 2022 from https://www.motiva.fi/ratkaisut/uusiutuva_energia/aurinkosahko/jarjestelman_valinta/aurinkosahkojarjestelman_teho

Motiva. (2021, August 20). Aurinkosähköteknologiat. Retrieved March 24, 2022, from https://www.motiva.fi/ratkaisut/uusiutuva_energia/aurinkosahko/aurinkosahkojarjestelmat/aurinkosahkoteknologiat

Mylly, T. (2014, May 24). Diesel-koneen huolto on helppo tehdä itse. Retrieved June 15, 2022, from https://www.nettivene.com/artikkeli/diesel_koneen_huolto_on_helppo_tehda_itse

Mylly, T. (2014, May 7). Näin teet perämoottorin vuosihuollon. Retrieved June 15, 2022, from https://www.nettivene.com/artikkeli/nain_teet_peramoottorin_vuosihuollon

Pidä Saaristo Siistinä ry. (n.d.) Ympäristötietoa. Retrieved May 2, 2022, from https://www.pidasaaristosiistina.fi/ymparistotietoa

STEK. (2022). Sähkö ja vene -opas. Retrieved April 28, 2022, from https://stek.fi/veneilijalle/sahko-ja-vene-opas/

STEK. (n.d.). Veneilijän sähkölaskuri. Retrieved April 28, 2022, from https://gravasoftdemo.azurewebsites.net/laskuri/etusivu.html

Sunwind. (n.d.). Venepaneeli 12V. Retrieved April 25, 2022, from https://www.sunwind.fi/product/category/?cap=154&Venepaneeli-12V

Suomen Purjehdus ja Veneily. (n.d.). Veneilijä ja ympäristö. Retrieved May 2, 2022, from https://spv.fi/matkaveneily/vastuullisestivesilla/

Turvallisuus- ja kemikaalivirasto. (n.d.). Veneiden myrkkymaalit. Retrieved May 5, 2022, from https://tukes.fi/luulotpoiskemikaaleista/veneiden-myrkkymaalit

Turvallisuus- ja kemikaalivirasto. (n.d.). Antifouling-esite. Retrieved May 5, 2022, from https://tukes.fi/documents/5470659/11781251/Antifouling-esite/0c8ab6a0-6d13-df8b-0381-723573598d18/Antifouling-esite.pdf?t=1552031926000

Väre. (n.d.). Aurinkopaneelien sijoittaminen ja suuntaus. Retrieved March 21, 2022, from https://vare.fi/aurinkopaneelit/aurinkopaneelien-sijoittaminen-ja-suuntaus/

Watski. (n.d.). Opas aurinkopaneeleiden hankintaan ja asennukseen veneessä. Retrieved March 22, 2022, from https://www.watski.fi/uutiset/opas-aurinkopaneelit